Trinity River Restoration Program Phase II Review

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Trinity River Restoration Program Phase II Review

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Executive Summary

The Trinity River Restoration Program (TRRP) was established in 2000 by the Department of Interior's Trinity River Record of Decision (ROD). The ROD was the result of decades of studies described the impacts of the Trinity River dams and outlined the plan to restore the Trinity River and its fish and wildlife populations. This plan focused on five main categories of restoration actions: flow management, sediment management, watershed activities, channel rehabilitation, and adaptive environmental assessment and management.

To date, the program has been split into two phases: Phase 1 spanning from 2003 to 2011 and Phase 2 spanning from 2012 to 2022. Throughout both phases, changes have been made to both the program and to the management actions. These changes have reflected the knowledge that has been gained through extensive scientific inquiry and lessons learned from dozens of implemented projects. In Phase 2 (2012-2022), the TRRP has implemented 14 channel rehabilitation and 42 watershed restoration projects, implemented revised flow management strategies to better mimic natural winter month flow variation, and adjusted sediment augmentation methods to better align with flow releases and geomorphic processes in the Trinity River. Many different methods of evaluating project success have been conducted in the Trinity River since the ROD, but these have largely focused on biological monitoring of juvenile and adult salmonid presence in the reach, or the presence of physical habitat features that meet biological habitat criteria. In general, these results show that rehabilitated areas provide improved or equal juvenile salmonid rearing habitat compared to non-rehabilitated areas, though the overall geomorphologic setting of the project was also a large factor influencing rehabilitation project effectiveness (Cooper-Hertel et al. 2022).

The purpose of the review document is to summarize the TRRP's channel rehabilitation, site revegetation, watershed projects, flow management, and gravel augmentation activities through 2021, with an emphasis on the channel rehabilitation projects implemented during Phase 2. The scope of the retrospective review is based upon group interviews, restoration site tours, and review of the existing available literature. This report builds upon an extensive body of literature produced in the TRRP, including lessons learned as part of the review of Phase 1 (Buffington et al. 2014).

This review further includes a discussion of: the perceived strengths and weaknesses of the design and design review process; the TRRP's responsiveness to the actionable recommendations from the Phase 1 Review; the degree to which the projects as implemented meet the stated design objectives of the project; a critical review of the program's overall approach to channel rehabilitation recommendations for Phase 3.

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ABBREVIATIONS

AEAM – Adaptive Environmental Assessment and Management
cfs – cubic feet per second
CVP – Central Valley Project
CVPIA - Central Valley Project Improvement Act
DOI – Department of Interior
DSS – Decision Support System
HVT – Hoopa Valley Tribe
IAP – Integrated Assessment Plan
LWM – Large Woody Material
NF – North Fork
RM – River Mile
ROD – Record of Decision
SAB – Science Advisory Board
TMC – Trinity Management Council
TRD - Trinity River Diversion
TRRP – Trinity River Restoration Program (also referred to as “Program”)
USFWS – U.S Fish and Wildlife Service
YT – Yurok Tribe

1. Introduction

1.1 PROGRAM OVERVIEW

1.1.1 ROD & TRRP Background

In the mid-20th century, the Trinity River Division (TRD) was developed and allocated substantial quantities of water from the Trinity River to the Central Valley Project (CVP), primarily to support agricultural and domestic water needs. Although Congress authorized the TRD as an integrated component of the CVP, Section 2 of the 1955 Trinity River Diversion Act (P.L. 84-386) specifically directed the Secretary of the Interior to ensure the preservation and propagation of fish and wildlife in the Trinity Basin through the adoption of appropriate measures. By diverting a majority – in some extreme years, over 90% - of the total upper Trinity River flows, these diversions compounded earlier and ongoing ecological impacts generated by historical gold mining and timber harvests. These factors lead to a precipitous decline in fish and wildlife populations shortly following the completion of the TRD.

To combat these impacts, several initiatives were created in the 1980s and 1990s. These included the Trinity River Basin Fish and Wildlife Task Force (established in 1984) and the Central Valley Project Improvement Act (1992), both aimed to improve fish and wildlife stocks. In 1981, the Interior Secretary increased base flow allocations to the Trinity River and initiated a study into the impacts of flow regulation and recommendations for flow management in the Trinity River. This and other parallel efforts in the Trinity River in the 1980s and 1990s culminated with two key documents: the Trinity River Flow Evaluation Final Report (Flow Evaluation Study) and the Trinity Environmental Impact Statement (EIS). Completion of these two documents provided a foundation for the 2000 Department of Interior (DOI) Record of Decision (ROD), signed on December 19, 2000. The ROD outlines the plan for restoration of the Trinity River and its fish and wildlife populations. Notably, the ROD focuses on impacts related solely to dam construction and operation of the TRD. The ROD also established the Trinity River Restoration Program (hereto after referred to as TRRP or "Program") as a designated body to coordinate the efforts to restore the Trinity River.

Timeline of TRRP/ROD programmatic milestones

1963: Trinity/Lewiston dams completed

1981: Interior Secretary increased flows and initiated Flow Evaluation Study

1999: Flow Study completed, used as Preferred Alternative in EIS/EIR

2000: Record of Decision (ROD) signed

2003-2011: Phase 1 Channel Rehabilitation projects

2004: First ROD flow release

2011: Trinity River Channel Design Guide

2012-2022: Phase 2 Channel Rehilitation projects

2014: Phase I Review Report

2018: Headwaters Report and TRRP "Refinements" process begins

2022: Phase 2 Review initiated

2023: Science Plan drafted

The Trinity River Restoration Program (TRRP) was established to restore the form and function of the Trinity River. Management actions intended to restore this form and function are organized into these categories:

1. Flow Management
2. Sediment Management
3. Watershed Activities
4. Channel Rehabilitation
5. Adaptive Environmental Assessment and Management (AEAM)

Combined, these management actions are intended to address the impacts caused by decades of flow diversion on a historically prolific anadromous salmon and trout system (USFWS HVT 1999). More information about these management actions is provided in subsequent sections of this report.

> The TRRP PURPOSE is…
> *… to mitigate impacts of the Trinity River Division of the Central Valley Project on anadromous fish populations in the Trinity River by successfully implementing the 2000 Trinity River Record of Decision and achieving Congressionally mandated restoration goals.*
>
> TRRP GOAL
> *The long-term goals of the Program are to: 1) restore the form and function of the Trinity River; 2) restore and sustain natural production of anadromous fish populations in the Trinity River to pre-dam levels; and 3) to facilitate full participation by dependent tribal, commercial, and sport fisheries through enhanced harvest opportunities.*

The Trinity River Restoration Program is a collaborative organization of eight primary program partners. These eight program partners include:

- Hoopa Valley Tribe
- Yurok Tribe
- California Natural Resources Agency
- Trinity County
- U.S. Bureau of Reclamation (Reclamation)
- National Marine Fisheries Service (NMFS)
- U.S. Fish and Wildlife Service (USFWS)
- U.S. Forest Service

The TRRP operates with oversight from the Trinity Management Council (TMC). The TMC includes one appointed representative per partner group (listed above) and sets priorities, goals, and schedules for program activities and implementation, and provides guidance, oversight, and review to the TRRPs Executive Director.

The organizational structure of the TRRP is shown in Figure 1. The primary group types are highlighted below.

Science Advisory Board (SAB) is a multidisciplinary committee tasked to resolve technical matters and provide research and recommendations to the TMC.

Workgroups & Subcommittees that interact with and support the design teams and design groups. The workgroups have evolved throughout the duration of the TRRP.

Trinity Management Council functionally serves as the TRRP's Board of Directors and includes an appointed representative from each of the eight primary program partners.

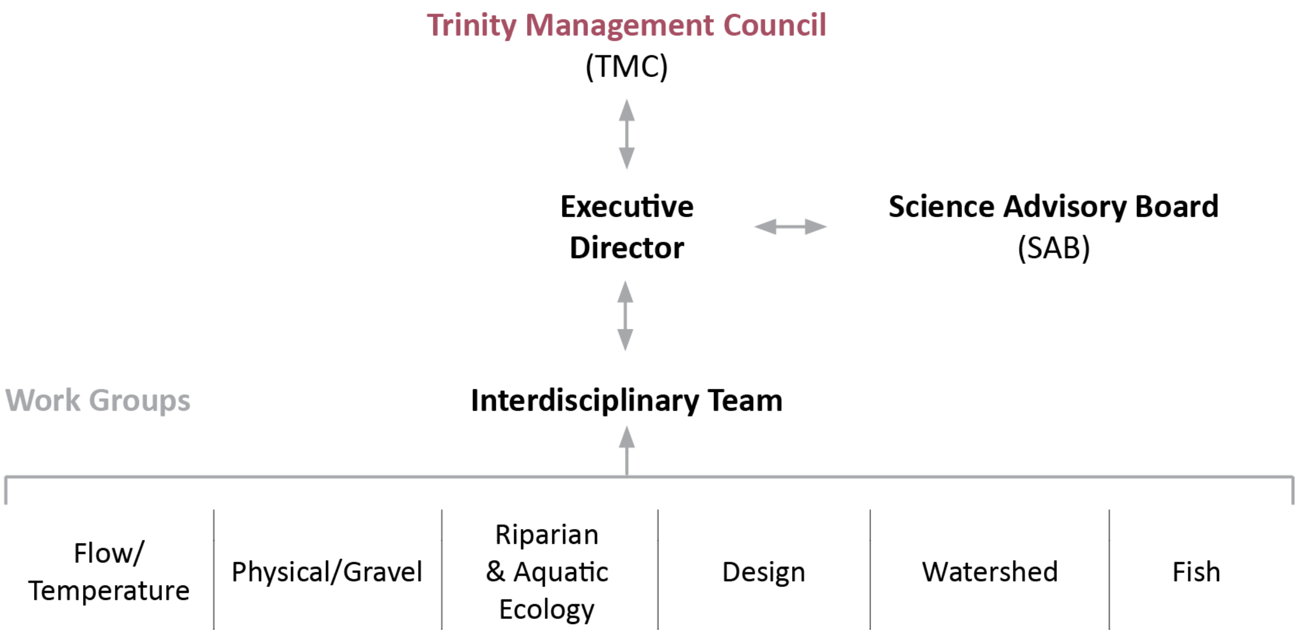

Figure 1. Organization structure and collaboration processes for the TRRP.

1.1.2 Channel Rehabilitation Program Phasing and Projects

The Flow Evaluation Study (USFWS HVT 1999) identified 47 channel rehabilitation projects to be completed as part of the Channel Rehabilitation Program, and the ROD called for projects to be reviewed after approximately one half of them were built. Initiation of this review marked the conclusion of Phase 1. Following review of Phase 1 projects, the TRRP entered Phase 2. The following subsection provides a brief overview of Phase 1 activities and the results of that review, followed by a brief summary of Phase 2 activities and the scope of this review, with a particular focus on Channel Rehabilitation projects.

Phase 1 (2005-2011) Overview and Review

Seventeen channel rehabilitation projects were built in Phase 1 between 2005 – 2011. Phase 1 projects were relatively smaller in size and scale and included a lighter touch, in hopes that these types of projects would set the river on a more positive trajectory and enable it to "heal itself." These earlier channel rehabilitation included project elements such as: "feathering" the river channel edge (re-grading the channel banks at a more gradual slope, often 10H:1V), removing riparian vegetation that encroached in response to flow management and was "locking" the channel in place, removing or notching riparian berms that formed partially in response to this vegetation encroachment, and lowering floodplain surfaces to activate at the 1.67-year event (corresponding to 6,000 cfs at Lewiston).

Several foundational documents of the TRRP were developed in Phase 1, including:

- Conceptual Models and Hypotheses for the TRRP: consolidation of restoration-oriented scientific understanding at the time in the Trinity River (TRRP 2009).
- Federal Register Correction on Flow Volume Determination: Clarification of how annual restoration flow volumes are calculated, aligning the EIS, Record of Decision, and court decisions (USBR 2006).
- Master Environmental Impact Report (EIR): Master environmental impact report and assessment for channel rehabilitation and sediment management for remaining Phase 1 and Phase 2 sites in the TRRP (RWQCB and USBR 2009).
- Integrated Assessment Plan (IAP): Summarization of Program goals and objectives and identification of the scope of research needed to evaluate restoration of the Trinity River and its fisheries (HRRP and ESSA Technologies, Ltd. 2009).
- Channel Rehabilitation Design and Implementation Process Review Report: Guidance on the TRRP process as well as specific recommendations on nine conceptual designs that had been implemented as of the report (CH2MHill and Entrix 2010).
- Trinity River Channel Design Guide: Documentation of the science and engineering behind most of the channel rehabilitation actions that had occurred at the time of publication (in 2011; HVT et al.).
- Trinity River Large Wood Analysis and Recommendation Report: Summary of the supply and storage of large wood within the 42- mile reach of the Trinity River and recommendations on large wood loading in Phase 2 restoration projects (Cardno Entrix and CH2MHill 2011).
- McBain Associates. 2015. Trinity River active bar mapping, Lewiston Dam to the North Fork Trinity River Confluence, Summer 2014. Prepared for Hoopa Valley Fisheries, Hoopa, California.
- Hoopa Valley Tribal Fisheries Department and McBain Associates. 2022. Coarse sediment storage synthesis on the Trinity River: Recommendations and Correlations to Juvenile Chinook salmonid rearing habitat.
- Hoopa Valley Tribal Fisheries Department and McBain Associates. 2021. Performance, evolution, and longevity of constructed channel and floodplain features on the Trinity River, California.

- Hales, G, A Hilton, S McBain, S Howlin. 2020. Statistical evaluation of Trinity River point bar mobility and bed scour during annual spring ROD releases for WY 2009-2013. Report to Hoopa Valley Tribal Fisheries Department. McBain Associates and Western EcoSystems Technology, Inc.

In 2011, the TRRP requested review of their Phase 1 activities. An overview of recommendations resulting from this review and an assessment of the TRRP's response to them is provided in Section 4.

Phase 2 Overview and Review (2012-2021)

Following review of Phase 1, the TRRP entered Phase 2, which spanned the time between 2012 and 2021. Phase 2 included design, analysis, and in some cases, construction of many of the remaining channel rehabilitation projects identified and recommended in the Program's flow evaluation study (USFWS and HVT 1999). Thirteen projects were constructed during Phase 2, while five are currently in some stage of design. Lessons learned from the Phase 1 review improved project performance in a number of areas. These include:

- Meeting water temperature objectives in most years.
- Improving riparian vegetation establishment.
- Completing mandated infrastructure improvement to accommodate increased flows.
- Producing habitat gains at specific restoration sites.
- Increasing the number of salmon smolts produced.
- Refining the TRRP's restoration techniques and strategies based on new science.

Throughout Phase 2, the TRRP and its partners have continued monitoring the effectiveness of its channel rehabilitation implementation. This monitoring has been used throughout Phase 2 to refine and improve the design of channel rehabilitation projects. Results of this monitoring have led to increased implementation of new channel meanders, increased density and frequency of large wood placements, and more aggressive floodplain lowering to accommodate more frequent inundation. While these evolutions have been ongoing, and many valuable internal analyses have been completed and published in various forms (e.g., Hoopa Valley Tribal Fisheries Department and McBain Associates. 2021), there has not been an external review of restoration actions since the TRRP Science Advisory Board's Phase 1 Review (Buffington et al. 2014), which is the purpose of this report.

To fulfill the ROD-mandated review of Phase 2 as well as formally capture lessons learned within the program and advancements in the broader restoration practice, the TRRP initiated the Phase 2 review. In May 2022, the Phase 2 review effort began by convening a panel of expert restoration practitioners with a variety of specialties in geomorphology, engineering, fish biology, and vegetation. The scope of this review was limited to review of the existing extensive library of TRRP-related literature, studies, and reports developed in the Trinity River over the past three decades, a kickoff meeting and rapid field visits to several key project sites, and a series of separate group interviews with each of the TRRP partners. These efforts have resulted in the compilation of this Phase 2 review document.

Phase 2 Timeline

2022	June 1	Contractor hired to assemble expert panel
	June 28	IDT Kick off meeting
	June 30	Site tours
	Sept 12	Stakeholder feedback/ public meeting
	Sept 12	Site tours
	October	Interviews with TRPP partners
2023	Feb 1	Retrospective Report
	June	TMC meeting (virtual)
	July	Final Report

Several documents developed in Phase 2 that offer key analysis or assessment related to the Trinity River or TRRP, and which are discussed in more detail in the following sections, include:

- Headwaters Report: A review of the TRRP conducted upon request by TMC members. TRRP is using the recommendations from this review as part of a "TRRP Refinements" effort to improve program governance (Headwaters Corp. 2018).
- Fine Sediment Impacts in the Trinity River: A summary of the history of fine sediments in the Trinity River and re-evaluation of the current situation for fine sediment, providing recommendations on sediment management for riverine ecosystem function (Buxton 2021).
- Long-Term Analyses of Estimates of Abundance of Juvenile Chinook: An analysis of 30 years of data on juvenile Chinook salmon abundance in the Program Reach, in relation to TRRP management actions (Pinnix et al. 2022).
- Trinity River Juvenile Salmonid Habitat Synthesis: An analysis across the restoration reach looking into flows, physical terrain, hydraulics, and fish distribution (Cooper-Hertel et al. 2022).
- Cottonwood Seed Dispersal Synthesis: The development of a seed dispersal model for cottonwood to improve timing of flow recession meant to promote establishment of cottonwoods (Bair et al. 2020).

- Vegetation Encroachment Synthesis: An analysis of the colonization and encroachment of woody plants along the river channel (HVTFD and McBain Associates 2021).
- McBain Associates. 2015. Trinity River active bar mapping, Lewiston Dam to the North Fork Trinity River Confluence, Summer 2014. Prepared for Hoopa Valley Fisheries, Hoopa, California.
- Sediment Transport in the Trinity River data synthesis: An assessment of sediment transport data collected in the Trinity River over a 12-year period for temporal and spatial patterns to provide recommendations for guiding management decisions (Gaeuman and Stewart 2017).
- River Corridor Pilot Report: The first steps at identifying a river corridor management strategy to develop a more holistic conceptual foundation that supports the various restoration actions of the TRRP (Gaeuman et al. 2016).

1.2 PROGRAM REACH REVIEW EXTENT

The Flow Evaluation Study and ROD defined the linear area along which restoration actions would be authorized within the Trinity River (Program Reach). This is defined as the 39.9-mile reach from the confluence with the North Fork Trinity River upstream to Lewiston Dam (RM 72.2 – 112.1; Figure 2). Notably less well-defined is a formally accepted lateral extent (areas outside of the main channel) of the Program Reach.

For the purposes of this Phase 2 Review effort, we have adopted the lateral extent proposed by the River Corridor Management Strategy as the lateral limits of the channel rehabilitation projects review. In the River Corridor Management Strategy, the following lateral limits and associated description are provided:

> *Lateral extents of the valley corridor are defined as the hydraulic floodplain that is inundated once every 500 years on average, regardless of the geomorphic history that produced the surface. The 500-year flood extents were modeled by using HEC-RAS (CDWR 2007). Since the Trinity River experienced an intense period of mining in the 19th century, the hydrologic floodplain has been confined in many areas by mine tailings. Where floodplain widths are reduced by tailings, the 500-year floodplain has been expanded to include these sediments. Artificial confinement by dredging significantly reduced the valley width through much of the river. The valley corridor has also been expanded to include areas where the 1944 or 1960 river position was beyond the current 500-year floodplain (Gaeuman et al. 2016).*

It should be noted that the Program Reach is the bounds of the recommended 47 channel rehabilitation project sites as described in the ROD. Projects have also been implemented much more widely throughout the Trinity basin, including in tributary watersheds on public and private lands.

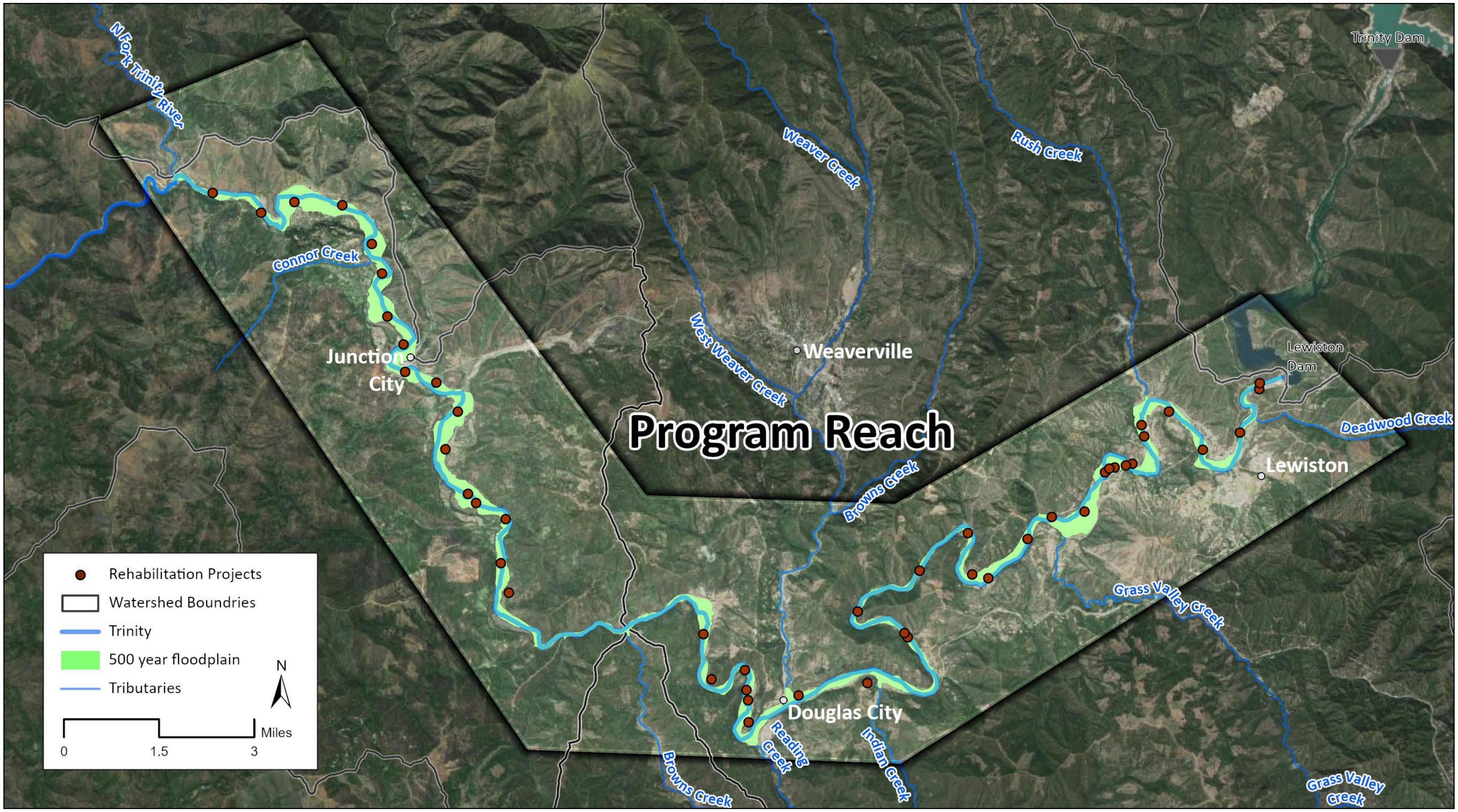

Figure 2. Trinity River Restoration Program reach overview. The linear extent of the Program Reach is defined as the confluence with the North Fork Trinity River upstream to Lewiston Dam (RM 72.2 – 112.1). The definition of the lateral extent of the project has not been formally adopted, however, for the purposes of this review it includes the 500-year floodplain as defined by Gaeuman et al. 2016.

1.3 WATERSHED OVERVIEW

Numerous studies on the Trinity River Program Reach and contributing basins have been conducted by TRRP staff and partners since the ROD was implemented. Among other items, these studies included investigations into subtopics such as the physical watershed context, geology and geomorphology, large wood dynamics, hydrology, water temperature, ecology/biology, and vegetation. While a large body of work is available to provide more supporting information on each of these subtopics, the following subsections provide an overview and some key findings related to each of these subtopics.

1.3.1 Physical Watershed Context

The Trinity River is headwatered in the Trinity Mountains and drains 2,950 square miles of steep, dissected terrain in the Klamath Mountains of Northwestern California. The river trends generally in a northwestern direction, flowing into the Klamath River near Weitchpec, California. The basin is mostly forested, although much was clear cut in the mid-20th century. The maximum elevation in the watershed is approximately 9,000 feet, with the minimum at the confluence with the Klamath at about 200 feet above sea level. Approximately 80 percent of the lands within the Trinity basin are federally managed (by the USDA Forest Service and the U.S. Bureau of Land Management), with much of that land being forested. Approximately 10 percent of the area includes industrial timberlands, with the remaining small percentage of land in the watershed owned by other private landowners.

Mean annual precipitation in the watershed is approximately 60 inches, primarily falling as rain (snow in the upper portions of the watershed in the Trinity Mountains) in the late fall, winter, and spring months.

1.3.2 Geology and Geomorphology

Within the Program Reach, the Trinity River valley is confined by a narrow valley, with frequent contact between the channel banks and valley walls. In non-alluvial reaches, bedrock outcrops provide lateral and vertical controls of the channel. Alluvial reaches of the river are in lower slope areas where large sediment wedges are stored, some of which are the result of hydraulic mining (Buffington et al. 2014). Through these reaches, the channel is relatively sinuous and exhibits pool-and-riffle sequences. While knowledge of pre-disturbance channel morphology is somewhat limited, it is believed that before transformation by placer mining and dams the Program Reach likely exhibited periodic reaches of an anabranching or alternating gravel bar sequences. Historically, these alternate bar sequences or anabranching channels would have created velocity, substrate, and topography variation at a wide range of flows, creating crucial habitat for salmonid life stages. Alternate bars also provide important amphibian habitat (USFWS HVT, 1999).

The geomorphology of the Trinity River was profoundly altered in the 19th and 20th centuries by gold mining. In particular, placer mining for gold essentially flipped the sediment of entire alluvial valley bottom upside down, burying the fine more mobile sediments deep below the coarser sediments. These coarser sediments, which include the larger size fraction of cobbles, essentially serve as an artificial cap on the floodplain and channel boundary and create a situation where the river is not able to move and rework the sediments in its bed and banks. Within the Program Reach, this condition is exacerbated beyond other placer-mined systems because the dams have muted the high flow regime (e.g., the 1.5-year event decreased by 90% compared to pre-dam conditions). This eliminated the naturally occurring higher magnitude floods that may be able to mobilize this size fraction (USFWS HVT, 1999).

An additional impact on the river was an influx of sand-sized sediment eroded from areas clear cut in the 1950s and 1960s, notably in the drainage basins of Grass Valley Creek and Rush Creek. Large storms, such as that of December 1964, brought in large volumes of mostly coarse-sand-sized sediment that remained in the channel due to the river's reduced competence. Without the dams, the natural high flows would have been capable of flushing out even such large fine sediment inputs in less than a decade, but because high flows had been largely eliminated by flow regulation, the sediment filled pools and built-up vegetated berms (discussed below). Thus, some of the earliest restoration projects on the Trinity River aimed to remove sand from the system, through repeated dredging from deep pools that acted as sediment traps, and to reduce the influx of sediment to the system, such as the sediment basins built in the lower reaches of Grass Valley Creek and a dam situated relatively high in its catchment.

1.3.3 Large Wood Dynamics

In stream and river systems that have experienced little or no anthropogenic alteration, large wood is a naturally occurring component. Over time, vegetation within the floodplain is often recruited into the channel through flooding, erosion, wind throw, disease, beaver activity, or other natural mortality. The factors that influence wood inputs into the system and retention/storage of the materials include the amount of large wood coming in from upstream sources, lateral inputs from tributaries, wood input due to forest mortality, tree fall from fires or wind, bank erosion, mass wasting, previously buried wood stored in bed sediments (Benda and Sias 2003), the ability of the channel to store mobile wood, and the longevity of the wood (the time it takes to break down). Cardno Entrix and CH2MHill (2011) described historical and contemporary large wood processes in the Trinity River basin in detail and their work is summarized in the following paragraphs.

Historically, the Trinity River basin likely supported a densely-forested valley with species including cottonwood, pines, Douglas fir, and incense cedar. The channel was likely dynamic, with multi-channel reaches and highly complex habitats. The present geology, climate, and vegetation of the area suggest that, historically, wood within the basin was widely available and readily recruited into the channel. Early historical photos indicate a wide alluvial floodplain with mature conifers, snags, and large wood in the river.

Prior to the onset of mining, wood contributions into the Trinity River between Lewiston and the North Fork would have come from three primary sources: (1) The entire watershed upstream of Lewiston; (2) Tributaries along the upper river reach from Lewiston Dam to the North Fork; and (3) Main valley and floodplains. The relative contribution of each source is unknown but flows in the tributaries are small relative to the pre-TRD Trinity River hydrograph and were unlikely to deliver substantial quantities of large wood except in large flood events or debris flow/torrents. After construction of the Trinity and Lewiston dams in the 1960s, wood recruitment from the upper watershed to the project reach was completely eliminated. The third natural source of wood debris is the floodplain and hillslope forests along the Trinity River. The primary mechanism of wood recruitment from these sources is lateral erosion by the river that triggers mass wasting from the hillslopes and bank erosion of alluvial floodplains. Large trees grew along the Trinity River and were occasionally recruited to the river via these lateral migration processes where they would form snags and logjams.

However, the floodplain source of large wood to the Trinity River was substantially altered by European settlers. During the era of heaviest logging and mining between 1850 and 1950, new demands for wood in the basin, especially related to gold mining, led to a logging boom. Placer mining, and then later hydraulic and dredge mining, removed vast swaths of floodplain and upslope forests and vegetation as they overturned all of the sediments stored in the riverbed and floodplains. During this period, the river would have still experienced large peak flows (more than 10 times the peak flows the dams can release today) and mobilization of this newly exposed sediment supply, which likely created a broad braided river channel in the impacted areas with little or no woody vegetation.

Presently, wood is supplied to the river from tributaries and occasionally along the mainstem, but the supply from upstream continues to be trapped and removed behind the Lewiston and Trinity dams. The present supply of large wood from tributaries to the project reach is controlled by fires, floods, logging, debris flows, and other mass wasting events in the 418 square miles of mountainous terrain that drains into tributaries that enter the Trinity River between Lewiston and the North Fork. The supply of large wood from the mainstem floodplain is increasing because the post-dam riparian forests, which became established after the onset of flow regulation in 1964, are now groves of mature, 40+ year old alder trees.

With the implementation of restoration projects, another source of large woody material is provided for the Trinity River through direct wood placements at the individual project sites. These projects are described further in Section 2.

1.3.4 Hydrology

The TRD dramatically changed the hydrology of the Trinity River, including the Program Reach, and flow management has been a contentious issue ever since. As noted in the Flow Evaluation Study (USFWS HVT 1999), diverse physical and ecological processes depend upon variability in the flow regime. The magnitude, duration, frequency, timing, variability and rate-of-change of flows all play important roles in supporting a robust mosaic of habitats in the riverine ecosystem. While the need for high-flow simulation seems to be well accepted within the TRRP and amongst stakeholders, there is less emphasis—and consensus—on the need for continued adaptive management of the other aspects of the pre-dam flow regime, including lower summertime baseflows.

Annual flows on the Trinity River before the TRD varied significantly. Rain-on-snow events could create flows as high as 80,000 to 100,000 cubic feet per second (cfs), while late summer flows could drop below 100 cfs. The highest annual flow events typically occurred on the Trinity River from mid-November to late March (USFWS HVT, 1999).

As noted previously, the Trinity River Division of the CVP began flow regulation and water diversion on the Trinity River in 1960. At its inception, flow regulation diverted up to 90% of the Trinity River's water to the Central Valley. This diversion meant the river rarely flooded as it once routinely had, and portions of the main channel began filling in with sand and other sediments from the tributaries. The lack of regular winter floods also led to vegetation encroachment as plant species responded to near-static water levels. These changes combined to reduce salmon habitat contributing to a salmon population decline of up to 96% (USFWS HVT, 1999).

Daily mean flows from the early 1910s through 2022 recorded at the USGS gage at Lewiston (#11525500) are presented in Figure 3. The timing of three key changes in flow management are also highlighted: the beginning of trans-basin diversions in 1960 under the CVP and TRD acts, the secretarial decision in 1981, which increased flow releases into the Trinity River, and the ROD in 2000.

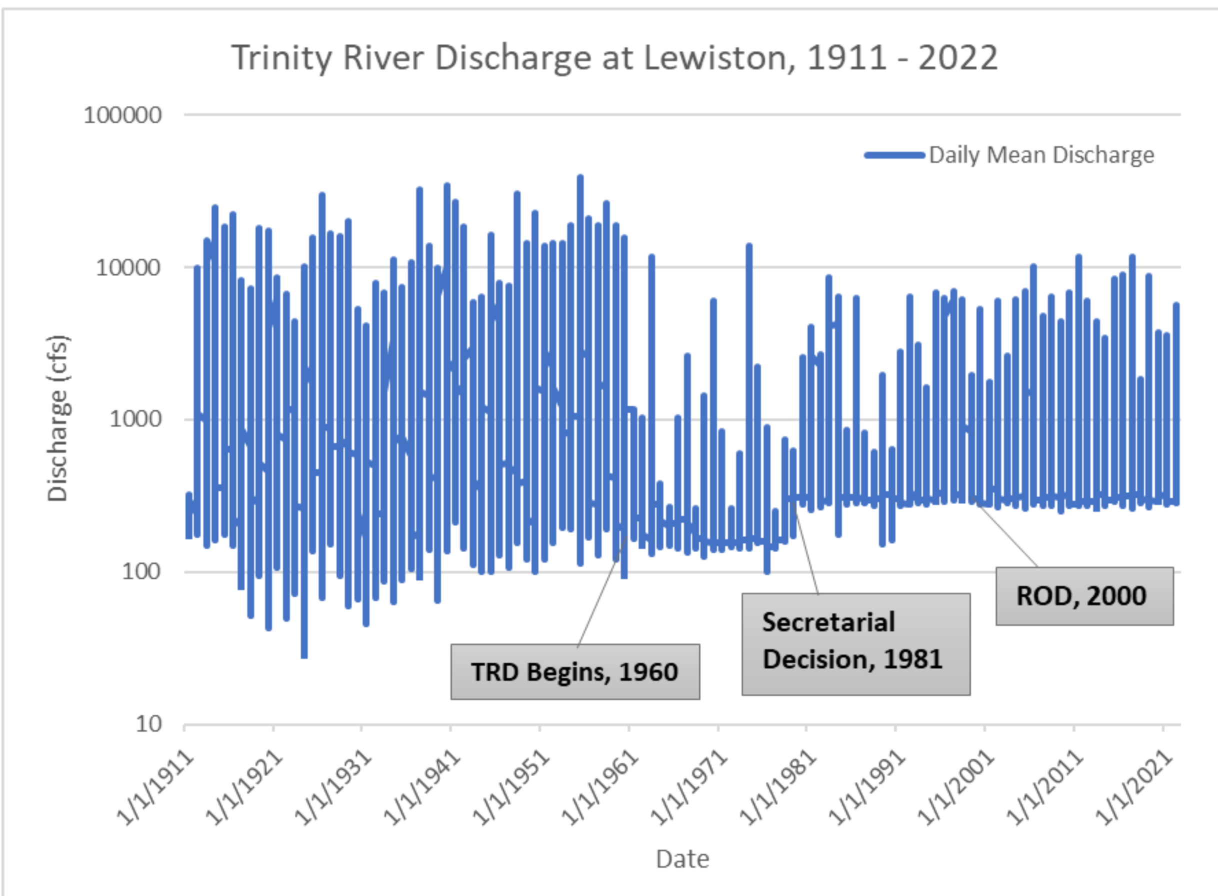

Figure 3. Daily mean flows at the USGS gage at Lewiston from 1912-2022 with the timing of three key changes in flow management are also highlighted.

Peak flows were much higher on the Trinity River prior to the TRD in 1960. The volume of water diverted from the Trinity River watershed after 1960 is evident, as well, with 90% of the river's volume diverted until the secretarial decision in 1981, and as much as 50% of the river's volume diverted since the ROD in 2000. After the ROD, the dam-release hydrology of the Trinity River was modified to be more representative of a snowmelt-dominated regime, with increased discharge in the spring and lower (but elevated above historically natural) flows in the summer and fall. Under the current flow management scenario, discussed in more detail in Section 2.1.1 of this report, the type of water year determines the flow release schedule from the dam for that specific year.

Summer baseflow values prior to 1960 were regularly as low as 100 cfs, with minimum flows of less than 60 cfs occurring several times per decade between 1915 and 1940. Low baseflows were an ecologically important part of the flow regime, playing important roles for vegetation and ecology (described in more detail in subsequent sections), and sustained summer baseflows of 450 cfs are not consistent with the pre-dam flow regime.

Under the current management regime, flood events within the mainstem of the Trinity River are largely the result of either tributary floods caused by winter storm events or infrequent safety-of-dam reservoir releases during periods of unusually large snowpack runoff. These infrequent large reservoir releases occur in the winter or spring, in coordination with gravel augmentation actions. Reservoir releases have historically not been timed to occur at the same time as unimpaired rainfall-runoff from the watershed below the dam in the early fall and winter, resulting in the loss of a key part of the Trinity River flow regime, particularly in the upper reaches of the restoration area.

1.3.5 Water Temperature

Seasonal water temperatures are also an important part of the current Trinity River hydrograph. Suitable water temperatures are critical for all life stages of salmonids, especially cool water throughout the summer. Prior to the dams, juvenile salmonids and adults migrating in the spring and summer are thought to have spent much of the summer period in higher, cooler reaches of the tributaries or in deep pools (> 6 feet) within the mainstem. Pools this deep or greater often allowed low flow water temperatures to stratify, providing cooler water near the riverbed for adult salmonids to hold, while simultaneously providing warm water at channel margins where juvenile salmonids and other organisms forage and grow (Buxton et al. 2022).

Today, both access to the headwaters and cooler, deeper stratified pools with cool ground water near the bottom are limited. Many of these headwater tributaries in the upper reaches of the Trinity watershed above the dams are now blocked to salmonids looking for cool-water refugia. The lower reaches that salmonids historically moved out of during the summer when conditions naturally became shallow and warm are now the only habitat available to sustain juvenile salmonids and migrating or holding adult salmonids throughout the summer. To support these populations (despite the deviation from the historical ecological condition), dam releases above historical baseflow discharges provide a flow of cool water. While the cool water releases limit the negative effects of temperature on rearing/holding salmonids, they also impose significant change to the river's ecology and may create water velocities that exceed those that adult salmon require for passive resting while spring Chinook mature for spawning. While it is unclear how existing pool habitat compares with pre-disturbance conditions to which the fish are adapted, these summer dam releases may also be altering pool stratification and the availability of the warmer channel margin habitats important to the growth of juvenile salmonids. Furthermore, the cooler water temperatures in the Trinity River because of these dam releases also fall below the optimal range for juvenile salmonid growth and may be related to declining juvenile salmonid sizes in the Trinity (Cooper-Hertel et al. 2022). Ecological change resulting from sustained dam releases above historical baseflow discharges is seen in the unnatural growth of vegetation along the channel margins that correspond to the sustained flow levels.

Water temperatures in the Trinity River are monitored to understand how well the dam releases meet specific water temperature criteria. Water temperature targets are specified for two locations on the Trinity River to help provide adult salmon suitable conditions for upstream migration and holding in the mainstem channel. The compliance target locations are located at Douglas City and above the confluence with the North Fork (NF) Trinity River (TRRP 2022a). Water temperature compliance monitoring was also conducted at Weitchpec near the confluence of the Trinity River with the Klamath River during Phase 2 but was recently removed as a compliance location.

The temperature compliance targets are daily average values and vary with time of year and location on the river. Releases from Lewiston Dam are therefore adjusted to maintain water temperatures below (or equal to) the temperature criteria provided in Table 1 below.

Table 1. Temperature compliance targets for the Trinity River.

Location	*Annual Time Period*	*Allowable Maximum Water Temperature*	*Target Species & Life Stage*
Trinity R. between Lewiston-Douglas City	July 1 – September 14	60°F (15.5°C)	Summer holding for spring run Chinook Salmon Juvenile rearing for Coho Salmon
Trinity R. between Lewiston- NF Trinity R.	September 15 – September 30	56°F (13.3°C)	Spawning Chinook Salmon Migrating adult Coho Salmon
Trinity R. above NF Trinity R.	October 1 – December 31	56°F (13.3°C)	Spawning Chinook Salmon, Coho Salmon, and steelhead trout

1.3.6 Aquatic Ecology & Fisheries Biology

Anadromous Salmonids

The seasonal return of salmon has been deeply celebrated by the tribal communities living along the Trinity River as well as others that would travel there to join in during harvest times since time immemorial. Careful management over the millennia provided a primary food source that supported many thousands of people via large populations of anadromous steelhead trout (*Oncorhynchus mykiss*), Coho salmon (*O. kisutch*), and Chinook salmon (*O. tshawytscha*), among other native fish and wildlife species.

As noted above, the Trinity and Lewiston dams (TRD) were completed in the early 1960's, dramatically altering the river corridor. More than 100 miles of anadromous salmonid habitat above the Lewiston dam was lost, forcing salmon to rely on a compressed range of the mainstem below Lewiston. The upper Trinity watershed provided important rearing habitat and safe summer water temperatures; habitat features that the river below Lewiston lacks (USFWS HVT 1999). Today, populations of wild salmonids have declined, and several in the Trinity River are listed under the federal Endangered Species Act or California Endangered Species Act[1]. In addition to blocked habitat access from Lewiston Dam, changes in the abundance of spawning and rearing habitat within the lower Trinity River is assumed to have contributed to the decline of these populations.

Restoration of habitats by the TRRP is informed by the life histories and habitat requirements of the anadromous fish species that continue to occupy the river corridor. The life histories of each species in the Program Reach are outlined below (Figure 4) to provide context for review of restoration activities, with brief descriptions of the habitat components and life stage timing critical to the growth and survival of each species.

[1] Coho salmon: Federal and state listed as Threatened, Southern Oregon/Northern California ESU; steelhead trout: State listed as Species of Special Concern, Klamath Mountains Province DPS; Chinook salmon: Federal ESA candidate and Spring-run is state listed as Threatened, Upper Klamath-Trinity ESU (CNDDB 2023).

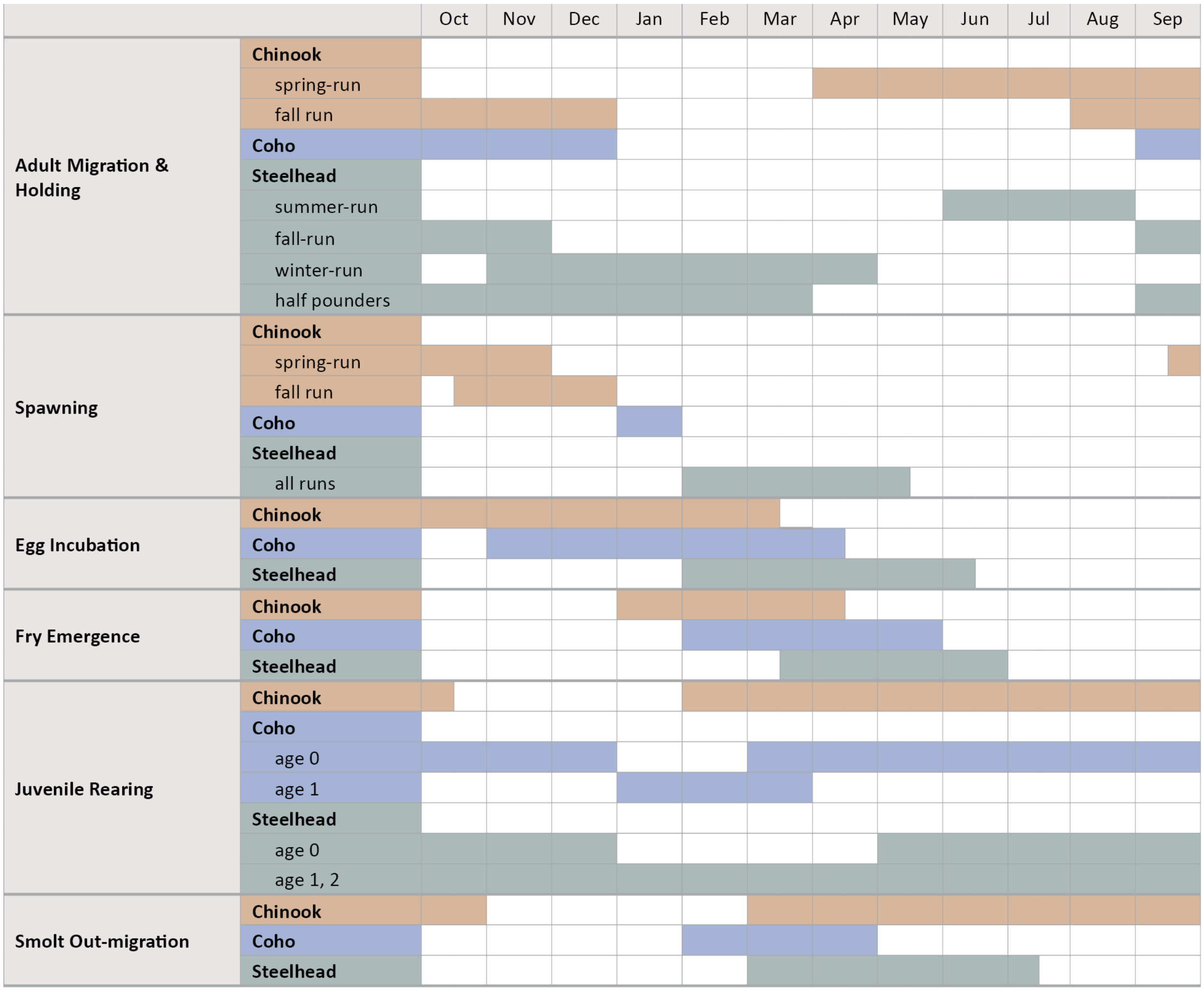

Figure 4. Fish use and life history timing in the Trinity River. Figure adapted from TRRP, 2022.

Chinook. Trinity River Chinook salmon populations are composed of two races, spring-run and fall-run. Spring-run Chinook salmon ascend the river from April through September, with most fish arriving at the reach below Lewiston (River Mile 111.9) by the end of July. These fish remain in deep pools until the onset of the spawning season, which typically begins the third week of September, peaks in October, and continues through November. The fall-run Chinook salmon migration begins in August and continues into December. Fall-run Chinook salmon begin spawning in mid-October, activity peaks in November, and continue through December. Juvenile Chinook salmon typically leave the basin (out-migrate) after a few months of growth in the Trinity River, with outmigration beginning around March and ending by late May or early June.

Coho. Adult Coho salmon migrate up the Trinity River and Klamath River from mid-September through January and spawn from November through January. The emergence of coho salmon fry in the Trinity River begins as early as late February and continues through March. Juvenile Coho remain in the Trinity River Basin for their first winter and into the following spring before out-migrating between February and May. Preferred habitats for juvenile Coho rearing in the Trinity

River include lower-velocity, deep pool habitats (especially during the winter) often occurring in off-channel areas and areas near instream cover, such as large woody debris, overhanging vegetation, and undercut banks.

Steelhead. Steelhead trout return to the Klamath-Trinity watershed throughout most of the year. Summer-run adults, or those steelhead that enter the river in an immature state and mature several months later in freshwater, commonly reach Lewiston (RM 112.0) by early June and continue to arrive through July. They enter major tributary streams by August and remain in deep pools until they spawn in February. Winter-run steelhead, or those steelhead that return to the watershed already sexually mature and spawn shortly, thereafter, enter the river between November 1 and April 30 and spawn in April and May. Summer-run adults generally use areas that are farther upstream than areas used by winter-run adults.

In addition to runs of adult steelhead, the Klamath and Trinity Rivers also support a run of immature steelhead known as "half-pounders", which spend only 2 to 4 months in the ocean before returning to the river in late summer and early fall. Half-pounders feed extensively in freshwater and are highly prized by sport anglers. Half-pounders overwinter in the river without spawning before returning to the ocean and return as mature adults during subsequent migrations.

After emergence from spawning gravel, steelhead fry and juvenile steelhead remain in freshwater for between two and three years, using similar habitats to those of juvenile salmon such as pools and edge or margin habitats with cover from large wood or overhanging banks. They can also be found in riffle/run areas with cobble bottoms. Rearing steelhead, especially as they get older, often prefer higher velocities than salmon of similar size. Outmigration of steelhead smolts from the Trinity River begins in early spring and continues throughout June (USFWS, 1998).

Key Habitat Criteria for Salmonids

Although the three species of anadromous salmonids that inhabit the Trinity River and are described above have unique habitat preferences and timing for their spawning, growth, and out-migrating life stages, these species share common life-history requirements that should be considered when making crucial decisions regarding restoration of the fisheries. These are summarized and included in 2 below. The implementation of the TRD and associated management actions have resulted in fewer gravel bars and deep pools in the mainstem Trinity River, reducing key aquatic habitats that salmonids rely on (USFWS HVT 1999).

Table 2. Life stage of anadromous salmonid species in the Trinity River. Specific habitat types needed by each life stage, and the associated river processes that create these landforms in the river corridor, are also included.

Life Stage	*Specific Habitat Types*	*Associated River Processes*
Adult Migration and Holding	Deep pools with cool summer water; cover from large wood, boulders, or overhanging banks/vegetation	Lateral and vertical channel migration, natural sediment transport processes, scour around large wood or other features, stratification of groundwater, hyporheic or cooler tributary inflows and surface water flows.
Spawning	Riffles with adequately sized spawning gravels; nearby pools or cover to rest and/or defend redd	Lateral and vertical channel migration, natural sediment transport processes, natural woody debris recruitment/retention
Egg Incubation	Low percentage of fine sediments in water; adequate flow through gravels	Lateral and vertical channel migration, natural sediment transport processes, natural hydrologic runoff characteristics
Fry Emergence	Interstitial spaces in gravels/cobbles of channel bed; low-velocity, shallow margin habitats or off channel areas with cover and available forage	Lateral and vertical channel migration, natural sediment transport processes, regular floodplain inundation, natural hydrologic runoff characteristics
Juvenile Rearing	Variety of habitat types, including low-velocity, shallow habitats with cover and available forage. Abundant deep pools, side-channel areas and interstitial cobble space for overwintering	Lateral and vertical channel migration, natural sediment transport processes, regular floodplain inundation, peak flows that form off-channel habitats or features
Smolt Outmigration	Suitable rearing habitat (as above) available in adequate quantities along the migratory path to support foraging and prey escape opportunities	Natural hydrologic runoff characteristics consisting of Spring and early summer high flows and warming water temperatures to cue smoltification and downriver migrations

Other Species

Although the primary focus of the Trinity River Flow Evaluation was on anadromous salmonids, the fish community in the Trinity River is composed of several additional species including Pacific Lamprey, Green Sturgeon, Speckled Dace, and the Klamath Smallscale Sucker and the non-native Brown Trout and Eastern Brook Trout. Several native species that occupy the Trinity River are of biological, cultural, and economic significance, and their life histories and habitat requirements are briefly outlined here to illustrate the diversity of habitat required by the fish community.

Pacific Lamprey (*Entosphenus tridentatus*) are harvested by the Hoopa, Yurok, and Karuk Tribes and remain an integral part of their culture today. Pacific lamprey are a parasitic species of anadromous lamprey native to the Trinity River. Adult Pacific lamprey migrate upstream and spawn during the spring. Their eggs are deposited in pits excavated in gravel and cobble substrates, which are usually associated with run and riffle habitats similar in character to salmon spawning areas. The eggs hatch into a non-parasitic larval stage, referred to as "ammocoetes". Ammocoetes drift downstream into slow-water habitats, where they burrow into sand or silt substrates. They spend from 4 to 5 years in freshwater, where they feed on organic detritus. The juveniles metamorphose into the adult form just prior to seaward migration, at which time they become parasitic. Adults remain in the ocean usually 6 to 18 months before they begin their spawning migration.

Green Sturgeon (*Acipenser medirostris*) are also harvested by tribal fisheries in the lower Klamath and Trinity Rivers and these fish have cultural significance to the Hoopa, Karuk, and Yurok. Green sturgeon migrate up the Klamath and Trinity Rivers between late February and July to spawn. Gray's Falls (RM 43) is believed to be the upstream limit of sturgeon migration in the Trinity River, and therefore sturgeon are not assumed to be present in the Program Reach.

Other notable sensitive aquatic species include the foothill yellow-legged frog and the western pond turtle. Historically, the river has supported diverse wildlife communities, many of which are dependent on floodplain habitat. The timing and temperature of water has significant impacts on many of these flood- and flow-dependent species.

1.3.7 Vegetation

The historical vegetative condition of the Trinity River corridor within the project area is largely unknown. However, the climactic and geomorphic context of the system along with limited available lines of evidence (e.g., early 1900s photographs from upstream of the project area as seen in Fiori and Martin 2011) provide some clues of the valley bottom vegetative composition. These photographs suggest that the valley bottom included conifers and deciduous plants, with deciduous shrubs and trees along the active channel. Additional anecdotal evidence from the late 1800s suggests that contributing hillslopes were densely forested with pines, Douglas fir, incense cedar, and cottonwoods species (Cardno Entrix and CH2MHill 2011).

In its pre-disturbance condition, plant assemblages that established and persisted within the Trinity River corridor and Program Reach were dependent first upon the system's climate (e.g., precipitation, growing season) and then upon the semi-alluvial geomorphic context of the Trinity River. Within this semi-alluvial setting, in some areas where alluvial storage did occur, the river corridor was likely occupied by plants that were morphologically adapted to establish and persist on alluvial geomorphic landforms (e.g., willows, cottonwoods). This presumably created complex feedback loops between the Trinity River's vegetative composition and geomorphic processes including bar migration, natural leveeing, and planform manipulation (e.g., split flow, channel narrowing). In other non-alluvial segments where bedrock served as a confining feature, vegetation establishment along the channel margins was likely absent or much more limited (HVTFD and McBain 2021).

The onset of hydraulic and dredge mining in the 1840s, particularly sluice/rocker box mining in the early 1900s, was the first significant direct impact to vegetation within the Trinity River Corridor. In addition to direct removal of vegetation from the valley bottom and contributing hillslopes, mining impacted sediment sorting (removing fine substrate, and leaving coarser sediments behind), dramatically increasing sediment volumes, unnatural aggradation, and altering the riparian topography in a way completely disconnected from the co-evolution of vegetation and a semi-alluvial stream (HVTFD and McBain 2021).

This was followed in the early 1960s, by the most significant indirect impact to vegetation within the Trinity River Corridor, the construction and operation of the TRD as part of the CVP. The construction and operation of the TRD dramatically altered baseflows, with initial discharges held steady at 150 cfs for nearly two decades. This instigated the growth and formation of an unnatural strip of vegetative encroachment established along the boundaries of the near-static water level. This encroachment and establishment simultaneously narrowed the active channel width and disconnected former floodplain surfaces by fostering sediment deposition within the vegetative strip forming topographic “levees” along wetted margins (Figure 5). As fish populations precipitously declined, the ROD adopted the Trinity River Flow Evaluation, and a more natural flow regime that targeted fish and vegetation was implemented. This flow regime came with the scientific realization that what is good for riparian vegetation is typically beneficial for salmonids. The new flow regime was intended in part to provide sufficient geomorphic work to counteract the vegetation encroachment and set the channel on a reparative trajectory to reconnect the feedback loops between geomorphic processes and vegetation (HVTFD and McBain 2021). Notably, the ROD still elevates late summer baseflows above historically low flows (based on temperature concerns discussed above). This still alters vegetation dynamics, leading to less downslope establishment of vegetation than historically likely occurred (e.g., fewer more transient obligate species at lower elevations on riverbanks and bars).

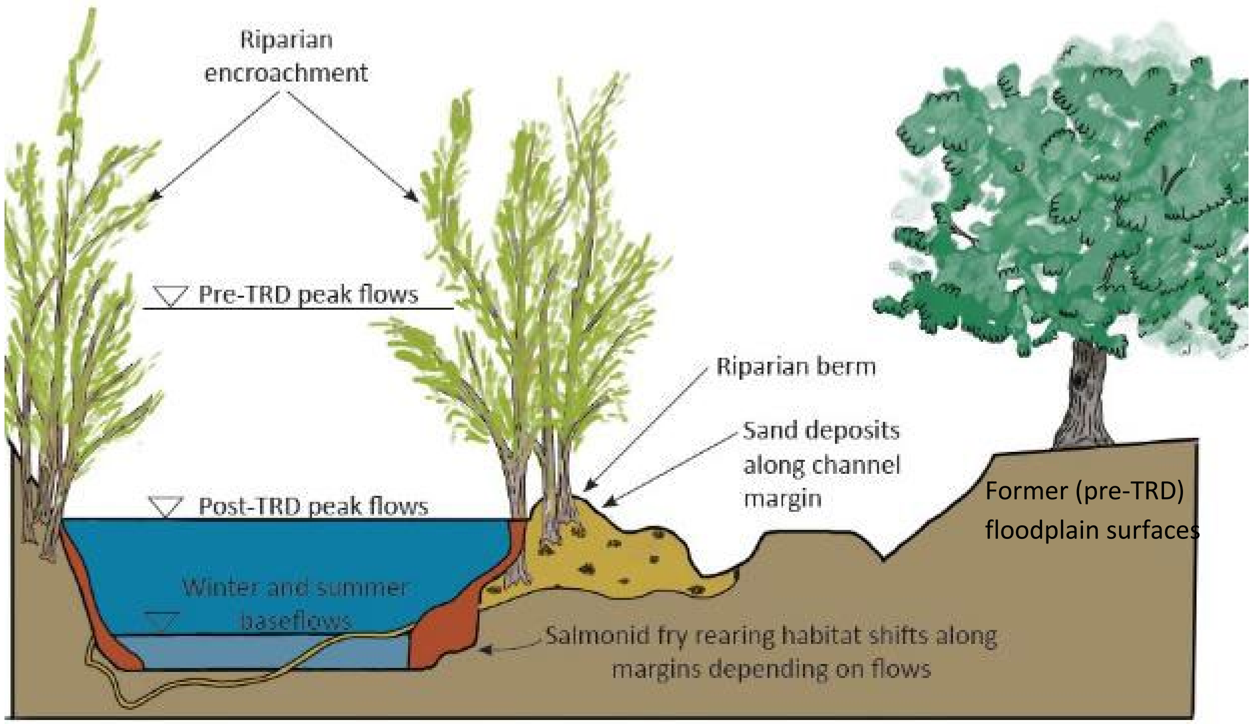

Figure 5. Schematic showing channel cross section and flows under pre-TRD and post-TRD conditions. Figure adapted from Hoopa Valley Tribal Fisheries Department and McBain Associates 2021.

1.3.8 Human Alterations History

The Trinity River, contributing basin, and Program Reach have been significantly altered by humans. Arguably the most significant impacts are mining, hydro regulation, and timber harvest. The combined historical and ongoing impacts from these land uses have affected the river and channel ecosystems in numerous ways and have resulted in a Trinity River through the Program Reach that is a very different than that which historically existed. Because the impacts of hydro regulation (Section 1.3.4, Section 1.3.7) and timber harvest (Section 1.3.3) are summarized above, this section focuses on the impacts related to mining.

Mining. One of the most significant impacts to the Program Reach has been mining, which included hydraulic mining of the hillslopes and dredge mining of the valley bottom. Sluice mining began in the 1860s, when gold miners used powerful hydraulic cannons to erode soils from contributing hillslopes within the Program Reach. As the soil was removed by powerful hydraulic cannons (Figure 6), the soil washed downslope into the valley bottom. This process dramatically altered the sediment supply to the river, making several orders of magnitude more sediment available for transport than the supply under natural conditions.

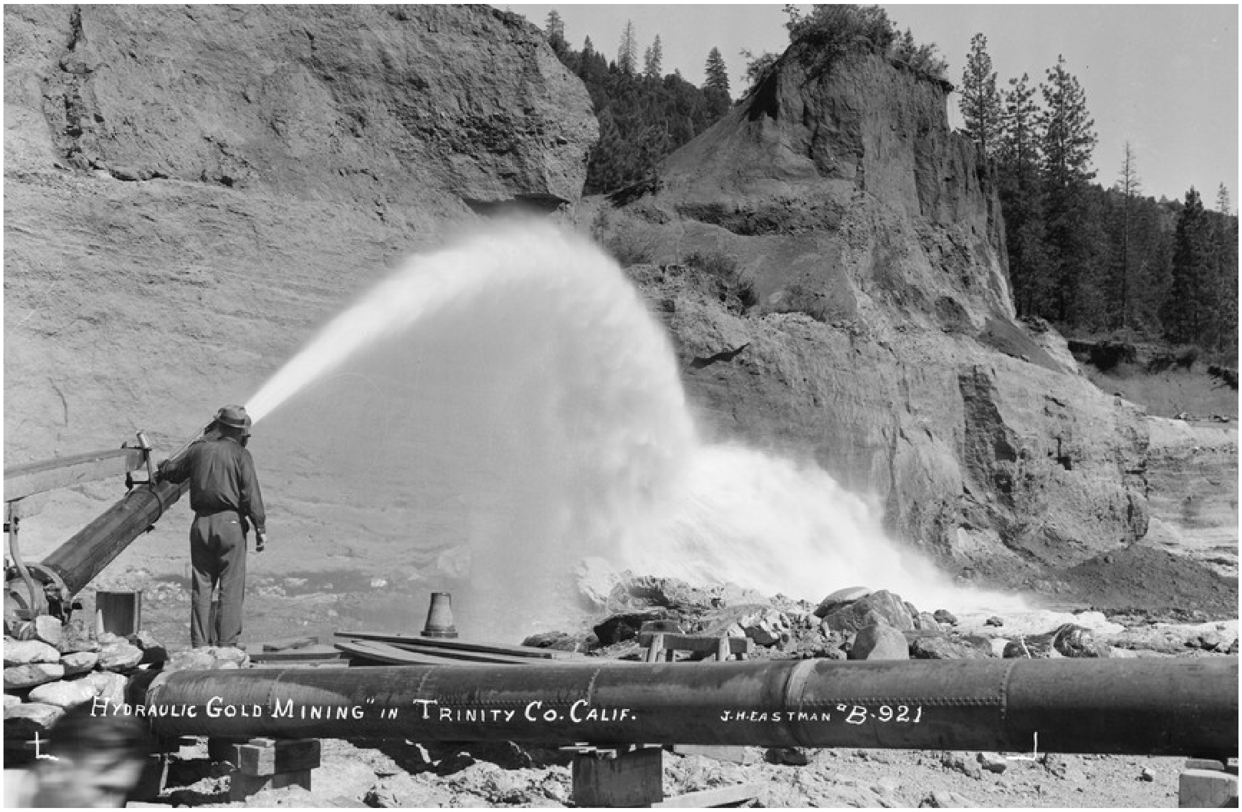

Figure 6. Hydraulic sluice mining (with "water cannons") on the Trinity River in 1939. Image courtesy of UC Davis Library Digital Collections, Eastman's Originals Collection.

Dredge mining, which occurred after hydraulic mining of the hillsides, reworked over 70% of the Trinity River floodplains within the Program Reach, creating large tailing piles of coarse sediment. The dredges that searched for gold placer deposits were essentially houseboats equipped with mining shovels that dug their way back and forth across the floodplain. Excavated floodplain sediments were sorted inside the dredge, separating gold from the other alluvial sediments which were deposited in long rows of arc-shaped tailings piles (Figure 7). In many places, the river was relocated along the valley wall to facilitate dredge mining (Krause et al. 2012).

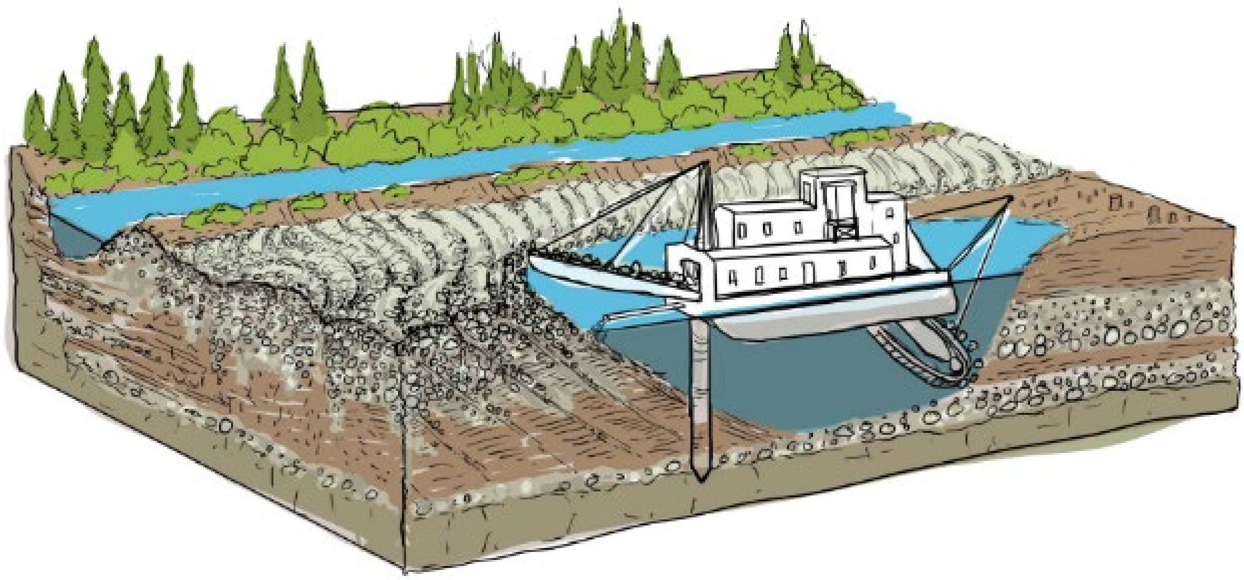

Figure 7. Schematic illustrating a dredge mining operation and the legacy impacts of re-sorted natural sediment stratification, floodplain condition, and channel and riparian conditions.

This process reconfigured the Program Reach's alluvial sediments into deposits that have very differing stratigraphy from the way a river would naturally sort material. This re-organization of floodplain and river channel sediments is problematic for many reasons. First, vegetation struggles to root in the coarse material left on the top of the tailings that hold neither soil nor water. Second, groundwater and hyporheic conveyance of through-flow or permeability is significantly disrupted. And third, the original river planform and the relationship of that planform with flow and vegetative patterns is broken and artificially simplified into one channel and often pushed to the margins of the valley. The resulting channel is greatly simplified, and no longer a product of natural geomorphic expression of flow and vegetative characteristics. This generally creates a simplified and straightened flow pattern that offers little habitat for rearing, holding, or spawning salmonids.

2. Program 'Retrospective'

As discussed above, the TRRP is intended to address the impacts caused by decades of flow diversion on a historically prolific anadromous salmon and trout system (USFWS HVT 1999). The foundation for the TRRP's work, found in the Flow Evaluation Report and the ROD, identified five management actions as a foundation for fishery recovery. These actions have been ongoing since signing of the ROD in 2000, and include:

1. Flow management
2. Sediment management
3. Watershed activities
4. Channel rehabilitation
5. Adaptive environmental assessment and management

The following sections describe each of the five management actions in more detail, followed by a discussion of changes of that management action since the ROD with particular emphasis on changes that have occurred within the Phase 2 period.

2.1 MANAGEMENT ACTIONS OVERVIEW

2.1.1 Flow Management

The Trinity River Flow Evaluation Study of the 1990s showed that higher flows are necessary on the Trinity River to maintain or restore salmon populations. Informed by this Study, in 2000, the U.S. Department of Interior directed that approximately 50% of the river's water would remain in the river (not be diverted to the Central Valley) to help support the restoration of the river and its fisheries. This water would be used increase both summer and winter baseflows and for releases intended to mimic historical inter-annual flow variation.

In an effort to facilitate flow management, the ROD defined five water-year types along with the minimum volume of water to be released into the Trinity River for each. The ROD specified volumes allotted to the river for these five water year types, with the water year type to be determined by State forecasts of reservoir inflow (3). Early in the water year various flow management scenarios are modeled and reviewed to improve restoration flow objectives that can be met in any given water year type. Based on this modeling and early water year forecasts in February and March, technical representatives of the Trinity River Restoration Program develop flow release recommendations within the water year type allocation of restoration flows to meet various restoration objectives and management targets. These flow recommendations are then presented to the Trinity Management Council (TMC) in March or early April for consideration.

The flow release recommendation, if approved by the TMC, is then forwarded to the Bureau of Reclamation and U.S. Fish and Wildlife Service as Central Valley Project Improvement Act (CVPIA) co-lead agencies for the U.S. Department of Interior, which has the final authority over dam releases.

Table 3. The five water year types and descriptions that dictate flows to the Trinity River and Program Reach.

Water Year Type	*State Forecast Inflow to Reservoir (acre-feet)*	*Allocation to Restoration (including base flows) (acre-feet)*
Extremely Wet	> 2,000,000	815,000
Wet	1,350,000 – 1,999,999	701,000
Normal	1,025,000 – 1,349,999	647,000
Dry	650,000 – 1,024,999	453,000
Critically Dry	< 650,000	369,000

While peak flows have improved following adoption of the ROD, muted peaks from winter storms and spring runoff continue to limit the dynamic nature of the river by reducing the stream power available to mobilize sediment. While some limitations related to infrastructure along the river exist (e.g., homes, bridges) preventing fully naturalized flow peaks, the existing maximum release of 11,000 cfs is now considered by some (according to interviews completed as part of this process) to be insufficient to rework the sediments within the more alluvial portions of the Program Reach. Thus, the reduced stream power due to dam regulation, combined with the large grain sizes left from gold dredging, has reduced the ability of the Trinity River to erode its banks, adjust planform geometry, and reorganize the larger size classes of sediments left behind as dredger tailings. For example, the reduced peak flows have proven insufficient in some sites to erode channel banks and cause channel migration. Further channel adjustment is expected to occur extremely slowly or not at all, due to the contemporary hydrology depositing sediments that are of smaller grain-size and at lower elevation than those deposited by pre-dam hydrology and through mining activities.

Despite flow changes adopted following the negotiations of the ROD, the current baseflow management regime is now thought to be inconsistent with conditions to which Trinity River salmonids evolved. The sudden decrease in baseflow in the fall from 450 cfs to 300 cfs may have detrimental effects on salmonid margin habitats or migratory/spawning behaviors due to hydrologic cues dramatically different than the natural environmental pattern of fall rainfall increasing river flows. Pre-dam baseflows in the Trinity River were characterized by lower flows in summer than in winter due to lower evapotranspiration rates and greater precipitation in the winter, which is the opposite of the existing flow management regime.

As noted above, these artificially elevated baseflows also have disrupted the natural feedback loops between riparian ecology and geomorphic processes within the Program Reach. This includes artificially dense, persistent riparian shrubs along the low flow channel margin and potentially a greater prevalence of more obligate emergent plant species lower down along the channel margin.

Similar to infrastructure limitations related to naturalized high flows, there are existing stakeholder-related limitations on naturalizing baseflows closer to the historically normal levels (e.g., closer to 100 cfs). These limitations mainly include recreational use of the river during the summer months for recreational purposes (e.g., whitewater rafting, fishing). The evolution of Trinity River flows as it relates to key ecological and recreational industries is shown in Figure 8.

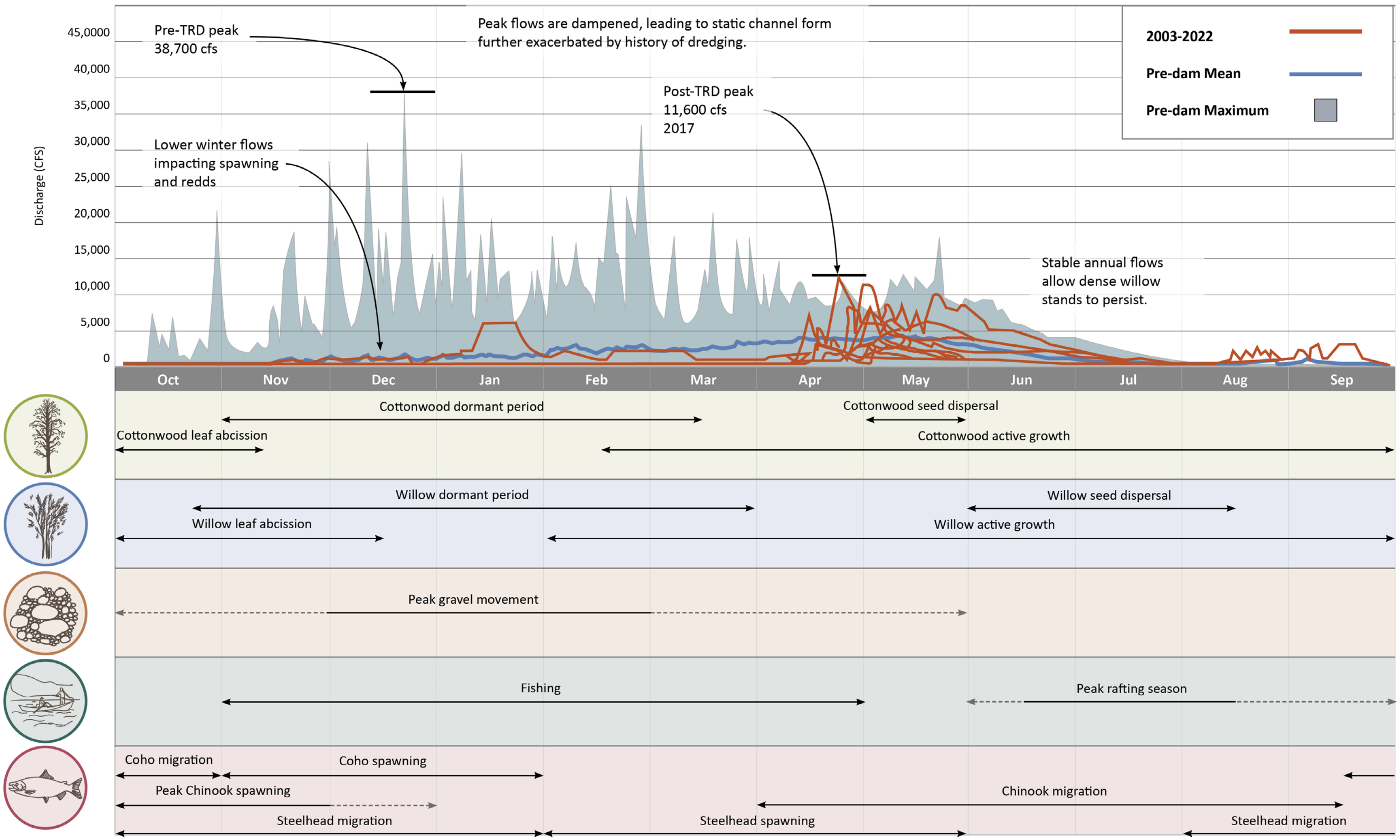

Figure 8. Trinity River hydrograph from 2003-2022 (in red), overlaid on a 'natural' Trinity River hydrograph (pre-TRD in grey). Hydrograph is shown in relation to riparian vegetation growth, sediment transport, recreational use and fish use in the river.

Water Temperature

Flow releases from Lewiston Dam are also managed to meet water temperature compliance mandates. Water temperature compliance targets were in place for Douglas City, the Trinity River above the North Fork Trinity, and at Weitchpec during Phase 2. Performance related to water temperature compliance targets at each of these three locations are discussed below. Weitchpec was a temperature compliance target location throughout Phase 2, but was recently discontinued as a monitoring location.

Douglas City Water Temperature Compliance. Between July 1 and September 14, water temperatures are not to exceed 60°F at Douglas City to support summer holding for spring run Chinook Salmon and for rearing juvenile Coho Salmon (*O. Kisutch*). The compliance mandate for September 15 through September 30 at Douglas City is 56°F and supports spawning Chinook Salmon and migrating adult Coho Salmon (Table 4). Water temperature targets during these periods were exceeded at least six out of the 11 years of Phase 2. Water temperatures during the summer holding period and/or September spawning period of 2021, 2020, 2018, 2016, 2015, and 2014 were above water temperature targets at Douglas City (exceeded for: 17 days, 15 days, 22 days, 14 days, 11 or more days, and 16 days, respectively. In 2019 the gage was offline most of the summer, therefore it is unknown if, or the degree to which, water temperatures were exceeded. Many of these years were either dry or critically dry years or had extremely warm summer air temperatures that likely resulted in warmer-than-normal water temperatures (TRRP, Annual Reports 2012 – 2021).

Table 4. Maximum allowable water temperatures for the Trinity River at Douglas City. Water temperatures have exceeded these targets in at least 6 of the past 11 years.

Annual Time Period	*Allowable Maximum Water Temperature*	*Target Species & Life Stage*
July 1 – September 14	60°F (15.5°C)	Summer holding for spring run Chinook Salmon Juvenile rearing for Coho Salmon
September 15 – September 30	56°F (13.3°C)	Spawning Chinook Salmon Migrating adult Coho Salmon

Trinity River above the North Fork Trinity Water Temperature Compliance. The target to not exceed 56°F on the Trinity River above the North Fork (NF) Trinity River from October 1 through December 31 supports spawning Chinook Salmon, Coho Salmon, and steelhead. Water temperatures above the NF Trinity River were usually below the targeted temperature (56°F) during Phase 2 (TRRP, Annual Reports 2012 – 2021).

Weitchpec Water Temperature Compliance. The temperature target point near Weitchpec at the confluence of the Trinity and Klamath Rivers (Table 5) is meant to ensure that temperature regimes are suitable for out-migrating salmonid smolts between April 15 – July 9. In all years of Phase 2, water temperatures exceeded targets during the compliance period at Weitchpec (2020: for 37 days; 2019: for 17 days [possibly more due to gage malfunction]; 2018: for 43 days; 2017: for 28 days; 2016: for 37 days; 2015: for 41 days; 2014: for 30 days; 2013 and 2012 several periods of days exceeded targets; TRRP, Annual Reports 2012 – 2021). The TMC recently approved the recommendation of the Fish Workgroup to eliminate the Weitchpec temperature compliance objectives (M. Dixon, U.S. Bureau of Reclamation pers. Comm, 2023).

Table 5. Maximum allowable water temperatures for the Trinity River at Weitchpec. Water temperatures have exceeded these targets all years since 2012.

Water Year Type	*Annual Time Period*	*Allowable Maximum Water Temperature*	*Target Species & Life Stage*
Normal & Wetter Wet (Optimum)	April 22 – May 22	55.4°F (13°C)	Juvenile outmigration (all species)
	May 23 – June 4	59°F (15°C)	
	June 5 – July 9	62.6°F (17°C)	
Dry & Critically Dry (Marginal)	April 22 – May 22	59°F (15°C)	Juvenile outmigration (all species)
	May 23 – June 4	62,6°F (17°C)	
	June 5 – July 9	68°F (20°C)	

The effect of elevated water temperatures on fish in the river likely varies depending on life stage. The importance of suitable water temperatures was an important part of early salmonid recovery efforts in the Trinity River (Fish Workgroup, 2022). In 2022, a subgroup of the Fish Workgroup was developed with the goal of reviewing existing information and refining existing water temperature objectives. Findings from this effort indicated that water temperature objectives may not be sufficient in the late Fall to protect incubating of Coho and Chinook Salmon eggs from water temperatures that exceed the optimal thermal criteria of 6-10°C (Fish Workgroup, 2022). For adult fish, Gough et al. (in prep) evaluated the relationship between observed water temperatures in the Trinity to pre-spawn mortality in female Chinook. No correlation between water temperature metrics and pre-spawn mortality in the restoration reach was found.

2.1.2 Sediment Management

Over time river systems carry sediment eroded from uplands down to lowlands and coasts. However, this longitudinal continuity of sediment transport through river systems can be interrupted, most importantly and pervasively by dams. Dams trap sediments, causing sediment to accumulate in reservoirs, where it can result in loss of reservoir functions and short dam lifespans as reservoir storage capacity is lost. By trapping sediments, dams deprive downstream reaches of their natural sediment load, especially the gravels that were formerly transported by the river.

Downstream reaches typically experience a sediment deficit, which results in excess erosive energy, a phenomenon widely known as 'hungry water', which causes erosion of the bed and banks and loss of channel forms such as gravel bars and riffles, in turn resulting in loss of aquatic habitats (Kondolf

1997). The problem has been especially well documented on salmonid-bearing rivers. In reaches below dams, gravels needed for spawning and rearing habitat are transported downstream without replacement by gravels from upstream, resulting in the disappearance of riffles and gravel bars.

Because of the predominant trend towards sediment deficit and its deleterious effects, there is increasing interest in projects to restore sediment loads downstream of dams, either by passing sediment through or around dams, or by mechanically augmenting sediment supply downstream (Kondolf et al. 2014). Moreover, reservoirs with large storage (relative to the river's annual flow) commonly reduce high flows, which reduces the dynamism of the river channel. Gravel beds formerly mobilized every year or two may go several years or more without being moved, allowing riparian vegetation to establish in the active channel. Where tributaries deliver fine sediment to the mainstem river below dams, if the post-dam flows have been reduced so they no longer transport them, the sediments can accumulate within the reach, and deltas can form at the tributary confluences. To mitigate these dam-induced impacts, controlled high-flow releases designed to mimic the action of natural floods (morphogenic flows) are increasingly required in licenses for hydroelectric dams and as part of programs to restore river function (Loire et al 2021, Staentzel et al. 2020, Williams et al. 2019), and are well illustrated in the pulse flows released on the Trinity River.

Dam-induced changes in flow regime are typically accompanied by reductions in the river's sediment load as reservoirs trap sediment, creating conditions of sediment starvation directly below the dam. Reservoirs trap 100% of the river's bedload (the coarse sediment that moves along the channel bed by rolling, sliding, and bouncing, consisting of gravel and sand), and a percentage of the suspended load (sand, silt, and mud held aloft in the water column by turbulence), which generally depends on the residence time of sediment-charged waters within a reservoir, which is commonly approximated as a function of the ratio of the reservoir storage capacity divided by the mean annual inflow of water (Brune 1953). Even if a post-dam flow regime were to mimic precisely the pre-dam flow regime, the river system would be severely dis-equilibrated by the loss of its sediment load (Kondolf and Wilcock 1996, Wohl et al 2015). Thus, increasingly, morphogenic flows are prescribed along with partial restoration of sediment load (Tena et al 2012).

The Trinity River is among the best documented cases of dam-induced impacts on salmonid habitat, and of a coordinated program of morphogenic flow releases from Trinity and Lewiston dams. These flow releases have been accompanied by a Sediment Management Plan, which is primarily focused on partial restoration of sediment load, through mechanical additions of gravel to the channel (gravel augmentation). This gravel augmentation is an effort to combat the interruptions in sediment continuity created by the dams upstream of the Program Reach. Gravel augmentation occurs at multiple locations in the Project Reach (Figure 9). Below Indian Creek, it is generally considered that tributaries provide sufficient gravel that the river is not supply limited.

The Sediment Management Program is founded on specific recommendations in the ROD, including:

- Release flows up to 11,000 cfs to transport and distribute cobbles and gravels from tributary deltas to create bars, riffles, and floodplains in downstream reaches.

- Replenish cobble and gravel storage in the reach immediately downstream of Lewiston Dam that is most impacted by the loss of upstream coarse sediment supply.
- Introduce long-term periodic gravel and cobble supply in first fifteen miles below Lewiston Dam at a rate equal to that transported by high flow releases to maintain cobble and gravel storage, enabling the river to create and maintain complex instream habitat.
- Recommended flow releases will be larger in wetter water years than drier water years.

The mechanics of the program include addition of gravel to the river during high flow releases using mechanical placement during summer and early fall along the channel margins, typically at rehabilitation sites. From these places, the gravel can be transported downstream and thereby distributed throughout the river during higher flows later in the year.

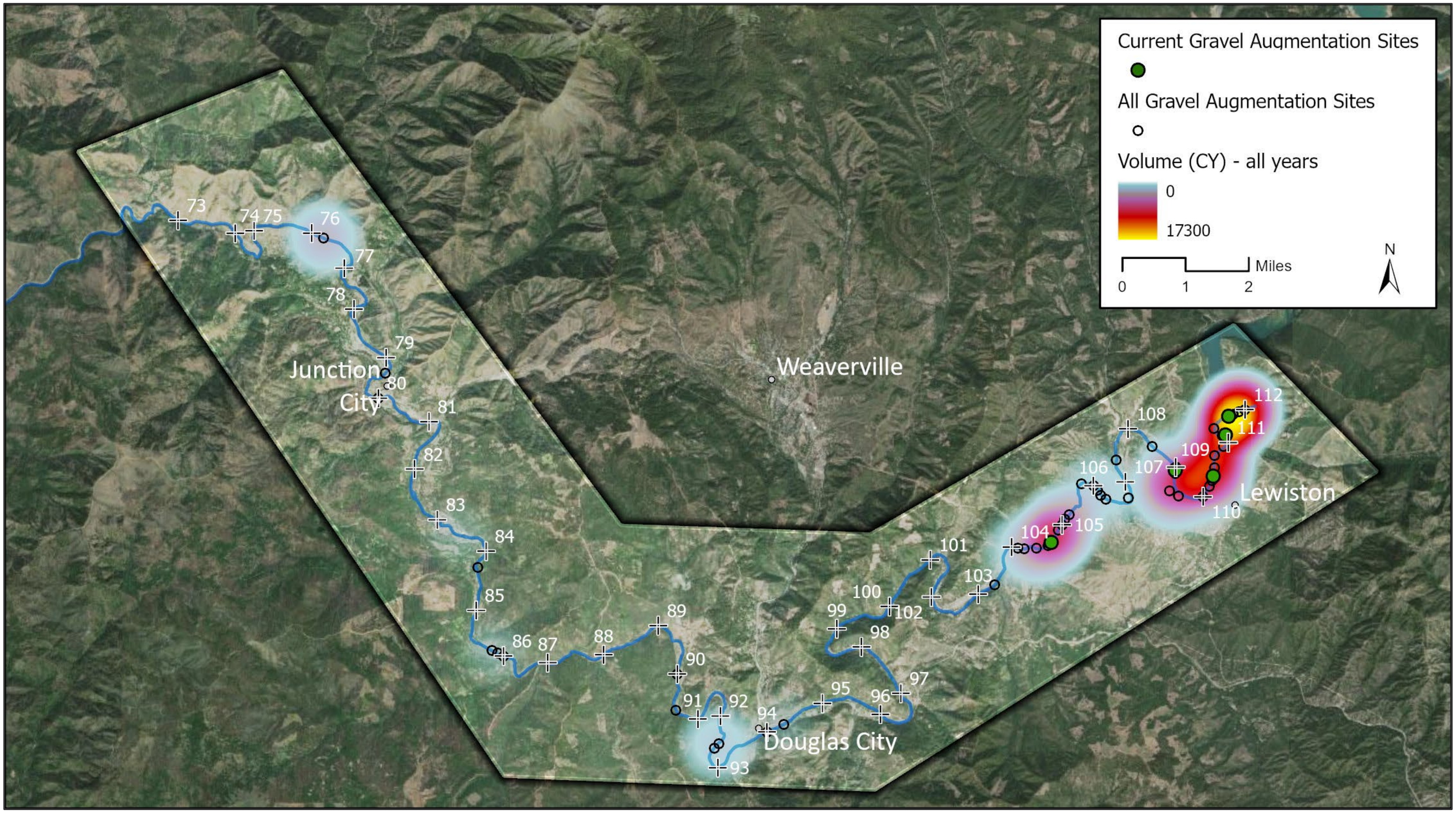

Figure 9. Overview of gravel augmentation sites and the quantity of gravel (in cubic yards) added to each of the augmentation sites since the program's inception.

2.1.3 Watershed Activities

Watershed restoration actions include fish passage / barrier removals, habitat improvements, flow improvements, road maintenance, road rehabilitation and road decommissioning on private and public lands within the upslope lands contributing to the Trinity River below Lewiston Dam, including the South Fork Trinity River basin.

Fine sediment (sand and silt) delivery from tributary watersheds to the Trinity River increased due to construction of roads, logging, mining, and other land uses. As noted earlier, the combination of increased erosion in the watersheds with reduced flows on the river resulted in large accumulations of fine sediment in the river channel in the 1960s through 1980s, and excessive fine sediment accumulation in active channel areas severely impacted survival and development of salmon and steelhead eggs. Removing large volumes of sand that had filled pools was an early restoration action on the Trinity. Extensive erosion control and sediment trapping was undertaken on tributaries such as Grass Valley Creek, where upland erosion control, construction of Buckhorn Dam, and construction of sediment traps on the floodplain above the confluence with the mainstem Trinity River largely eliminated Grass Valley Creek as a sediment source, and mainstem gravels have shown a pattern of decreasing fine sediment content (Buxton 2021).

Continued watershed actions through the TRRP are intended to improve land use practices and remove unused logging roads, thereby improving overall ecosystem function in the Trinity River watershed, and increasing salmon and steelhead production. Given the reduction in fine sediment delivery to the mainstem, it has been suggested that the watershed program evolve to focus more on habitat improvement and less on further fine sediment reduction.

2.1.1 Channel Rehabilitation

As outlined in preceding sections, the reduction of the magnitude and frequency of flood flows and alteration of sediment dynamics through the Program Reach related to the TRD have significantly altered the geomorphic and ecological function of the Program Reach. The scope and scale of these impacts have rendered the river incapable of 'healing itself.' Due to this deficit, mechanical channel rehabilitation (hereafter, channel rehabilitation) was deemed necessary by the Flow Evaluation Study and ROD to restore dynamic alluvial processes that exhibit natural process characteristics of the pre-dam river, but at a smaller scale.

Methods for channel rehabilitation described included direct removal of mature riparian vegetation and encroaching riparian berms, creation of side channels, addition of coarse sediment, and the return of annual high flow releases (though still smaller than pre-dam floods) to enhance and maintain the rehabilitated channel. These methods were based on observations of earlier and ongoing channel rehabilitation efforts. As early as 1970, restoration actions associated with maintenance of spawning riffles and deep pools through mechanical means and flushing flows were being pursued (Krause 2012). Efforts continued in the 1980's with side channel construction (USFWS 1989; USBR 1984) and in the 1990's with 'feathered edge' projects which attempted to address the confinement of the channel by the riparian berm (USFWS and HVT 1999).

The Flow Evaluation Study and ROD provided an overview of the channel rehabilitation strategy, and emphasized the need for adaptive management, but provided few specifics on approach to design. Towards the end of Phase 1, a Channel Design Guide was developed in 2011 to coalesce much of the new information and strategies that had become available since the ROD, and to provide a more systematic design approach to the multiple design groups working in the Trinity basin. Channel rehabilitation design recommendations from the Channel Design Guide (HVT et al. 2011) fell in four general categories: (1) rehabilitation on a forced meander bend; (2) alternate bar rehabilitation over longer reaches; (3) side channel construction over short reaches; and (4) tributary delta maintenance. Rehabilitation on a forced meander is intended to remove the riparian berm along a low flow channel on the inside of the bend and restore a functional floodplain. Point bars would also be constructed using a grain size properly scaled for natural mobility thresholds by the ROD high flow regime (<5 in diameter). Alternate bar rehabilitation targeted locations with long straight reaches having low channel complexity and habitat value. The strategy was to increase sinuosity by fostering an alternate bar sequence through the site. Two methods were recommended: (1) increase low flow sinuosity by adding point bars longitudinally spaced to meander wavelength commensurate with the ROD high flow regime; and (2) increase low flow and bankfull sinuosity by adding point bars and removing the riparian berm to foster lateral migration opposite the point bars.

The projects identified and recommended in the Program’s flow evaluation study (USFWS and HVT 1999) were to be assessed after one half of them were built in “Phase 1” of the Program. Seventeen projects were built in Phase 1 between 2005 – 2011. The second half of projects identified and recommended in the Program’s flow evaluation study (USFWS and HVT 1999) were initiated in the Trinity River between 2012 – 2021 (Table 6). Not all of the remaining projects that were originally identified have been implemented; 14 projects were constructed while five are still in design.

Table 6. Channel rehabilitation projects implemented or in design during Phase 2, as well as remaining (not constructed) projects. The different types of restoration elements included in each project as well as project location are provided.

Project Details			*Project Features*									
Year Implemented	**Project Name**	**RMs**	**Bankfull floodplain**	**Low floodplain**	**Feathered Edge**	**High-Flow Off-Chan**	**Gravel Bar**	**Wetland**	**Low Flow Side Chan.**	**Large Wood**	**Berm Rem/Notching**	**Rip. Veg. Removal**
2012	Lower Steiner Flat	90.1–-91.1				x	x		x	x	x	x
2012	Upper Junction City	79.8–-80.4		x					x	X		
2013	Lower Douglas City				x	x			x	x		
2013	Lorenz Gulch	89.4–-90.2				x			x	x		
2014	Lower Junction City	78.8–-79.8	x	x						x		
2015	Upper Douglas City	93.6–-94.6				x	x			x		
2015	Limekiln Gulch	99.7–-100.6				x			x	x		x
2016	Bucktail	105.3–-106.4	x	x		x		x	x	x		
2017	Deep Gulch	82.4–-82.9		x			x		x	x		
2017	Sheridan Creek	81.6–-82.4						x		x		
2019	Chapman Ranch Phase A	82.8–-83.8	x	x		x	x		x	x		
2020	Dutch Creek	85.0–-86.6		x		x	x		x	x		
2021	Chapman Ranch Phase B	82.9–-83.8	x	x		x	x		x	x		
2022-2024	Oregon Gulch	81.0–-81.9	x	x		x	x	x	x	x		
	Evans Bar	84.3–-85.2	In design									
	Sky Ranch	80.2–-81.0	In design									
	Upper Conner Creek	77.4–-78.2	In design									
	Upper Rush Creek	107.8-108.8	Potential for future work but not in active design									
	Upper Steiner Flat	91.9-92.2	Potential for future work but not in active design									
	Lower Rush Creek	107.1-107.8	Potential for future work but not in active design									
	McIntyre Gulch	97.2-98	Potential for future work but not in active design									
	Middle Steiner Flat	91.3-91.9	Potential for future work but not in active design									
	Poker Bar	101.8-102.8	Not likely to move forward									
	China Gulch	101.0-101.6	Not likely to move forward									
	Soldier Creek	83.7-84.2	Not likely to move forward									
	Tom Lang Gulch	103.0-103.8	Not likely to move forward									

2.1.2 Adaptive Environmental Assessment & Management

The ROD specifies the development of an Adaptive Environmental Assessment and Management (AEAM) Program. The AEAM Program, guided by the TMC was intended to ensure the proper implementation of the ROD measures to ensure that the restoration and maintenance of the Trinity River anadromous fishery continues to be based upon the best available scientific information and analysis.

The AEAM organization consists of a Technical Modeling and Analysis Group and a Rehabilitation Implementation Group. The organization includes a support staff of engineers and scientists charged with assessing the Trinity River fishery restoration progress. As described in the ROD, the AEAM Team was to coordinate independent scientific reviews of the AEAM organization and may recommend management changes based on annual assessments of the evaluation of rehabilitation and flow schedule activities.

In 2018 as part of the programmatic "refinements" process, the TMC requested an assessment of the TRRP management and organization, including the AEAM process. Recommendations from this process, described in the Headwaters Report (Headwaters Corp. 2018) are intended to improve program governance. More detail on the findings of this report is provided in Section 2.2.5.

2.2 MANAGEMENT ACTION EVOLUTION THROUGH PHASE 2

The following subsections provide an overview of how each of the five management actions have evolved through Phases 1 and 2.

2.2.1 Flow Management

Since ROD flows were first implemented, considerable scientific inquiry and work by the TRRP Flow Workgroup has continued to evaluate flow management. This work has resulted in increased flow releases during key fish life stages and/or for other social and cultural reasons. Flow management changes to the ROD hydrographs that have occurred within Phase 2, include:

- Elevating flows at the beginning of the release to disperse steelhead smolts released from Trinity Hatchery.
- Releasing variable flows during key seasons (e.g., fall, winter) that increase habitat diversity and benefit fish and other organisms in stream channels.
- Maximizing the variability of hydraulic shear stress to increase sediment transport and bed scour.
- Variably inundating floodplain areas to recruit nutrients to the channel.
- Slightly elevating flows in early June to disburse Chinook salmon fingerlings.
- Correlating flows to accommodate root growth of the riparian seedlings during the first year.

Most recently, additional research by the Flow Workgroup suggested increased winter variability in the formal flow release schedule could be highly beneficial to meeting the TRRP's goals. This work resulted in a formal Winter Flow Variability proposal, which was passed by the TMC in December 2022 and recommended for implementation. The focus of the Winter Flow Variability proposal is to shift flow changes to reflect current knowledge about fish use and timing in the Trinity River, as well as to take advantage of opportunities to 'piggyback' releases from Lewiston on top of natural winter peak flows from tributaries, thereby increasing winter peaks to support geomorphic processes that create and maintain salmonid habitats. This increase in flow variability in the winter continues the process to return a more normative hydrograph to the Trinity River.

2.2.2 Sediment Management

Static vs. Dynamic Construction

The first projects on the Trinity River (ca. 1976) were intended to create static spawning riffles by installing lines of boulders and gabions across the channel and backfilling them with mechanically placed gravel. The design concept was to construct these features in hopes that the boulders would keep the gravel in place and provide spawning habitat over time. The same approach was tried on the Merced River (and the neighboring Tuolumne and Stanislaus Rivers), where the added gravels were promptly exported from the system by annual high flows (Kondolf et al. 1996). The approach partly worked on the Trinity River because the Trinity Dam upstream is so hydrologically large that the reservoir would rarely spill, thus high flows were rare. As a result, the static spawning gravel features stayed in place longer than they did on Merced and its neighboring systems (Kondolf and Minear 2004). However, they gradually lost gravel and required periodic additions of fresh gravel, as documented in records of follow-up projects. Similar projects to construct riffles have been undertaken with some success on the Mokelumne River, below a very large reservoir that has also eliminated virtually all natural high flows (Merz et al. 2006). However, these gravel projects were single-purpose efforts, which attempted to create suitable static spawning habitat in specific locations, rather than sustaining geomorphic processes of gravel transport, including replenishment and dynamic deformability of riffles, which would (as a matter of course) create diverse habitat benefiting various species and life stages.

Over time, the management philosophy within the Trinity River evolved from these static spawning gravel placements. For one thing, the goal of restoration expanded from creating salmon spawning habitat to emphasize restoring rearing habitat for juvenile salmon, and other species were also explicitly considered. Following the ROD, limited high (morphogenic) flows were restored. This allowed a new approach to restoration, in which gravel is introduced to the channel and the high flows allowed to transport it downstream, depositing in naturally formed gravel bars and riffles, termed 'dynamic construction' (Gaeuman 2014). Today, gravel is added at multiple sites on the Trinity River (upstream of the Weaver Creek confluence), and its effect on channel form monitored (Gaeuman et al 2017).

Volumes of Gravel Added in Augmentation Program

Among key changes in the gravel augmentation program since the ROD has been a reduction in volumes of gravel added to the river. The rates of sediment augmentation currently are less than 20% of the rates originally proposed in the Flow Evaluation Study that was the basis for the ROD (USFWS and HVT 1999). The reduced rates are motivated by three factors (Dr. Gaeuman, Yurok Tribe, personal communication). First, monitoring of augmented gravel indicated that the river transports less gravel than anticipated by the Flow Evaluation Study, as augmented gravels have not travelled very far downstream in most cases. Second, the volumes specified by the Flow Evaluation Study would have been challenging operationally, with insufficient time to practically input all the needed gravel during the brief windows of high flow. Third and most importantly, there are very few places where TRRP can add gravel. The program has been limited to publicly owned sites along the river, with a nearby suitable source of gravels such as dredger tailings, or at least a stockpile site. There are few such places, and they have been mostly in the upper reaches: four of the five sites are within 3 miles of the dam, while the fifth site (Loweden Ranch) is within 8 miles. After repeated additions of gravel, these reaches have tended to aggrade with gravel, at least until a wet year with multiple high flows can remobilize the added gravel. The program has restrictions on accessing the river from private land and must be sensitive to objections to having gravel trucks drive through residential neighborhoods. This uneven distribution of gravel augmentation points has not been able to restore sufficient gravel quantities to all reaches of the river, with some reaches of the river (such as RM 13-26) having very little gravel, as reflected in low gravel bar areas. The Program proposed additional sites for gravel augmentation this year, which could significantly improve the distribution of gravels throughout the river.

While some reaches such as the reach just below and above the Indian Creek confluence have experienced aggradation (likely due to lowered capacity of the river to transport the load supplied by Indian Creek and the backwater effect of these delta-like deposits), other reaches remain sediment starved because of the lack of gravel supply. This is a result of decades of dam-induced sediment starvation and the lack of suitable sites for augmentation. It could be informative to develop a "spreadsheet" style sediment budget for individual reaches accounting for sediment supply and transport. This could consist of measured actual sediment transport rates, calculated sediment transport capacities, volumes of gravel augmented, and changes in sediment storage as reflected in change in gravel bar area. An analysis of bed mobility and scour data for multiple sites along the entire Project Reach from 2009-2013 indicated that the bed was less mobile than had been assumed, consistent with observations from individual sites (Hales et al 2020). The Program has responded to the relative immobility of the bed (and measured rates of bedload transport) by reducing the size of gravels mechanically added to the river. The maximum size of substrate added has decreased from 6 inches in the early 2000s to 5 inches by about 2008, to 4 inches by 2015 (Dr. Gaeuman, Yurok Tribe, personal communication). There is increased recognition that future augmentation should include additional finer gravels, as these are the sizes most easily transported and thus the "first to go".

Mobilizing the River Corridor Bottomland

As the program has evolved, projects have become larger laterally in their area of bottomland covered, allowing space for channels to laterally migrate, thereby recruiting gravel from eroded banks and creating more complex channel geometry. For example, the Chapman Ranch project had a larger footprint than prior projects and was designed with features to deflect flow into banks with the intention of eroding the banks to recruit coarse substrate, and increasing sinuosity and overall channel complexity. This is a very encouraging trend in the restoration program as described by the River Corridor Management Strategy (Gauemen et al. 2016), as it effectively increases the "process space" in which the river can flood, erode, deposit, and migrate (Ciotti et al. 2021). One of the limitations to this approach will be areas where the bottomland sediments are too coarse to mobilize as a result of placer mining, as well as constrained by outcrops of bedrock. In addition, in sites where lateral migration has been initiated, such as Deep Gulch and Chapman, there are concerns that as lateral migration occurs, larger substrate may armor the toe of the slope, and these coarser lag deposits may inhibit further lateral migration in the future.

2.2.3 Watershed Activities

Watershed activities such as road maintenance, road rehabilitation and road decommissioning on private and public lands are intended to reduce the fine sediment supply to the Program Reach by improving land use practices and remove unused logging roads. Since 2008, a total of 69 watershed projects have been implemented, including 42 watershed projects in Phase 2 (Table 7; Figure 10).

Table 7. Types of Watershed Action projects implemented in the Trinity River.

Project Type	*Number of Restoration Projects*	*Years Completed*
Roads and Sediment control	27	2008-2022
Habitat Restoration	6	2010-2022
Fish Passage	10	2008-2020
Other	4	2008-2012
Unknown	22	2009-2018

Since the ROD, many watershed projects in streams currently accessible to fish have been completed. These "low hanging fruit" projects have largely focused on addressing sediment delivery from forest roads, decommissioning roads, and improving stream-road crossings for fish passage. Moving forward, watershed actions are expanding to future reaches that have high intrinsic potential for supporting anadromous fish. The review of these projects suggests the general approach to watershed projects has remained relatively constant over time. The impact of illegal cannabis grow operations on water quality within the Program Reach was highlighted by interviewees throughout this process. Illegal, outdoor cannabis cultivation can have environmental impacts that extend far beyond the specific cultivation site, including increased pesticides and other chemicals in the water column of downslope or adjacent water bodies, water diversions that reduce instream flow, unscreened water diversions that trap and kill fishes residing in the water body, and physical alterations to the watershed from road building and clearing activities (Carah et al. 2015). These impacts are assumed to be present within the Trinity River watershed, but development of strategies to mitigate for these impacts remains a challenge for the Program.

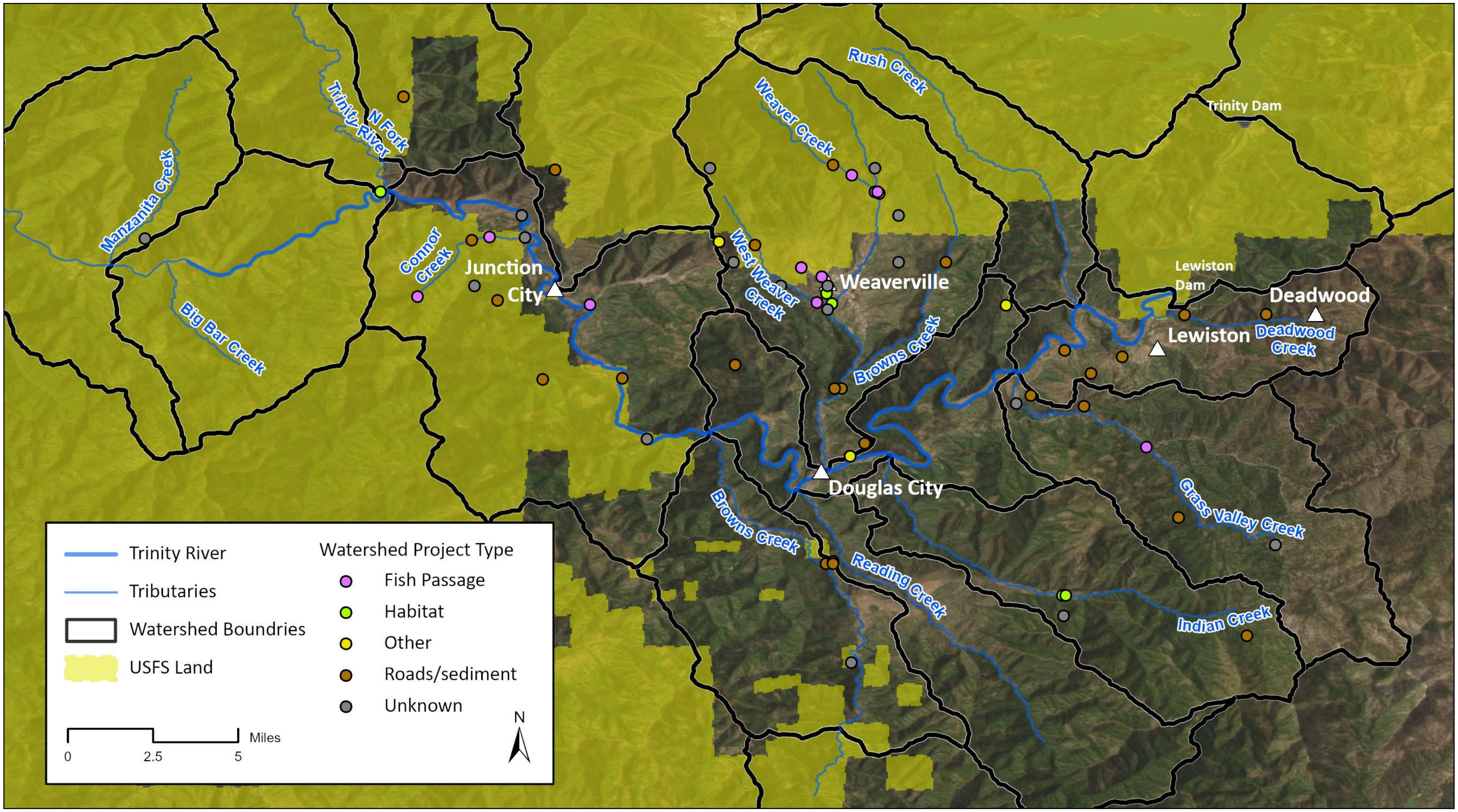

Figure 10. Watershed projects under the TRRP since approx. 2008. Data provided by TRRP.

2.2.4 Channel Rehabilitation

The Flow Evaluation Study identified 44 potential main-channel and three potential side-channel sites for Channel Rehabilitation within the Program Reach. These sites were identified primarily by a field-based exercise and were incorporated into the ROD. The sites were located where coarse sediment was available, meander bends existed, and in long, straight reaches where channel rehabilitation could result in substantial changes in channel complexity and salmonid habitat availability. Sites were initially selected for the anticipated expectation that improvements or rehabilitation would be self-maintaining (i.e., would be sustained) under the ROD flow regime without the need for active maintenance.

The Flow Evaluation Study and ROD also recommended that the channel rehabilitation strategy focus on encouraging channel dynamics by means of planform and bankfull channel dimensional adjustments. Though few details on how specific design elements would achieve the ROD objectives were provided in either the ROD or Flow Evaluation Study, the scale of design and construction originally envisioned in the Flow Evaluation Study was expected to be modest, limited to the bankfull corridor and less than two meander wavelengths per project. Initial projects focused on floodplain and bankfull elements, with early designs including lowering of small, flat floodplain features to inundate between 0 and 1 ft deep at the approximate 1.67-year return interval flood as defined by the ROD flow releases (corresponding to 6,000cfs at Lewiston). In an attempt to reverse the riparian encroachment and channel simplification caused by the TRD, the Flow Evaluation Study and ROD recommended removal of riparian berms and building dynamic alluvial features to prevent future riparian encroachment, berm formation, and channel simplification. Large wood placement was not considered a part of channel rehabilitation actions and revegetation/vegetation management were not explicitly mentioned at the time of the ROD and Flow Evaluation Study.

Over time, the TRRP has developed a better understanding of the flow volumes that are necessary to support dynamic alluvial processes in the channel, as well as the limitations presented by the volume and size-characterization of material located in existing floodplain terraces and the semi-alluvial (as opposed to truly alluvial) nature of the Program Reach. This knowledge has encouraged evolution in the design of channel rehabilitation projects as well.

The Flow Evaluation Study and the ROD provided a broad framework and starting point for channel rehabilitation strategy and techniques. Given site observations and advancement in the science and practice since the ROD was signed in 2000, refinement was needed.

Design Team Evolution

Initially there was one large design team for channel rehabilitation projects. Then, starting in 2010, four separate design groups were formed, consisting of multidisciplinary teams of engineers and scientists. The four separate design groups are (1) Federal; (2) Hoopa Valley Tribe (HVT); (3) Yurok Tribe (YT); and (4) State. While there is some overlap and integration between these design groups, these groups develop designs separately, which allows for application of that specific group's expertise in creating fish habitat and restoring river processes. Some groups, principally the Hoopa Valley Tribe, rely partially or fully on external consultants (mainly McBain Associates) to develop and complete designs. The creation of multiple design groups increased the diversity of design perspectives incorporated into the site design process during Phase 2. Integration between the design groups occurs through the larger Restoration Implementation Workgroup (RIG), which is a formally recognized Program work group.

Channel Rehabilitation Design Guidelines

Project designs and implementation methods have changed substantially with new monitoring data, lessons learned from previous projects, advancements in the larger river restoration practice, and new voices contributed to the design process. In January 2011, the Channel Rehabilitation Design Guidelines for the Mainstem Trinity River ('Guidelines'; HVT et al. 2011) were issued so that the four design groups could use a common and consistent suite of design criteria. The Guidelines used empirical relationships and data from reference reaches to develop design methods and features at reach and site scales. These included: (1) planform design dimensions that accommodated wavelength and radius of curvature dimensions that were appropriate for the ROD's high-flow regime; (2) bankfull channel dimensions that resulted in recommended ranges for bankfull channel width and depth; (3) low flow channel dimensions that resulted in recommended ranges for low-flow channel width; (4) guidelines for constructed bars; (5) guidelines for secondary channels; (6) floodplain design dimensions and guidelines for flood plain inundation for geomorphic purposes; (7) riparian vegetation design criteria; (8) large wood placement guidelines; and (9) other considerations such as incorporating bedrock into designs. The Guidelines document also described a detailed hydrologic analysis for design groups to use.

Phase 1 Channel Rehabilitation Projects

Early projects were relatively small in scale and focused on removing riparian vegetation and lowering floodplain surfaces to be inundated by 1 foot of water at the 1.67-year return interval flood as defined by the ROD flow releases (corresponding to 6,000cfs at Lewiston). Over time, following a deeper understanding of fish life history habitat needs, geomorphic response of the channel under the ROD flow regime, and staff turnover at the TRRP, projects in the latter half of Phase 1 started to include more focus on instream aquatic habitat features, including adding large wood, and creating side channels and increasingly varied, complex habitats. Projects became more complex, though the scale of projects remained relatively small (by today's standards).

The Channel Design Guidelines (HVT et al. 2011) also described the channel rehabilitation design evolution that occurred in Phase 1. In addition to the changes listed above, the Guidelines (HVT et al. 2011) describe how designs over the course of Phase 1 evolved to encourage more diverse native riparian revegetation on varied geomorphic surfaces and to consider a broader spectrum of faunal species and life histories, in addition to Chinook salmon (e.g., Coho salmon, steelhead trout, western pond turtle, foothill yellow-legged frogs, Pacific lamprey, riparian and riverine birds).

Phase 2 Channel Rehabilitation Projects

The remaining series of rehabilitation projects (26 remaining after Phase 1) that were originally identified and recommended in the Flow Evaluation Study (USFWS and HVT 1999) were advanced between 2012 – 2021 and are considered part of "Phase 2." Not all of the remaining projects that were originally identified have been implemented; 14 projects were constructed while three are still in the active design process. Of the nine remaining projects identified in the Flow Evaluation Study, five are likely to move forward while four are not likely to be constructed for various reasons, including landowner or adjacent infrastructure constraints (M. Dixon, personal communication, 2023).

The projects implemented in Phase 2 evolved throughout the phase and ultimately incorporated many of the suggestions identified in two key Phase 1 review documents, the Design and Implementation Process Review Report (CH2MHill and Entrix 2010) and the Review of the Trinity River Restoration Program following Phase 1 Report (Buffington et al. 2014). These Phase 1 lessons learned led to a design approach that included both habitat features that fish would be able to immediately utilize while also designing to encourage the river to evolve and change over time. This included more aggressive lowering of floodplain surfaces, addition of large wood structures, and active construction of side channel and alcove features.

Projects early in Phase 2 included similar elements to the latter half of Phase 1 but tended to be larger in spatial scale than previous projects. Projects designed and implemented in the last few years of Phase 2 have reflected changes to design approaches being currently utilized in the broader river restoration practice, with an emphasis on restoration over the full river corridor (Gaeuman et al. 2016), floodplain lowering to have surfaces flooded multiple times per year, higher large wood density numbers, and providing space for natural deformability and dynamism where feasible (e.g., Ciotti et al. 2021; Figure 11). Given that the ROD does not allow for restoration of mining-related impacts, projects later in Phase 2 have explored and implemented creative opportunities to remove dredge spoils from the floodplain, such as excavating the material from the active river valley and moving them to the nearby Eagle Rock quarry on the Oregon Gulch Project.

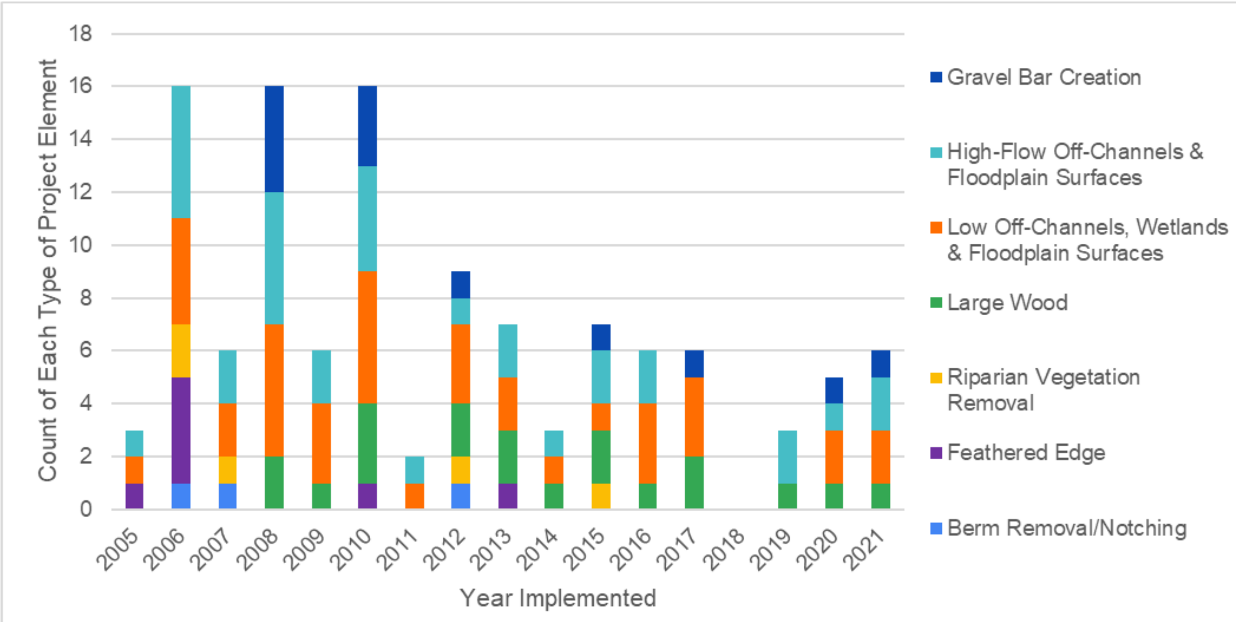

Figure 11. Types of features included in Rehabilitation projects since 2005. Though fewer total features in Phase 2 projects compared to Phase 1 projects are shown due to fewer total number of projects implemented, the spatial extent and scale of Phase 2 projects is on average much larger (see Figure 12 below).

Phase 2 projects, particularly those in the latter half of Phase 2 (since approximately 2019), have a much larger footprint than many of the Phase 1 projects, reflecting the current understanding that the ROD flow releases are insufficient at producing large-scale channel evolution. The total material volume moved for all projects implemented in the TRRP since 2005 is shown in Figure 12. Though there is significant variability, these volumes generally show an increasing trendline as the scale (i.e., volume of material moved, number of plants planted, number of habitat elements constructed) and spatial extent of projects has increased since Phase 1 efforts. In summary, channel rehabilitation designs have evolved since the start of TRRP project implementation, with four general periods spanning from early Phase 1, late Phase 1, early Phase 2 and late Phase 2. Projects within each of these time periods typically had similar design philosophies, with examples shown in Figure 12.

Revegetation and vegetation management has been included as a part of Channel Rehabilitation. Similar to the evolution of the instream components, revegetation has evolved from removal of willows/alders forming riparian 'berms' and desired passive recruitment, to active site-specific plantings, and in the later parts of Phase 2 towards a fully integrated approach that aims to balance active revegetation with regenerative passive recruitment. This integrated approach pairs with the more dynamic geomorphic processes and larger spatial (in particular lateral) extents of project work and aims to reconnect the dynamic feedback loops between geomorphic processes and ecological succession.

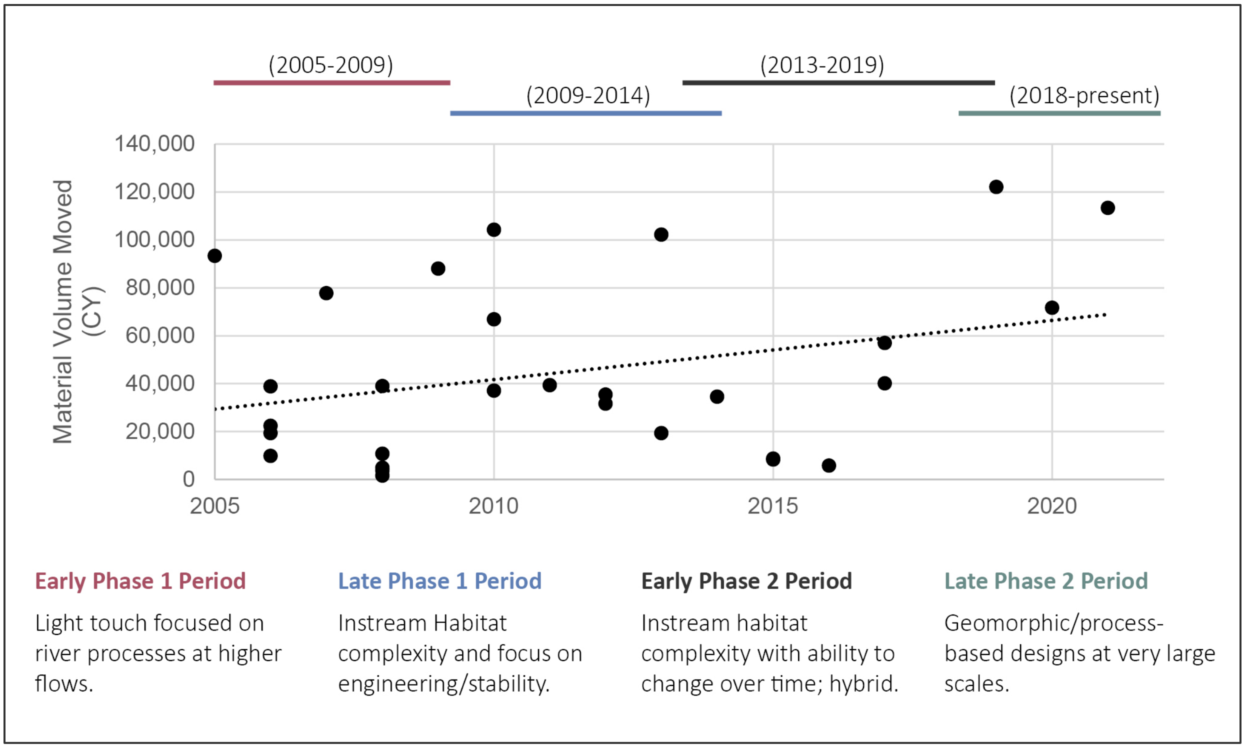

Figure 12. The total material volume moved for all projects implemented in the TRRP since 2005. Though there is significant variability, these volumes generally show an increasing trendline as the scale and spatial extent of projects has increased over the four general design philosophy periods. Example projects from each period are also shown.

2.2.5 Adaptive Environmental Assessment & Management

As described in the ROD, the AEAM process in the TRRP is to be guided by the TMC. The purpose of AEAM in the TRRP is to ensure that the restoration and maintenance of the Trinity River anadromous fishery continues based on the best available scientific information and analysis, by:

- Ensuring the proper implementation of the ROD measures.
- Conducting appropriate scientific monitoring and evaluation efforts.
- Recommending possible adjustments to the annual flow schedule within the designated flow volumes provided for in the ROD or other measures.

In interviews conducted in 2018 to support the Headwaters Report and TRRP refinements process, it was generally agreed that adaptive environmental assessment and management is intended to be part of the TRRP process, but there was no agreement as to how (or if) the TRRP is implementing AEAM at all (or whether it wants to, or whether it can). In general, there was no clarity among interviewees as to what questions the TRRP is trying to answer, what hypotheses are to be "tested" through program implementation, how to synthesize information to make it useful for decision-makers, and how (or if) decision-makers on the TMC would even use such information (Headwaters Corporation, 2018).

The Headwaters Report (Headwaters Corporation, 2018) described the following about the AEAM process in the TRRP:

- TRRP science is viewed by many as being a lower priority in the budget than construction projects. Many interviewees described science (or adaptive management) as receiving what is left over in the budget after construction projects are funded. The TRRP was described as data rich but information poor. For example, there is a belief that the TRRP is creating more habitat for fish and producing more juvenile fish, but there are no reports showing these results and making these connections. Generally, there was agreement among the interviewees that the TRRP is not operating under an agreed-to Adaptive Management Plan.

The Science Plan (Pickard et al. 2022) further identified challenges to enacting a successful AEAM process in the TRRP. Though many of the planned management actions have been implemented in Phases 1 and 2 of the Program, and substantial learning has occurred, effective adaptive management has been limited. Reasons for the challenges include the following (as described in the Science Plan [Pickard et al. 2022]):

- Failure to adopt the Integrated Assessment Plan, which was intended as an adaptive management plan.
- Adaptive management has largely been done through 'passive adaptive management' which results in slower learning. This is at least in part due to the difficulty of having true replicates in a river context. It is also a result of the desire to do what is best for fish now and fear of negative impacts that might result from experimentation with a range of alternatives.
- The Flow Evaluation Study proposed a suite of management actions that are expected to work in combination to achieve goals. However, it is difficult to disentangle findings and determine which individual action or combination of actions is working or not working.
- Factors outside of the Program control, such as climate change impacts to environmental conditions, influence Program outcomes.
- The Program has not adjusted for human and environmental changes that have occurred since the Flow Evaluation Study.
- The ability to adjust and adapt has been difficult to implement in practice given ROD limitations (real or perceived).
- Lack of clarity on the legally allowable adjustments to management actions under the AEAM framework of the ROD.
- Implementation has also been hampered by failed motions on agenda items related to adaptive management components. Successful adaptive management cannot occur without commitment from both the scientists (to ensure science is rigorous and decision relevant) and management to 'close the loop' at the adjust stage.

- The link back to decision making has been flawed. The Program was described as 'data rich and information poor' (Headwaters 2018).
  - The recent effort to draft cross-cutting, multi-year synthesis reports has greatly improved the move from data to information relevant to decision makers.
  - However, synthesis reports are about three years behind data collection and would be more useful if they could be accelerated.
  - The lag in synthesis reporting is likely in part related to the lack of capacity as well as clarity in roles for Program staff and Program funded partner staff (i.e., where do synthesis reports fit on the 'to-do' list).
- Insufficient stakeholder input up front. Stakeholder and/or Partner concerns are not tabled early enough and have not been addressed with the same level of rigor as the scientific inputs. This may inadvertently create the situation where decision makers must make a decision using inputs on the ecological aspects supported by science and inputs on the socio-economic side without supporting evidence either for or against the stated concern (e.g., reductions to fishing). Lack of evidence tends to result in decision makers reverting to risk adverse positions, which will differ depending on their priorities. As noted below, earlier input from stakeholders and/or Partners would mean that the Program can investigate their concerns more fully and provide decision makers with the information they need to make an informed decision.

The Science Plan (Pickard et al 2022) provides clarification on roles and responsibilities of various groups within the TRRP, as well as opportunities for adaptive management across all management actions for Phase 3.

2.3 PROGRAMMATIC EVOLUTION THROUGH PHASE 2

The following subsection provides an overview of how selected programmatic and operational elements of the TRRP have evolved through Phases 1 and 2.

2.3.1 Overall TRRP Process & Collaboration

The foundation for the overall TRRP organization and collaboration process is described in the ROD and other documents, and in Section 2.1.2 of this Report. In 2018, the Headwaters report made the following recommendations based on their qualitative "health assessment" of the structure and function of key TRRP governance:

1. Amend ROD using the "Cooperative Agreement too" to help the TRRP develop a new approach to governance and decision making.
2. Create a "TRRP program document" that gives TRRP participants a guide to implementation. This will streamline implementation by avoiding the need to reference multiple "foundational" documents that are not always clear and sometimes contradictory.

3. Develop an official adaptive management plan.

In 2018, Headwaters recommended the following process for implementing these TRRP programmatic refinements:

1. Work with a skilled facilitator to help lead a 1–3-day workshop to refine recommendations.
2. Signatories and non-signatories negotiate the organizational structure of the program, the decision-making process, program financial management, and other higher-level administrative features. Technical representatives negotiate the Adaptive Management Plan in parallel with that process with final approval by the TMC negotiators.
3. TRRP continues to implement current ROD management actions and fund monitoring and other projects that are currently led by the Tribes while the above negotiations are in progress.

More detail on these recommendations can be found in the Headwaters Report (2018).

The Trinity River Science Plan (Pickard et al. 2022) provided more information on how the TRRP has addressed, or is in the process of addressing, the key findings of the Headwaters Report (2018). Specific to the organization and programmatic processes in the TRRP, actions that have been taken to address the findings of the Headwaters Report have included:

- Restructuring the organization of senior program staff within the TRRP.
- Developing a refined Annual Science Planning Process that elevates the role of the IDT in defining annual science priorities and making recommendations for how to implement those science projects.
- Revising the TMC bylaws to reduce deadlocks during voting processes.
- Revising the charter of the Science Advisory Board to encourage better integration of independent scientific advice into the science work of the TRRP.
- Improving opportunities for stakeholder engagement in the TRRP, such as public input at quarterly meetings and development of a new TRRP Stakeholder Advisory Committee to replace the former Trinity Adaptive Management Working Group (TAMWG).
- Addressing conflicts of interest between decision-making and other groups by using independent, technical reviewers and developing clearer science priorities and TRRP goals/objectives.
- Increased transparency and organizational processes to assign funding within the TRRP.

More detail on these can be found in the Science Plan (Pickard et al. 2022).

2.4 MANGEMENT ACTION SUCCESS CRITERIA

Fundamental to evaluating the effectiveness of any action is the definition of clear success criteria. Descriptive success criteria were not specifically outlined in the ROD, therefore, the definition of success for the TRRP itself is largely defined by broad program goals, which are to:

1. Restore the form and function of the Trinity River.
2. Restore and sustain natural production of anadromous fish populations in the Trinity River to pre-dam levels.
3. To facilitate full participation by dependent tribal, commercial, and sport fisheries through enhanced harvest opportunities.

Individual management actions do not have programmatically defined success criteria. TRRP has utilized program goals to provide the framework with which individual actions are evaluated for success and effectiveness.

2.4.1 Flow Management Success Criteria

Flow management is arguably the easiest and most straightforward of the management actions for which to evaluate success. Because flow and water temperature are basic variables and can easily be measured and tracked over time, it is relatively easy to track if the TRRP is hitting the flow and temperature goals. This ease of data tracking allows the TRRP to determine and evaluate if the flow and temperature are supporting the Program's goals.

2.4.2 Sediment Management Success Criteria

Gravel augmentation programs for sediment management lend themselves well to an adaptive management approach. Typically, in these programs, managers proceed with an agreed-upon program, but use results of monitoring to assess the conceptual models on which the management actions were originally based, and then to revise management prescriptions accordingly (Healey 2008). The Trinity River provides a good example of this kind of adaptation.

Aside from counts of salmon spawning in augmented gravels, there have been relatively few studies of the potential ecological consequences of gravel augmentation. The Coarse Sediment Storage Synthesis Report (Hoopa Valley Tribal Fisheries and McBain Associates 2022) explicitly makes the connection at the scale of the 64-km (40-mi) Project Reach between the areas of active gravel bar documented by McBain Associates (2015) and habitat predicted by the Trinity River SRH-2D model. McBain Associates (2015) found a trend of habitat persisting at active bar areas with increasing flow in the subreaches affected by augmentation projects. The 2022 Synthesis found a consistently strong relationship between active gravel bar density and channel complexity across the Project Reach, providing evidence of the benefits of gravel augmentation. An analysis of over 100 sites of bed mobility and bed scour experiments over the Project Reach (2009-2013) indicated that bed mobility was less than assumed early in the program, and provided improved prediction tools for managers (Hales et al 2020).

At the reach scale is the detailed study of the ecological functions of a dynamically constructed gravel bar complex in the Lowden Ranch reach, 11 km (7 mi) downstream of Lewiston Dam (Figure 2). Here changes in channel form, habitat suitability for fish, and ecological functions have been monitored downstream of a gravel augmentation location since 2011 (e.g., Ock et al. 2015). The addition of gravel allowed the channel to build gravel bars, which increased bed relief and habitat diversity through 2016, such that the depths of pools increased while shallow waters became shallower. However, continued gravel additions resulted in bed aggradation and filling of pools, which resulted in a small reduction in habitat diversity (Gaeuman et al. 2019). Thus, gravel additions at Lowden may have locally become "too much of a good thing" as the gravel supply exceeded the transport capacity and resulted in the simplification of the channel. This is consistent with the hypothesis of Yarnell et al. (2006) that either a lack of sediment or an excess of sediment can lead to reduced habitat complexity. While this effect may be manifest at the scale of a given subreach (reflecting limited transport downstream), it is not generalizable across the 40-mi Project Reach, much of which remains gravel starved. Moreover, the overall volumes added to the Trinity are in the same ballpark as the volumes added to Clear Creek below Whiskeytown Dam, which is a much smaller river system. Thus, overall, the levels of gravel augmentation seem reasonable, but there are local "traffic jams" where gravel has accumulated due to inadequate stream power to move it downstream.

Detailed measurements of temperature and water quality of surface water interacting with dynamically constructed gravel bars have demonstrated that upwelling zones in the tail of the gravel bar and its alcove provide thermal refugia for juvenile fish during the warmest times of the day. Concentrations of suspended particulate organic matter (S-POM) decreased significantly from the upstream to downstream ends of the gravel bar, indicating strong S-POM retention by the gravel bar (Ock et al. 2015). Similar observations are available for two rivers in Japan (Ock et al. 2013), but such studies have not been widely undertaken in sites of gravel augmentation elsewhere, despite the potential importance of such ecological benefits on rivers below dams.

From an ecological perspective, there are questions about what species and runs of fish benefit from the additional spawning gravels. On the Trinity River, gravel additions in the reach directly below the dam have been questioned because of the likelihood that these will benefit principally fish from the hatchery located there, to the detriment of wild fish. However, on balance, the benefits are considered to outweigh the drawbacks and gravel augmentation has been resumed directly below the dam. Similarly, gravel projects below many dams throughout the Sacramento and San Joaquin River systems have been criticized as benefiting primarily salmon raised in hatcheries, rather than wild runs that are threatened with extinction (Kondolf et al. 2008). Exceptions include the gravel augmentations on the mainstem Sacramento River below Shasta and Keswick Dams, for which there is evidence that these gravels have been critical in the survival of the endangered winter run Chinook salmon (*O. tshawytscha*), and in nearby Clear Creek, where benefits to wild fish have been documented. Thus, in evaluating the benefits of mechanical gravel augmentation projects, we must consider not only the abiotic factors of gravel supply and channel form/habitat, but also biotic interactions.

2.4.3 Watershed Activities Success Criteria

Despite its broadscale name, the primary intent of the Watershed Activities management action is to reduce fine sediment within the Program Reach. Similar to flow management, this singular measurable variable lends itself well to being monitored and measured. It is important to note that fish passage and aquatic restoration in the tributaries is also included as a part of this Management Action, and have varied definitions of success criteria. While interviews completed as part of this process generally believe these projects to be successful, limited measurable reporting or quantitative success criteria appear to be available.

2.4.4 Channel Rehabilitation Projects Success Criteria

Interviews and work products reviewed suggest a key element of the definition of success for Channel Rehabilitation projects within the TRRP is the fish population recovery and response. Currently, the primary measure for post Channel Rehabilitation project success within the program has been fish capacity evaluations (see subsection below). Aside from this, success criteria for different channel rehabilitation sites vary widely depending on the project design, implementor, and project location. Success criteria rarely identify the timescale, spatial scale, or flow event(s) over and at which success is measured or will be evaluated. Recently, design reports have described the anticipated evolution and changes expected in the rehabilitation project area over time. However, these projects are infrequently subjected to formal re-evaluation to assess whether performance measures have been met. It should be noted that a Program Objectives and Targets Summary document is in preparation (TRRP 2022b). While this document links Fish, Physical, and Riparian and Aquatic Ecology objectives to Management Actions (e.g., Gravel Augmentation, Channel Rehabilitation), they stop short of identifying the specific design criteria and associated restoration features that would achieve these objectives, such as “build and maintain floodplain rearing surfaces that activate at the 5% exceedance flows during January – March” or “install large wood structures that provide cover in pools greater than 3 feet deep at low flow used for adult holding.”

Juvenile Fish Criteria for Post-Project Success Monitoring

Fish habitat suitability and capacity in the Program Reach have been used as metrics in the design process and in evaluation of the evolution of Channel Rehabilitation sites. As new technology became more readily available into Phase 2, use of 2-dimensional hydrodynamic models, combined with detailed bathymetry that has allowed for detailed assessment of fish habitat and capacity in the Trinity River. These advancements have led to the development of models that evaluate juvenile fish habitat capacity for constructed projects.

Following development of this modeling approach, Cooper-Hertel et al. (2022) completed a comprehensive effort that assessed TRRP channel rehabilitation project effectiveness against the following four objectives:

- Rearing habitat capacity both for areas that have received mechanical rehabilitation and for those that have not.
- Rearing habitat capacity patterns between rehabilitation sites.

- Identify topographic attributes that contribute to habitat capacity.
- Evaluate the habitat capacity within reaches given frequency and duration of flows during the critical rearing period.

From these analyses, (Cooper-Hertel et al. 2022), found the average capacity for juvenile Chinook rearing was primarily either no different or greater in rehabilitated areas when compared to non-rehabilitated areas. However, substantial variation in capacity was related to the location of the project reach within the greater watershed and the local geomorphic character of the reach. Also in a few instances, such as rehabilitation sites from early in Phase 1, capacity for juvenile Chinook was lower in rehabilitation sites compared to non-rehabilitated areas, indicating the techniques used at those sites, or the changes in the sites, have not been sustained over time and should likely be revised for future rehabilitation efforts (Cooper-Hertel et al. 2022). Notably, this analysis only looked at projects completed through 2016, with more recent projects using different design strategies implemented since then anticipated to be included in future model updates. Rehabilitation sites with the smallest values of habitat capacity were typically areas with narrow, single-threaded channels that had little connection to floodplain or margin habitats, including most sites in reaches with incised or confined planform settings throughout the lower half of the restoration reach (Cooper-Hertel et al. 2022).

Findings also emphasized the importance of connectivity to side channel and floodplain habitats and more frequent, extended periods of high flow connections to off-channel areas and floodplains. Cooper-Hertel et al. (2022) found that limiting factors to juvenile salmonid capacity varied depending on the location within the Program Reach. This indicates there may be a need to utilize different strategies for restoration among different sections of the TRRP project area.

Long term monitoring (since 1989) of an outmigrant trap located near Willow Creek suggests that at least for juvenile Chinook, abundance estimates are greater post ROD than Pre ROD (T. Gast and Assoc. 2021). The trap is located a fair distance downstream so tying these population numbers solely to conditions in the project area is difficult.

2.4.1 Adaptive Environmental Assessment and Management Success Criteria

Arguably the most challenging of the management actions to develop success criteria for is AEAM. While the Headwaters Report (2018) and the Science Plan (Pickard et al. 2022) outlined multiple steps for improving AEAM and potential avenues for success criteria, these have yet to be formally adopted.

3. Review Methods

3.1 METHODS

The scope of this review and subsequent recommendations was limited to information readily available through the TRRP's website, as well as field visits, targeted interviews, and a public meeting, which are summarized below. For the purposes of this effort and these recommendations, it was assumed that no changes to the ROD shall occur.

3.2 FIELD VISITS

Review of the TRRP's Phase 2 activities included rapid field tours of several sites over the course of two separate field trips for panel members and TRRP staff/partners (Figure 13). Sites visited included Bucktail, Chapman Ranch, Deep Gulch, Sheridan, Lowden Ranch, Hocker Flat, Wheel Gulch, Lower Junction City, Sawmill, and Dutch Creek, among others.

Figure 13. Members of the project design group provide an overview of the design process during field tours.

3.3 INTERVIEWS

To begin the interview process, a list of individuals involved in work in the Trinity River through the TRRP and its partner agencies was developed by Reclamation. This list was further refined in collaboration with Reclamation and the Expert Panel. Individuals with the same partner agency affiliation were grouped to form the basis of the interview cohorts. Interviews were conducted via the virtual meeting software Zoom for each interview cohort, and typically lasted a total of 1.5

hours. In total, nine interviews were conducted for eight cohorts (Table 8). Scheduling conflicts required two interviews with Yurok Tribe staff.

A series of interview questions were developed to guide the interview of each cohort. In general, the following questions (or minor variations on) were asked to each cohort:

1. Please describe your experience with the TRRP (each interviewee).
2. In your own words, what is the purpose of the TRRP? Has this shifted over time?
3. Can you tell us a little about what you know about watershed actions, gravel augmentation, flow, or channel rehab?
4. What are the actions of the TRRP (flow, gravel, channel rehab, watershed) that are most important to the success of the TRRP? What do you engage with most frequently?
5. What does your ideal annual hydrograph look like? Why?
6. What does adaptive management look like in the TRRP? What does successful adaptive management look like to you in the TRRP?
7. What does success look like for the TRRP as a whole? What does success look like for a specific channel rehabilitation project? How do you measure a successful project?

A summary of the key program or management action strengths and weaknesses discussed in each interview is provided in Appendix B.

Table 8. List of interview cohort affiliations and interviewees.

Interview Cohort	*Date of Interview*	*Interviewees*
U.S. Forest Service	*10/5/2022*	Eric Wiseman
U.S. Bureau of Reclamation	*10/6/2022*	Dr. Mike Dixon James Lee Brant Gutermuth Oliver Rogers Dr. Todd Buxton Chad Abel Dr. Eric Peterson
National Marine Fisheries Service	*10/19/2022*	Seth Naman Roman Pittman
U.S. Fish and Wildlife Service	*10/20/2022*	Dr. Nick Som Dr. Conor Shea William Pinnix Josh Boyce
Trinity County	*10/20/2022*	Patrick Flynn Liam Gogan
Yurok Tribe	*10/21/2022*	Wes Scribner Dr. Dave Gaeuman Kyle DeJulio Chris Laskodi
Hoopa Valley Tribe & McBain Associates	*10/21/2022*	Fred Meyer (McBain) Veronica Yates (HVT) Justin Alvarez (HVT) Scott McBain (McBain) John Bair (McBain)
California Dept. of Fish and Wildlife & Dept. of Water	*10/24/2022*	Trevor Morgan (CDW) Nancy Snodgrass (CDW) Kenneth Lindke (CDFW) Seth Lawrence (CDW)
Yurok Tribe	*10/31/2022*	DJ Bandrowski Aaron Martin

3.4 PUBLIC MEETING

A public meeting was held in Weaverville at the Redding Rancheria Trinity Health Center on September 12 in the evening. Awareness of the event was spread via multiple outlets, including newspaper, email, and on the Reclamation's Facebook page. Reclamation also followed up individually with stakeholders who have a known interest in the Program's activities including representatives from the whitewater rafting community, fishing guides, and others. The meeting included a large format map (Figure 14), multiple exhibits, and was open-house style. Information was captured by map annotating and notetaking. The results of these notes informed recommendations and reflections provided in this report.

Figure 14. Interactive mapping at the Phase 2 Review public meeting.

3.5 TIME-BASED REVIEW

The professional practice of applied river and stream improvement design is a relatively new component in the fields of science and engineering. While humans have long been modifying our waterways, the roots of applying Western science and engineering to enhance natural waterways for habitat and ecosystem function as a professional practice largely arose in the mid-1980s. Since this time, increasing public desire to improve degraded aquatic resources and associated environmental laws and regulations (e.g., listing of salmonids under the Endangered Species Act), has led to an acceleration of the scope, scale, and advancement of the professional river restoration practice.

As such, since the finalization of the Flow Evaluation Study (USFWS and HVT 1999), restoration design practices have evolved based on a combination of experience, regulatory oversight, and decades of observation of post-project performance. While some of the change in practice may be attributed to adaptive learning in response to project performance, much of the evolution of the practice has been driven by technological advancements, the rise of innovations within the myriad of professions that make up the practice, and scientific understanding of the changing climate. Therefore, solutions derived by the practice even a few years ago are often viewed as less advanced than those derived contemporaneously. Given this rapid evolution, it is important to note that the suggestions and reflections provided here may not be the same as those in the future. Additionally, suggestions that have survived the test of time should perhaps be viewed as emerging fundamental tenants of the evolving practice.

4. Phase 2 Responsiveness to Phase 1 Review Recommendations

4.1 PHASE 1 REVIEW RESPONSIVENESS

In June of 1999, the USFWS and the Hoopa Valley Tribe published recommendations for re-habilitation of the Trinity River channel in the Flow Evaluation Study (1999). These recommendations directly influenced the early approaches to channel/habitat enhancement efforts (Phase 1; 2002 – 2012). The review of these Phase 1 efforts was conducted in two parts: a Channel Rehabilitation-focused review by CH2MHill and Entrix (2010), and a broader programmatic review by Buffington et al. (2014). An evaluation of the TRRP's responsiveness to implementing these recommendations as part of Phase 2 projects is provided here. It is important to note that some of the recommendations suggested in the Flow Evaluation Study and again in the Phase 1 reviews (Buffington et al. 2014, CH3MHill & Entrix 2010) have yet to be realized and remain relevant today.

4.1.1 Phase 2 Responsiveness to CH2MHill & Entrix 2010 Programmatic Recommendations

During their review of the design and implementation process for Phase 1 channel rehabilitation projects, CH2MHill and Entrix (2010) developed a list of recommendations to help guide the remainder of Phase 1 projects and the upcoming Phase 2 design process. This included recommendations on the TRRP's Design Approach and Design Process, as well as General Recommendations. These recommendations are listed below, by category. An assessment of the Program's responsiveness to these recommendations during Phase 2 projects is then provided.

Design Approach

CH2MHill & Entrix included the following recommendations on Design Approach in their Phase 1 review:

1. **Recommendation: Immediately create as much of the target habitat as possible.**

   Design responsiveness to recommendation:

   Designs developed since the Phase 1 recommendations have undergone significant changes. Initially, projects relied on historical fluvial geomorphic process assumptions to achieve the desired target condition after implementation. However, the current approach is more proactive, focusing on both constructing the target habitat condition for near-term use and encouraging fluvial processes that create and sustain habitat in the long run.

   This change in approach presumably responds to the increasing realization that the bottomland of the Trinity River in the project reach is much less mobile and responsive than predicted in the Flow Evaluation Study and ROD. The decrease in channel mobility and responsiveness is discussed in Section 5 but is largely a result of hydromodifications that reduce stream power and ameliorate unnaturally coarse grain sizes or altered distributions of sediments left behind by mining activities. Therefore, geomorphic processes reliant on river discharge remain substantially muted. Consequently, Phase 1 designs that relied on flow-induced geomorphic evolution to reach a "mature" channel condition have not performed as expected.

Evidence of this evolving design/implementation approach is apparent in the scope of the projects implemented in Phase 2 or planned for future implementation. This includes measures such as more aggressive floodplain lowering, and construction of scour pools associated with the building of large wood structures. More recently, an additional shift in approach may be emerging. The most recent projects, such as Oregon Gulch, have incorporated a "Stage 0" or "Valley Reset" approach (Powers et al. 2019), which creates "anabranching and/or discontinuous channels that are dynamic." This approach is often more spatially extensive, and intensive, than the early Phase 1 approaches, but also relies substantially on fluvial process to develop mature habitat conditions over time, following implementation. The viability of this approach should continue to be monitored and evaluated for each project to understand if the desired dynamism is achievable given the Trinity River's peak flow and sediment-supply reductions, and the legacy of dredge mining-induced substrate alterations (e.g., larger size classes on the floodplain surface).

2. **Recommendation: Design and implement projects that are self-sustaining and, where possible, trigger future changes that further restore the system.**

   Design responsiveness to recommendation:

   The understanding of watershed and river corridor geomorphic processes has evolved significantly since the passage of the ROD (2000). Scientific studies and observations in the Program Reach have indicated that Phase 1 projects may be challenged to "self-sustain" or there are significant limitations on the river's capacity to trigger future beneficial geomorphic change. It is noted that self-sustaining is not operationally defined in the prior recommendations. Given that no definition of self-sustaining was provided, there are two possible interpretations of responsiveness to this recommendation. If "self-sustaining" means "retaining post implementation condition", then many projects have largely met this attribute. If, on the other hand, "self-sustaining" means "retaining the post implementation condition following a geomorphic disturbance event", then most projects have not been subjected to flows that would trigger channel disturbance.

   Given the low frequency and duration of flows that generate sufficient stream power to alter channel conditions, it is difficult to determine if, as implemented, the projects are achieving the goal to "further restore the system." Documentation of post project performance is heavily focused on suitable fish habitat (e.g., modeled stream flow outputs against habitat preferences for salmonids). This modeling and other empirical observations suggest that fish useable area immediately increases post-construction (Boyce et al. 2020), but then begins to dip after the project evolves. Interviews suggested that this trend is due to vegetation establishment which alters the post project surface.

3. **Recommendation: Actively engage the public to develop designs that are compatible with the human community, particularly regarding flooding, erosion, and public safety (recreational boating).**

   Design responsiveness to recommendation:

   Discussions in the field and through the interview processes suggest that while the TRRP program remains respectful and open to the public, community engagement seems to primarily focus on informing the public and explaining the rationale behind specific projects or actions and requesting public input on proposed designs or decisions. The degree to which this public input has been incorporated into the design process itself is not well documented, so it is difficult to evaluate how this recommendation has been followed and at what level along the engagement spectrum (Facilitating Power 2022) the TRRP is functioning. Public engagement in a program like this can be challenging because members of the public may react negatively to short-term changes at specific sites, particularly when these changes may be, or appear to, conflict with values stakeholders may have for the site. Nonetheless, sensitivity to public concerns can help craft projects that are more acceptable to the public while still achieving program goals.

4. **Recommendation: Revisit some of the early TRRP projects.**

   Design responsiveness to recommendation:

   Redesign and secondary implementation of channel rehab in previously completed project areas has generally not been pursued by the TRRP, but a significant redesign was accomplished at the Bucktail reach in 2016. According to the 2013 Value Engineering Study, the original Bucktail design circa 2007 provided only limited off-channel rearing habitat, largely due to flooding concerns stemming from Bucktail Bridge, a vehicular bridge at the downstream end of the reach. The planned replacement of that bridge removed a significant design constraint in terms of flood risk, and allowed the design team to develop a second design that greatly increased off-channel rearing habitat.

   Other early TRRP reaches may benefit from redesign, particularly those in wide alluvial valleys. However, interviews suggest that the TRRP lacks clear written programmatic justification and community support to revisit these sites, as they are often perceived as "done" once construction has been complete.

Design Process

1. **Recommendation: Understand the Physical Template by Characterization of historic and present geomorphic, hydraulic and ecological conditions of a project site helps inform the approach to rehabilitation action.**

   Design responsiveness to recommendation:

   There is not a standard template for the various basis-of-design reports which all design teams follow, though a draft outline has been recently compiled by the TRRP (April 2022).

The lack of consistency in the basis-of design reporting makes it somewhat difficult to evaluate this recommendation. However, from discussions with the various design teams and review of available design documentation, it appears that this recommendation has largely been adopted. In some cases, how these different disciplines (geomorphology, hydrology, hydraulics, ecology) interact to support the project's function (e.g., emergent vegetation is most closely associated with juvenile rearing habitat at this site; juvenile fish more regularly present at this type of flow), appears to be lacking from written design documentation. However, in general, data that provides an understanding of the Trinity River prior to all human alterations (particularly pre-mining) are very limited, and the scope and scale of alterations to the Trinity River and its floodplains are so extreme that in many cases, the influence of this data on a site's achievable restoration target is also less clear.

2. **Recommendation: Describe the Spatial and Temporal Conditions and Anticipated Evolution.**

Design responsiveness to recommendation:

During in-the-field review of various projects and review of design documents it is clear that most projects had or have anticipated performance expectations. In conversation and interviews, some project groups are working at the "River Corridor" spatial scale (as defined by Gaeuman et al. 2016). However, review of most design documents lacks a unifying spatial scale and/or provides maps/language that contain non-uniform spatial scales (e.g., 100-year floodplain, Environmental Study Limits, tax lots) making it difficult for the reader to connect multiple lines of evidence.

Design documentation for Rehabilitation projects typically predicts usable habitat area created for fish (based on flow and suitability curves) immediately following project implementation. However, the documentation provides less extensive discussion towards anticipated trends in geomorphic or ecological trajectory of the design. Review of design documentation also suggests temporal evolution uses time-based terms that are not operationally defined in the documents such as "immediate" and "long-term." Notably, this timing isn't related to hydrologic, geomorphic, or biologic thresholds or conditions.

Additional suggestions for how to better address this recommendation in Phase 3 are provided in Section 5.

3. **Recommendation: Standardize the Design Process.**

Design responsiveness to recommendation:

The most effective tool to standardize the design process at a programmatic level is a Design Guide. While there is an existing Channel Rehabilitation Design Guideline document (HVTFD et al. 2011) and it is described as a "living document" on the TRRP data portal, it has not been updated since 2011. Several interviewees requested that this document be updated. As updates to the document have not occurred in tandem with evolution of the design approaches utilized in the TRRP, the current design guidelines may be of limited value. This has led to a range of design approaches, that while perhaps reflecting regional specifics, lack clear, documented connections to the broader program goals and practice of river restoration.

Additional suggestions for how to better address this recommendation in Phase 3 are provided in Section 5.

General Recommendations

1. **Recommendation: Continue Collaboration.**

Responsiveness to recommendation:

The design work group (composed of four design teams) includes robust interdisciplinary and interagency representation by restoration design experts with decades of experience working on the Trinity River. Within design teams, each team member brings a unique perspective to the teams and has the opportunity to comment on designs as they are refined through set milestones. These design teams allow for strong collaboration and vetting of design approaches. For some design teams, it is unclear how much of this collaboration happens as comment/response type collaboration or more integrated design charettes/team meetings. While there is value in both types of collaboration, the experience of this panel suggests that more integrated, interdisciplinary designs result from integrated design charettes/team meetings. Additionally, while the depth of experience for this program on the design side is immense, there may be some benefit from design teams that work primarily on the Trinity River to periodically seek out lessons learned from work implemented in other areas/regions to expand upon the diversity of thought or approaches in the Program.

Some interviewees noted that collaboration between different design teams does not occur with enough regularity or consistency. Interviewees also consistently noted a growing disconnect between the Science Work Groups and the Design Group. Interviewees reported this was already a structural problem resulting from the different paces of the work groups, as the typical design project spans 18 months, while science publications typically span 3 to 5 years. However, the problems were greatly compounded by the COVID-19 pandemic and the lack of in-person meetings that resulted. Virtual meetings were held during the pandemic to maintain progress on workgroup activities, however, interviewees noted that meetings felt less collaborative. Without frequent in-person interactions (such as quarterly meetings) between the Science and Design sides, valuable input from the Science workgroups may not be conveyed effectively to design teams, especially during the periods in between publications from the Science workgroups. Likewise, valuable feedback from project performance is not effectively conveyed to the science workgroups, inhibiting adaptive management. The addition or reintroduction of any meetings should be carefully considered so that each meeting has a clear purpose, plan, and objectives.

2. **Recommendation: Define Success Criteria to Help Focus the Vision for Rehabilitation.**

   Responsiveness to recommendation:

   Success criteria have become more clearly defined in recent years. Parameters such as weighted usable area (pre-2020) or habitat capacity (post-2020), depth, velocity, distance to cover, topographic complexity and wetted width have been calculated for some projects as part of the design development process, to evaluate as-built conditions, and to monitor changes in project reaches after high flow events. However, there is a lack of consistent design documentation content across the different design groups. This inconsistency makes a further understanding of how the various design efforts coalesce around the broader goals set by the TRRP difficult.

   Success criteria seem to be primarily focused on individual projects or project components and not necessarily clearly linked (or linkages explicitly defined) to higher level TRRP goals and objectives. Updated programmatic-level success criteria in support of the ROD would be useful to unite efforts within the Program. Updating or refinement of the original management objectives (Table 9) outlined in Flow Evaluation Study (USFWS and HVT 1999) based upon the contemporary understanding of may be a useful starting point, and is discussed in more detail in Section 5. Within the project design documents reviewed, there is a lack of consistent content with each design team using a different format and often using dissimilar approaches.

Table 9. The management objectives from in the Trinity River Flow Evaluation (USFWS and HVT 1999) provide an example framework of success criteria that could be applied at the program level.

Peak Release (cfs)	***Duration (days)***	***Water-Year Class***	***Management Objectives Achieved through Flow Related Geomorphic Processes***
1,500	36	Critically Dry	• Prevention of germination/establishment of riparian vegetation low on alternate bars
4,500	5	Dry	• Mobilization of spawning gravels • Sand transport • All effects realized at lower flow level
6,000	5	Normal	• Channel bed surface mobilization • Significant mobilization of spawning gravels • Fine sediment movement • Channel migration • Floodplain inundation • Scour of 1–2-year-old seedlings • Groundwater recharge on floodplain • All effects realized at lower flow level
8,500	5	Wet	• Surface mobilization of alternate bars • Scour of bar margins • Coarse sediment movement • Scour of 2–3-year-old seedlings • All effects realized at lower flow level
11,000	5	Extremely Wet	• Significant scour of alternative bars • Large coarse sediment movement • Floodplain scour • Side-channel formation/maintenance • Sapling removal from alternate bars • All effects realized at lower flow level

3. Recommendation: Use Success Criteria to Link Monitoring and Design.

Responsiveness to recommendation:

Spawner surveys, snorkel surveys, bathymetric surveys, and topographic surveys are completed regularly to track success in increasing usable habitat area (spawning riffles, adult holding, thermal refugia, and velocity refugia), as well as increasing outmigrant and returning adult salmonid populations. However, as noted above, success criteria seem to be primarily focused on individual projects and not necessarily linked to higher level goals. Much of the project level anticipated benefits are focused on the area of juvenile rearing habitat created while higher level goals are much more encompassing and include geomorphic and ecological function. More clearly linking design documentation to planned monitoring efforts would be useful to understand if and to what extent success criteria are linked to monitoring.

4. **Recommendation: Think Big and Capitalize on the Limited Locations Where it is Possible to Act Big.**

   Responsiveness to recommendation:

   As stated above, designs developed since the Phase 1 recommendations have evolved from projects that relied heavily on geomorphic process to drive desired final conditions to projects that focus on immediate creation of desired conditions. This has resulted in design efforts focusing on larger projects and increasingly more intensive alteration of existing conditions to actively create desired conditions.

   Thinking big and capitalizing on the limited locations where it's possible to act big, seems to have been successful in Phase 2. Examples include the relatively broad alluvial reaches of Bucktail (which saw a secondary mechanical intervention in 2016), as well as the Chapman Ranch, and Deep Gulch-Sheridan Creek projects. The Oregon Gulch channel rehabilitation project will be a continuation of the general trend in the Program to think big and capitalize on limited locations where it's possible to act big.

   Broad alluvial reaches with large potential for dramatic increases in usable habitat area still exist in the Program area. While some channel rehabilitation has occurred in many of these reaches, rehabilitation in Phase 1 projects was generally limited to bank feathering and floodplain grading to the geomorphic bankfull discharge. The state of the science has evolved toward designing for much greater amounts of wetted width and topographic complexity for a larger range of flows, particular for more frequent low flows. Considerable opportunities still exist to capitalize on these limited locations where it's possible to act big, and revisit reaches where previous attempts at rehabilitation have had limited success. Formally adopting the River Corridor Management Strategy and operationally defining at a programmatic level where it is possible to act big (e.g., site potential based upon confinement, slope, and/or stream power) may be a useful framework to most effectively prioritize sites to revisit and "act big."

5. **Recommendation: Look to the Tributaries.**

   Responsiveness to recommendation:

   Work in tributaries areas has occurred since the publishing of the Phase 1 recommendations. Much of this work has occurred on lands managed by the USFS and has involved modification of barriers to migration. Based upon interviews, a large Stage 0 style project was completed on Indian Creek in 2020 (Hubbard 2021), but the program's emphasis seems to remain primarily on projects along the mainstem River Corridor.

6. **Recommendation: Revisit the Hydrograph.**

   Responsiveness to recommendation:

   The TRRP has been responsive to this recommendation. We recognize that there are many factors outside the TRRP's control and that the flow-release structure imposes limitations on what is possible (e.g., magnitude of flow releases possible from the dam). According to the TMC Bylaws (TMC 2019), the flow release schedule must be approved by the TMC, which then makes a recommendation to the Bureau of Reclamation on the flows to be released. The Phase 2 reviewers noted that this is not consistent with the workflow and approval of other major Program activities, such as gravel augmentation and channel rehabilitation.

Within the bounds of these limitations, the Flow Workgroup has been actively working to optimize the timing, magnitude, and duration of flows on the Trinity River. Most notably, this has included the recent passing of the Winter Flow Variability proposal in January of 2023. Primarily, this proposal shifts a greater portion of the ROD water to be released into two distinct periods in the winter: the Flow Synchronization Period (December 15 to February 15) and the Elevated Baseflow Period (Between February 15 and April 15). Given the infancy of the Winter Flow Variability releases, the effectiveness of this program is currently unknown.

The importance of cold-pool releases from the reservoir for summer baseflows in supporting thermal refugia for spring-run Chinook continues to be a topic of discussion amongst Flow Workgroup members, and a subject of rigorous scientific inquiry. As with the artificially *low* winter baseflow releases, artificially *high* summer baseflow releases are likely impacting the Trinity River ecosystem.

A recent study by Buxton et. al (2022) demonstrated that summer baseflows as low as 35 cfs could have considerable benefits. These advantages include:

- Thermal stratification of deep pools which provides temperature diversity benefiting fish, turtles, and other species;
- Increasing vegetative establishment in the channel, adding habitat complexity and further improving bioenergetics; and
- Conserving water for release at other times of the year.

In contrast to natural conditions, the current regulated summer base flow of 450 cfs prevents stratification and creates a homogenous, cold river environment. This limits food availability and growth for juvenile salmonids, reducing their chances of surviving to adulthood and returning to spawn. However, risks of stratification like low oxygen levels would also need evaluation before reducing flows. Monitoring water quality issues would be prudent if flows are lowered.

7. **Recommendation: Capitalize on Opportunities to Work with Federal, State, and Local Agencies and Incorporate Future, Post-Rehabilitation Channel Conditions into Planning for Flood Mapping Updates.**

Responsiveness to recommendation:

Recently the TRRP has funded a position within Trinity County to facilitate project efforts and compliance with FEMA regulations. It was reported that flood mapping updates occur as part of every project, which requires extensive time and resources. Discussion of ways to streamline this process at a programmatic level, similar to the (now-rescinded) FEMA Region X Policy on Fish Enhancement Structures in the Floodway, could help move projects forward more efficiently while still providing the appropriate level of due diligence to ensure infrastructure in the mapped floodway has no flooding impacts from channel rehabilitation efforts.

8. **Recommendation: Take a More Active Role in Managing the Use of Wood.**

   Responsiveness to recommendation:

   Discussions with the design teams during project site field reviews highlighted several issues regarding the use of wood in rehabilitated sites. First, was the consideration that wood materials recruited or placed into the system are subject to management by recreational users to reduce perceived hazards to navigation and/or entanglement with fishing gear. While limited in scope, our interviews at public meetings suggested that both of these perceptions may not accurately portray the views of recreational users. For example, some in the rafting community suggested that they are comfortable with engineered large wood placements if placement's have signage, long lines of site, and is not on the outside of sharp bends (if ample time to navigate away from the wood is not available). These engineered large wood practices are in line with existing documentation and best practices in river restoration, such as those developed by American Whitewater (American Whitewater 2012). Adoption of these practices at a programmatic level may allow the TRRP to utilize engineered large wood more effectively to drive geomorphic change and provide habitat.

   It was also noted that there is a desire by some interviewees to avoid use of ferrous anchoring or creation of "immoveable structures." While this desire is understood, given the limitations on the size (e.g., length, diameter) of large wood that can be feasibly transported and installed via most construction methods relative to the stream power of the system, this can place limitations on the geomorphic effectiveness that these structures can be expected to initiate and achieve. More explicitly stating the design criteria for engineered large wood structures (defined flow/event for structure stability and factor of safety) in design documentation may help alleviate some of the perception of creating "immoveable structures."

   The difficulties of obtaining suitable wood materials and the cost of procuring them were also mentioned as a barrier to using these materials. There seemed to be general understanding that wood should be considered a more prominent component in site design as these materials have been shown to be important habitat components, and because current natural wood recruitment and retention is well below target conditions (as defined by Cardno Entrix and CH2MHill 2011). Many of the Phase 2 projects include wood additions but not necessarily at the levels of loading suggested by other investigations (Cardno Entrix and CH2MHill 2011). However, more recent projects such as Oregon Gulch have involved greater wood density and more than met the recommended densities. Clear and standardized reporting of how designed large wood volumes and key pieces as they compare to target levels of large wood loading (Cardno Entrix and CH2MHill 2011) would improve review of this recommendation going forward. It was reported by interviewees that there is increasing consistency between the design teams regarding approach to large wood design/loading. This sentiment was difficult to verify based upon readily available design documentation.

A large wood management strategy is currently being developed by Program participants. As the large wood management strategy has yet to be finalized and adopted, approaches to large wood structures in terms of placement, engineering, ballast, number of pieces placed, and species used all vary between design teams. From a limited review by the panel on the forthcoming strategy, it is clear that actions to address this recommendation are in progress and that considerable thought has gone into developing the strategy, as well as recognition across the program that a unified approach to large wood is needed.

9. **Recommendation: Continue Seeking and Developing Opportunities for Additional Partnerships, Outreach, Communications, and Funding.**

   Responsiveness to recommendation:

   As noted above, outreach does seem to have increased since Phase 1, but it is possible the level or type of engagement could be improved upon. The Oregon Gulch channel rehabilitation project will partner with the Eagle Rock quarry, which is adjacent to the project site. Excavated material will be hauled to Eagle Rock. While Eagle Rock did not buy this material, this may serve as a useful model for public/private partnerships.

10. **Recommendation: Continue Seeking and Developing Opportunities to Expand the Pool of Available [Channel Rehabilitation] Construction Contractors.**

    Responsiveness to recommendation:

    Interviews suggest that some teams have developed exclusive relationships with in-house channel rehabilitation construction teams or individual construction operators. Interviewees generally suggested this has been a positive experience based upon the collaborative relationship formed with construction contractors. The rational given for this is that combining or closely linking the design and construction phases of implementation results in cost savings, increases collaboration between the designers and construction contractors, and provides the designers with more significant influence to optimize as-built conditions. Not all of the design teams have chosen this path but it is also not clear if the diversity of construction operations has increased in the years since the Phase 1 recommendations have been available.

4.1.2 Phase Responsiveness to Buffington et al. (2014) Programmatic Review & Recommendations

The review by Buffington et al. (2014) focused on both the channel rehabilitation projects and the Program's overall activity within the context of the Program's foundational documents (USFWS HVT 1999, USDOI 2000) and was led by the Science Advisory Board (SAB). This review was performed in response to a request to the SAB to compile information and develop a comprehensive report that would provide an independent and impartial assessment of Phase 1 activities and progress toward achieving Program goals and objectives, along with recommendations for refinements in Phase 2 projects. This effort involved reviewing and synthesizing existing Program publications, as well as conducting original work using available data.

The Buffington et al. Phase 1 review included analyses of the Phase 1 channel rehabilitation sites and considered channel responses (e.g., geomorphic, habitat) relative to established Program objectives identified in the Integrated Assessment Plan. Changes observed at the channel rehabilitation sites were also assessed in relation to flows experienced in the Trinity River since construction, the relationships between geomorphology and fish habitat, and the distribution of juvenile fish habitat across channel rehabilitation design elements. Channel geomorphic responses were evaluated based on desktop analyses of lateral erosion and deposition and response of riparian vegetation to modification. Juvenile fish habitat availability was determined based on available site-level habitat assessments and aerial imagery during low flow conditions.

Recommendations from the Phase 1 report include suggestions for additional studies or monitoring, adaptations of programmatic or management strategies, and comments on methods for channel rehabilitation and gravel augmentations activities. Key recommendations are listed below, along with the responsiveness of Phase 2 projects that were developed after the recommendations were made.

1. **Recommendation: Developing a system-wide model for sediment transport.**

   Responsiveness to recommendation:

   The system-wide sediment transport conceptual model used on the Trinity River has evolved since the Flow Study, driven by observation and advances in science technology. The original "conveyor belt" concept model (Figure 15) that informed the TRRP's earliest management actions has transformed into a more nuanced model, recognizing the potential for coarse sediment to become trapped at various points along the river. Numerous tracer studies as well as morphological analyses have demonstrated that most gravel added to the river has not travelled long distances downstream (Gaeuman 2020). The distribution of sediment in active bars along the length of the project reach documented by McBain Associates (2015) further demonstrates the irregularity of gravel availability in the project reach and the need for additional augmentation sites, so that areas of gravel ''starvation' can be reached with additional gravel augmentation. Sediment budgets have been constructed for the Trinity River at different points in time, reflecting the evolution of sediment sources, deposition, and transport rates (reflecting sediment supply, caliber, and flow available to move the sediment) over the years (e.g., Wilcock 2010, Gaeuman 2013). A system-wide numerical sediment transport model has not been developed per se, although Gaeuman and colleagues did morphodynamic modeling of the project reach using the 'mobile' module of SRH-2D (Gaeuman 2020, Appendix C). An intensive program of sampling sediment transport over a period of about 15 years has been replaced with monitoring bedload transport noise with hydrophones at Lewiston, Limekiln, and Douglas City. These measurements will be used with curves relating transport rates to decibel values to estimate total loads at these stations, which are expected to be available within the year. Overall, substantial gains in the knowledge base of sediment transport patterns have been made, despite the lack of a transport model for the entire reach.

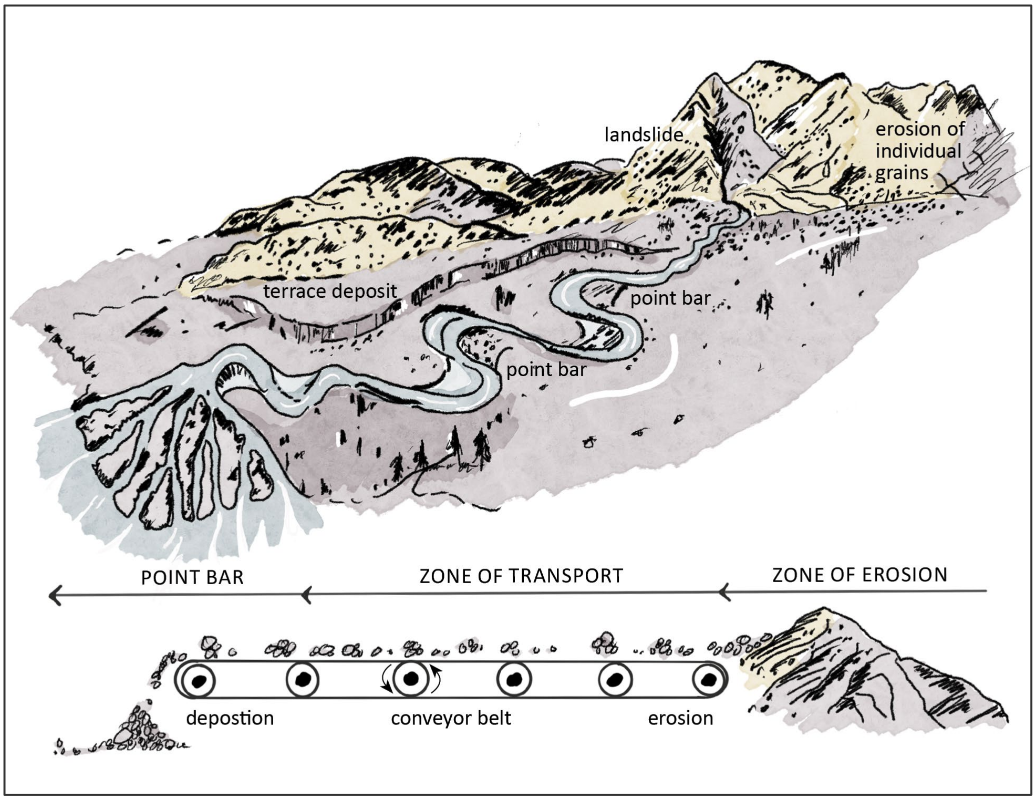

Figure 15. Original conceptual model of the "conveyor belt" for sediment transport which provided the foundation for the TRRP's original gravel augmentation management action (adapted from Kondolf 1997). The TRRP has since adopted a more nuanced model that recognizes sediment can become trapped along the river.

2. **Recommendation: Revising the wet and extremely wet water-year flow allocations to increase the magnitude and efficiency of geomorphic work in the Trinity River**

   Responsiveness to recommendation:

   As noted above in response to the "Revisit the Hydrograph" recommendation, significant effort has been undertaken by the Flow Workgroup to revisit the current flow release schedule and we acknowledge that there is much outside of the TRRP's control with respect to flows. Also, as noted above, the Winter Flows Variability Proposal has recently been adopted, which intends to more closely mimic flow conditions entering the reservoir. We understand that the response of the Program Reach to these changes will continue to be monitored, along with how these changes impact project performance. Future efforts should look to continue to optimize the benefits of these flows under the purview of the Adaptive Environmental Assessment and Management (AEAM) efforts.

3. **Recommendation: Improving the integration of various workgroup activities**

   Responsiveness to recommendation:

   As noted above in the response to the "Continue Collaboration" recommendation, collaboration reportedly occurs regularly within the existing design teams. Collaboration appears more limited across the different Channel Rehabilitation design teams, and between the Science Groups and the Design Group. Integration and collaboration between the different workgroups (e.g., Flow, Ecosystems) is less documented and understood, and could benefit from a more well-defined programmatic approach to workgroup collaboration.

4. **Recommendation: Developing a Decision Support System (DSS) to improve predictions (and timeliness) of site and system response**

   Responsiveness to recommendation:

   A DSS literature review was found on the TRRP document library (St. Clair and Burns 2013), but no other information was readily available through this data portal. Interviews and conversations with TRRP staff suggested that a DSS has been used to inform flow decisions and the Buxton (2023) Water and Temperature Report was provided as an example. While this paper provides "accounting of Trinity River water volumes and temperatures at compliance points in WY 2022," how it relates to a developed DSS is not apparent from reviewing the document.

   A formal decision support system (DSS) has not been developed by the Program that is specific to Channel Rehabilitation management actions. There was limited supporting detail in the Buffington et al. (2014) recommendation on how this DSS would function or the range of decision-making that the DSS would support. As a result, there was also limited understanding of how effective this recommendation may be from both the TRRP, interviewees, and the authors of this review. Some interviewees did note that there appears to be little transparency in the decision-making process as related to major program activities. This review suggests that the TRRP may have been responsive to this recommendation for Flow Management. The utility of a DSS to other aspects of the program, varies by the management action. A DSS for Sediment Management and Watershed Rehabilitation (particularly culvert replacement and forest road decommissioning) may be more applicable, but given the interconnectedness and multiple processes influencing river processes, a DSS for Channel Rehabilitation, may be more challenging and less useful.

5. **Recommendation: Refine monitoring and adaptive management efforts**

   Responsiveness to recommendation:

   Although there has been a great deal of informal learning and sharing of relevant experience among the different design teams, there has been relatively little documentation of these lessons learned. Field discussions with some of the design group members indicate that some members routinely visit prior sites. The frequency or timing of these visits has not been routinely documented.

   An excellent post-project appraisal was conducted on the Sheridan Creek / Deep Gulch project following an "emergency" response to concerns regarding bank erosion and site changes. However, this effort was conducted outside of any routinely compiled planning process, s (Gaeuman et al 2021). Unfortunately,this kind of comprehensive post-project appraisal has not been conducted for most sites, and the lack of such evaluations limits formal adaptive management ability.

   The detailed LiDAR topography and bathymetry surveys collected approximately every five years may provide an excellent basis for quantifying and evaluating channel changes in response to restoration projects, gravel augmentations, and high flows. However, standard practices for using these data sets to evaluate project evolution and performance have yet to be developed and implemented.

   Recommendations specific to channel rehabilitation project designs included:

6. **Recommendation: Continuing to design where possible to allow for dynamic alluvial processes**

   Responsiveness to recommendation:

   While this goal was not explicitly called out and emphasized in design documents reviewed, the Program's trend towards using success criteria such as topographic complexity and wetted width is consistent with design to encourage dynamic alluvial processes. Values for these success criteria have been calculated for recently completed projects. Explicit mention of model iterations related to alluvial processes such as erosion or aggradation was not obvious in design reports, so it is unclear to what level this is being completed.

   Many of the foundational documents of the ROD refer to the Program Reach as having "dynamic alluvial characteristics" or suggest a management goal of achieving "dynamic alluvial characteristics." However, as noted by Buffington et.al. (2014) and interviewees from this process, the classification of the Program Reach as truly alluvial is likely not appropriate. The understanding of the geomorphic processes of the Trinity River has evolved over the past two decades as projects have been implemented and results observed. There is now widespread recognition that many parts of the study reach are not truly alluvial, as a result of changes in grain sizes resulting from dredger mining, reduced high flows by upstream dams, lack of sediment load, and frequent bedrock outcrops. In general, the river becomes more alluvial in character with distance downstream of Lewiston Dam, as tributaries join, bringing in their floodwaters and sediment.

7. **Recommendation: Use models of channel morphodynamics, flow-habitat relationships, and fish production to inform designs**

Responsiveness to recommendation:

Channel Morphodynamics. From review of design reports, it appears that modeling using SRH-2D is routinely used to provide some evaluation of potential geomorphic changes following construction as a component of project design, often using competence-based evaluation approaches. The competence-based evaluations typically inform potential erosion or deposition and associated channel adjustment and evolution. However, though substrate data (e.g., pebble counts, test pits) at the project scale exists, the connections between model parameterization/results of these approaches and these substrate data are often not explicitly made in design documentation. It was also not clear from the design documentation the degree to which the modeling tools are being utilized during the design process as an iterative design tool to identify and refine rehabilitation elements, but this may simply be a detail that is not commonly reported.

Flow Habitat Relationships. The SRH-2D models appear to be commonly used to support quantification of flow-aquatic habitat relationships associated with proposed designs. Recent design reports regularly include quantification of changes in habitat availability predicted under proposed designs. The metrics used to characterize viable habitat vary across the reports, but this may be a result of larger evolutions in how suitable habitat is defined, analyzed, and represented (see below *Fish Production*).

Quantifications of increased habitat availability are typically based on the proposed design. The potential for change in the constructed project is generally represented and encouraged as a means to sustain and reinvigorate viable habitat. The balance (and potential change) in the increased habitat availability as a result of project evolution is generally acknowledged but is not typically qualitatively characterized or quantified in design documentation. This is not uncommon in the field, but future discussion may be warranted about a viable method to predict the change in the restored habitat availability over time based on expected/evaluated project evolution.

In addition, a more detailed description of the ecological significance of the flow levels modeled and analyzed would be valuable. For instance, relationships between flow and riparian habitat and native vegetation appear to be less uniformly addressed in project design reports.

Fish Production. The term "fish production" is not explicitly defined in this recommendation and therefore it is somewhat difficult to quantify. Review of design documentation and interviews suggest that forecasting of suitable fish habitat (e.g., Area under the curve of streamflow to rearing habitat curves) was being used to forecast habitat uplift and evaluate post-project performance. Even more recently, fish capacity has been adopted as a program standard for all projects based upon a recommendation from the Fish Workgroup in 2020. Both metrics satisfy the assumed intent of using “fish production” to inform designs.

Additional suggestions for how to better address this recommendation in Phase 3 are provided in Section 5.

8. **Recommendation: Review the synergistic effects of channel rehab and the other management activities on fish production**

   Responsiveness to recommendation:

   A synthesis report evaluating the physical juvenile habitat capacity of the 40-mile Program Reach was completed in August 2022 (Cooper-Hertel et al.). The document was an interagency and interdisciplinary collaboration by the Yurok Tribe, Hoopa Valley Tribe, and US Fish and Wildlife Service, which yielded actionable recommendations for channel rehabilitation design and flow management to further increase fish production.

   Additionally, efforts to tie fish production to TRRP actions have been conducted, though interviewees noted many challenges with this. One factor mentioned during interviews is staggered schedules or time lag between the fishery investigations and conclusion of outcomes, and the channel rehabilitation design and implementation schedules, which tend to be on a relatively more rapid timeframe. This lag or difference in timing has resulted in challenges to effective integration of the learning from the fishery investigations into project designs.

9. **Recommendation: Better quantify the response time for creating desired channel conditions and fish populations as a result of channel rehabilitation actions**

   Responsiveness to recommendation:

   Design documentation for Channel Rehabilitation projects suggests temporal evolution on time-based terms “immediately” and “long-term”, but those are not operationally defined. Also as noted elsewhere, suitable fish habitat and fish habitat capacity are being used to predict project response immediately post-implementation, but these are not explicitly tied to any additional anticipated responses at a longer timescale beyond post-project. Notably, the recommendation for response time is also not related to hydrologic, geomorphic, or biologic thresholds or conditions.

4.1.3 Responsiveness to Phase 1 Recommendations (both CH2MHill & Entrix 2010 and Buffington et al. 2014) at the project scale

TRRP Phase 2 restoration projects began in 2012 and continued through 2022 (Table 10). As a part of this Phase 2 review, a table which rates and comments on the effectiveness of all Phase 2 designs at incorporating these recommendations was developed and is included in Appendix A. The evaluation presented in Appendix A is limited to information readily available in the project's design documentation found on the TRRP data portal.

In most cases, projects effectively incorporated recommendations regarding maximizing habitat immediately following restoration actions throughout Phase 2, and in the few cases where this recommendation was minimally incorporated justification of this choice was provided. Recommendations regarding the inclusion of dynamic elements which may sustain, or trigger future restorative outcomes were incorporated well in some designs, adequately in others, and, in some cases, these elements were not included and/or the decision to not include them was not well documented. Design processes that effectively implemented hydraulic, morphodynamic, and habitat modeling generally were better able to describe the longevity, response conditions, and response times associated with their designs, though Phase 2 design processes implemented and communicated these analyses with varying degrees of efficacy.

Descriptions of how design teams engaged the public and incorporated feedback from the public, stakeholders, and project partners varied wildly from project to project. It was often difficult to compare the approaches used to elicit and incorporate external feedback in the design process between different designs. Regular discussion on how this information was considered or how it influenced design should be a regular part of reporting.

Table 10. TRRP Phase 2 Restoration Projects and implementation dates or date ranges.

Year	*Project Name*
2012	Lower Steiner Flat
2012	Upper Junction City
2013	Lower Douglas City
2013	Lorenz Gulch
2014	Lower Junction City
2015	Upper Douglas City
2015	Limekiln Gulch
2016	Bucktail
2017	Deep Gulch
2017	Sheridan Creek
2019	Chapman Ranch Phase A
2020	Dutch Creek
2021	Chapman Ranch Phase B
2022-2024	Oregon Gulch

4.2 THE DEGREE TO WHICH THE PROJECTS AS IMPLEMENTED MEET THE STATED DESIGN OBJECTIVES OF THE PROJECT

Because data collection was outside the scope of this effort and systematic monitoring reports at a project scale that are explicitly tied to a project's design criteria are not readily available, the panel is unable to provide a satisfactory answer to this question. However, it is apparent that while the fishery numbers are improving, the TRRP is falling short of the Congressional Statutory requirements to "[restore and maintain] the Trinity River anadromous fishery resources to pre-dam levels." The ROD does note that the AEAM Management Action, guided by the TMC, are to be used to ensure this restoration, which places a critical emphasis on the AEAM program. The ROD outlines tools available to the AEAM Management Action to meet this goal, such as possible adjustments to the annual flow schedule within the designated flow volumes that may be able to improve this trend. This will be discussed in more detail in the subsequent Recommendations Section.

5. Recommendations for Phase 3

For the purposes of this effort and these recommendations, it was assumed that no changes to the ROD shall occur. Recommendations are binned into three categories: Management Actions, Programmatic & Operational, and Public Engagement.

MANAGEMENT ACTIONS

Recommendation 1: Continue to Refine Flow Management using Best Available Science. Long term interdisciplinary and interagency cooperation on the Flow Working Group has led to commendable advances throughout the course of the ROD. These advances include the Winter Flows Variability proposal (Abel et al. 2022), which was formally adopted in 2023. While the supporting research and science-basis suggests this will move the TRRP closer to achieving its goals, it is recommended the program closely monitor the impacts of this proposal and continue to pursue further refinement of the flow release schedule as part of the Program's Adaptive Environmental Assessment and Management (AEAM).

More specifically, it is recommended that the Program continue to make progress towards an annual flow release schedule that more closely emulates the Trinity River's unimpaired flow regime. Additional potential refinements to explore include (1) reducing and providing more variable summer base flows to support unimpaired riparian and emergent vegetation; (2) integrating fall freshets; and (3) increasing winter base flows. We also recommend TRRP further explore the following questions/ideas posed by interviewees, which may help influence future AEAM flow recommendations:

1. Explore using environmental triggers, behavioral data, and life history strategy timing for flow changes as opposed to calendar dates (e.g., flow changes when juveniles leave the system).
2. Complete a spatial habitat suitability analysis of low flow differencing to understand if flow reductions are drying out redds or if this is a perceived issue (e.g., wetted width and depth throughout the Program Reach at a range of lower possible flows such as 450 cfs, 150 cfs, 100 cfs).
3. Continue conversation with the fishing guides/whitewater community to identify times when flow reductions closer to historical base flows may be less impactful to businesses (i.e., after kids return to school, when tourism drops during fire season).[2]

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[2]While we acknowledge that the ROD and TRRP are not tied to the recreational industry's uses of the Program Reach, there is a general desire by all involved to maximize beneficial uses for all stakeholders in the Program Reach.

4. Develop a deeper understanding of how lower or variable summer baseflows may alter the vegetation communities (HVTFD and MA 2021), particularly if an increase in emergent vegetation may be beneficial for juvenile rearing and these flows would help ameliorate riparian vegetation encroachment.
5. Explore amplifying high flows by coupling flow releases with tributary snowmelt peaks.

In addition to flow volume and timing, flow management to improve temperature-related aspects should be evaluated, particularly in light of the impacts of climate change on water temperatures and precipitation patterns. Recent studies indicate that cold pool releases from Trinity Lake are resulting in temperatures in the Trinity River that are lower than optimal for robust juvenile salmonid growth and development (Buxton et al. 2022, Cooper-Hertel et al. 2022). To understand how current water temperatures compare to the unregulated temperature regime and the associated impacts on bioenergetics and juvenile salmonid growth, it is recommended that water temperature be monitored in the Trinity River upstream of Trinity Lake in addition to the downstream reach. It is also recommended that the feasibility, cost, and benefits of modification of the Trinity River Diversion to enable temperature-controlled releases are evaluated.

Lastly, it is recommended that the Programmatic aspects of flow management should be revisited, in particular the Trinity Management Council's (TMC) veto authority over flow release schedule. The TMC does not hold similar power over other TRRP management actions and continued TMC control of the flow release schedule may result in decision-making that does not utilize the best available information.

Recommendation 2: Plan Additional Channel Rehabilitation Activities in Broad Alluvial Valley Reaches.

As noted previously, the science and practice of river restoration (here, Channel Rehabilitation) and the understanding of the Program Reach has advanced considerably since the passage of the ROD. Review of the performance of past projects has yielded insights that should serve to improve future project designs and ongoing management (Hoopa Valley Tribal Fisheries Department and McBain Associates. 2021). As a result, significant opportunities exist to improve and enhance the Trinity River ecosystem in reaches where earlier channel rehabilitation activities have been performed. Recognizing this, and under AEAM justification, it is recommended that additional channel rehabilitation projects be planned in areas where earlier program projects (e.g., "feathered edges") have already been implemented and where there remains an opportunity to "Act Big" (CH2MHill and Entrix 2010). Our understanding of AEAM suggests these actions are justifiable until the Program reaches its goal of "[restoring] and [sustaining] natural production of anadromous fish populations in the Trinity River to pre-dam levels" (defined as 60,000 returning adults (USFWS and HRVT 1999)).

The additional channel rehabilitation actions should vary by geomorphic context and achievable restoration targets within the Program Reach (see Recommendation 3) and be reflective of advances in the science and practice of river restoration. In the more alluvial, less confined, sub-reaches, projects should target dynamic floodplain reconnection type of actions. In all geomorphic contexts, there is an opportunity to increase the amount of large wood supplementation, with the function and anticipated benefits of the wood varying with the geomorphic context.

Planning of this work should include development of a geomorphic prioritization framework (see Recommendation 3). Additional planning-level tools such as spatial analysis of ownership and relative surface height above river level should be leveraged to help prioritize revisiting restoration sites.

Recommendation 3: Identify and Implement Additional Gravel Augmentation Sites.
To date, gravel augmentation along the Trinity has been limited by suitable sites to add gravel, and gravel availability, as reflected in area of mobile gravel bars, is highly variable. While some reaches have sufficient supply, or even over-supply, others remain sediment starved, such as approximately RM 104 - RM 96 (Grass Valley Ck to Indian Ck) (McBain Associates 2015). Active gravel bar mapping and analyses relating habitat availability to presence of active gravel bars (McBain Associates 2015, Hoopa Valley Fisheries and McBain Associates 2022) have documented better habitat in the reaches with active gravel bars. Thus, further gravel augmentation seems justified, but better distributed along the river.

We recommend that TRRP prioritize developing new gravel augmentation sites (beyond the five currently active sites) in locations that can help to increase supply in currently starved reaches, and we are pleased to see TRRP's proposal for nine new sites this year. We recognize establishing new augmentation sites is challenging, as TRRP needs sites that are on public land or otherwise accessible by the program, either a source of gravel such as dredger tailings or an area in which to stockpile gravel, and good road access (for stockpile site, preferably avoiding haul routes that traverse residential areas to the extent possible). We note that TRRP has proposed to begin using additional sites for augmentation, as detailed in a recent document *New Gravel Augmentation Sites Proposed for 2023* (*TRRP: Gravel augmentation sites* n.d.). Up to nine new sites are identified as potential augmentation locations. These new sites should go a long way towards mitigating the sediment starvation evident in some reaches of the river. As new augmentation sites are implemented, their effectiveness could be gauged in part by increases in active gravel bar area, as could be measured in follow-up studies to the McBain Associates 2015 analysis. We recommend that the Physical Workgroup take up the question of additional gravel augmentation and appropriate grain sizes. It seems the key priority is securing additional sites for augmentation to benefit reaches that have been in the large gaps between existing augmentation sites.

Recommendation 4. Tie Project Goals and Objectives to Geomorphic Setting.
The benefits of restoring dynamic channel processes (and their attendant ecological benefits) are widely acknowledged. However, the opportunity to achieve a desirable degree of dynamism is more feasible in some reaches of the river than others. Wide alluvial bottomlands (i.e., laterally unconfined reaches) provide more potential to restore laterally migrating channels and frequently occurring overbank flows than laterally confined valleys. Given these differences, we recommend that a project's goals and objectives be tied to its geomorphic setting and that the Program formally adopt agreement of geomorphic reaches. We then recommend that applicable project action types,

design objectives, and success criteria be tied to, and appropriate for a given reach's geomorphic setting.

This recommendation could be achieved through formal adoption of one of the prior "Anticipated Channel Pattern" efforts (HVT et al. 2011, Beechie et al. 2012, Buffington et al. 2014, Gaeuman et al. 2016) or by binning project sites with breaks at geomorphic thresholds that influence channel type such as valley width, slope, stream power. A conceptual example of how restoration strategies are influenced by valley width is provided below in Figure 16 (with restoration strategies adapted from Kondolf 2011). This figure plots projects on a two-dimensional field of relative stream power (y-axis) and alluvial bottomland width (x-axis), with previously and proposed Channel Rehabilitation projects plotted.

With a wider unconfined bottomland area available, and with sufficient stream power to mobilize sediments, there is greater potential to have dynamic channel processes such as meander migration, bank erosion and point bar deposition, and secondary channel development. For example, in these reaches, geomorphic-forcing log structures can be used to direct flow into banks to encourage bank erosion, such that dynamic stream processes create habitat during high flows. Structures built as part of the Chapman Ranch project nicely illustrate this approach, with erosion of outside bends (and scouring of deep pools, etc.) resulting from the structures. This approach is an example of 'prompted recovery', wherein the actual restoration is done by the river itself during high flows, and the structures are 'prompts' or guides to direct river energy to restore complex habitats (Downs and Gregory 2014). For such process-based restoration, our expectations need to be tempered by an understanding that habitat results are not immediate upon completion of construction but will occur over time as high flows interact with structures (Ciotti et al 2021), which places greater importance on event-based monitoring of channel habitat improvement. These restoration strategy types can then be tied to appropriate action types and project objectives (Table 11). We recognize the presence of dredge spoils alters development and adoption of this framework, as they render the river incapable of prompted or indirect recovery in many cases, and should also be included in framework development.

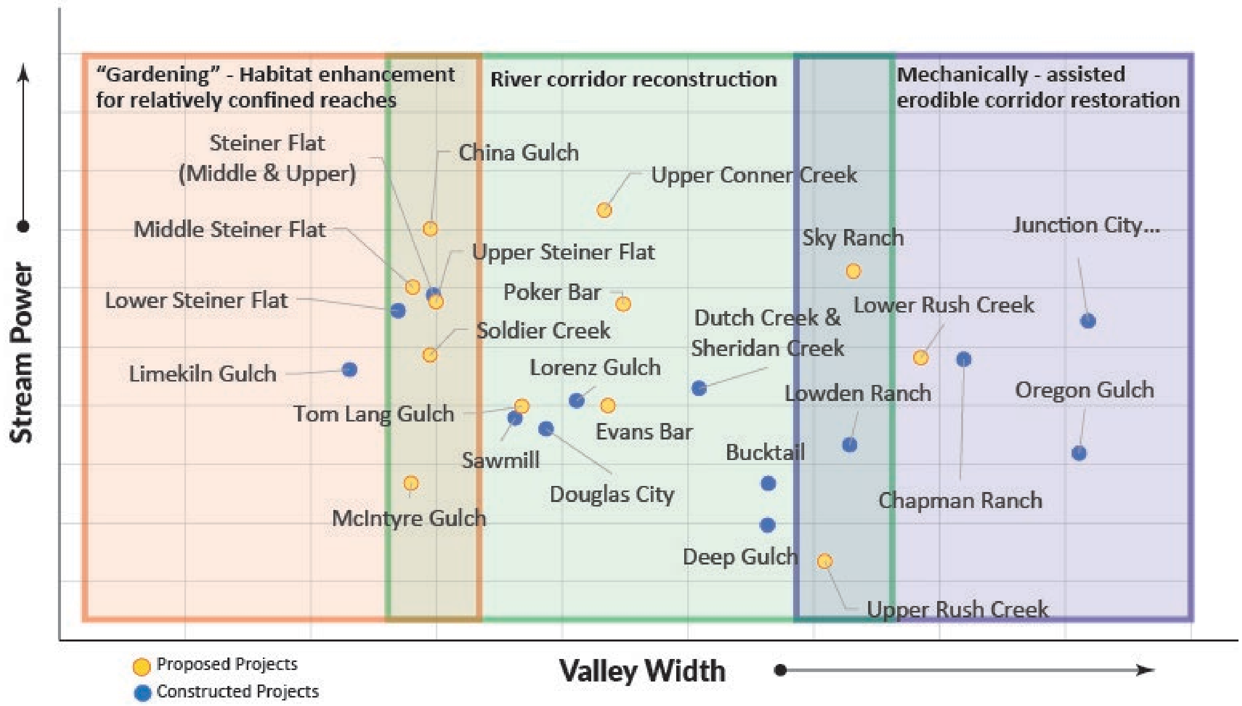

Figure 16. A conceptual framework for developing applicable restoration strategies for different geomorphic settings. Project restoration actions and objectives should vary by and be appropriate for their geomorphic setting.

Table 11. A conceptual example of how restoration strategy types can be binned by geomorphic setting, and then tied to appropriate action types and project objectives for that geomorphic setting.

Example Restoration Strategy Type	***Example Geomorphic Setting/thresholds***	***Example Applicable Actions***	***Example Project Objectives***
"Gardening" –- Resilient Habitat Features	Laterally confined	Wood-forced pool morphology Gravel augmentation Habitat large wood structures Construction of floodplain surfaces active during target juvenile rearing flow periods	Increase wood abundance by a target % Increase heterogeneity of habitat through construction of features to create cover, induce scour, etc. Increase marginal shallow-water, low velocity habitat for juveniles Increase local alluvial storage adjacent to placed structures
River Corridor Reconstruction	Partially confined	Side channel construction Habitat large wood structures Channel re-meandering	Increase availability of suitable depths/velocities for Chinook spawning Increase wood abundance by a target % Replace "bowling alley" channel geometry with complex channel geometry
Erodible Corridor–-Dynamic Floodplain Reconnection	Laterally unconfined Slope <1.5%	Geomorphic-forcing log structures (apex jams, meander-forcing jams) Floodplain roughness	Increase the proportion of the valley bottom occupied by channels and that is geomorphically active Increase geomorphic heterogeneity Increase ecological heterogeneity (e.g., Simpson's Diversity Index) Pieces of large wood/acre

Recommendation 5: Update the Channel Design Guidelines and Make it a Truly Living Document; with Special Considerations Given to Programmatic Goals and Design Criteria. Channel Rehabilitation Design Guidelines (CRDG) were developed in 2011 (Hoopa Valley Tribe et al. 2011) with the goals of supporting, unifying, and improving ongoing channel rehabilitation activities. The goal of the CRDG was to establish common design criteria and restoration strategies. The document authors recognized that design approaches would continue to evolve as new information, ideas, tools, and techniques became available and it was therefore intended to serve as a "Living Document".

Many recommendations within the CRDG have been supported by the post-project appraisals of individual feature effectiveness undertaken by the Hoopa Valley Tribal Fisheries Department and McBain Associates (2021), and such assessment of project effectiveness over time can serve to improve the CRDG into the future. With this in mind, the CRDG authors recommended that the appropriate TRRP technical workgroups lead evaluation of new and emerging rehabilitation design approaches/elements prior to implementation. This evaluation would ensure that each new design element or design approach would be (1) applicable to the Trinity River, (2) able to meet the goals and objectives of the ROD, and (3) consistent with any other changes in the programmatic approach to restoring Trinity River habitats. It was intended that following evaluation of the new design approach/element, a technical memorandum describing the design approach/element and associated methodology would be prepared and added to the CRDG. While several emerging technologies and practices have begun to be implemented within TRRP projects, the CRDG has not been updated and the new practices are not uniformly understood, embraced, or implemented.

We recommend that the CRDG be updated to current practices, and a renewed commitment be made to managing the guidelines as a living document. Providing the design teams with current and uniform design guidance should improve the likelihood that programmatic goals, objectives, design criteria, and design practices are integrated evenly across the entire program.

Recommendation 6: Provide Increased Programmatic Support for Management of Vegetation. Floodplain and emergent vegetation provide documented benefits for salmonids, particularly for juvenile rearing habitat. The importance of vegetation has received substantial attention since the passage of the ROD (e.g., Katz et al. 2017, Limm et al. 2009, Jeffres et al. 2008; Sommer et al. 2001). Vegetation slows water velocities, provides shelter from predators, and supports abundant aquatic and terrestrial food sources. These factors contribute to greater growth rates for fish utilizing floodplain and off-channel habitats compared to mainstem habitats, particularly during seasonal high flows (e.g., late spring freshet). Some studies indicate that these larger-sized juvenile fish show increased survival to adult life stages and greater success in returning to natal freshwater habitats to spawn (Unwin 1997, Hayes et al. 2008, Sommer et al. 2001). While management actions in the ROD include reference to revegetation, if the ROD were written today, it most likely would have integrated Revegetation and Vegetation Management as a standalone management action.

Within the ROD framework, revegetation is typically considered a subset of Channel Rehabilitation. Despite this secondary classification, the innovations and increasing successes of TRRP's revegetation efforts have demonstrated important benefits for salmonid habitat and have provided a living laboratory for the broader restoration industry concerning revegetation in harsh environments.

Based on advancements in the literature and the successes documented by prior revegetation efforts, we recommend that Riparian Revegetation and Management be programmatically reframed as a standalone long-term management and stewardship action to further elevate its importance. It is expected that this would provide additional funding for longer-term stewardship of the Program Reach to promote ecological plant succession that is not currently supported by river processes. For example, this could include targeted alder thinning, invasive species removal, and successional planting and management to support a thriving riparian corridor in support of the ROD objectives. These actions should however be informed by an updated evaluation of the current riparian berm condition (as recommended by HVTFD and MA 2021) and continued work on understanding target design surface elevations where juvenile fish use overlaps with riparian shrub and/or emergent vegetation communities. Elevating the importance of the Riparian Revegetation and Management in this way would allow the TRRP to build upon the significant gains that have already been made with respect to revegetation.

Recommendation 7: Standardize Basis-of-Design Reports.
We recommend that TRRP require all design teams to follow a standard basis-of-design report outline. Currently, design is being done by a variety of groups and the content and level of detail of design reports varies widely by design team. While a current draft document has begun to outline appropriate content, it needs additional work and approval. For large programmatic restoration efforts (such as the TRRP), programmatic-level guidance on a standard basis of design report template can help ensure a more standard level of design due diligence. Further, offering a TRRP-approved outline to use as guidance for each project-level Design Justification Report could ensure overall program goals and objectives are addressed at the site-specific scale.

It is recommended that a standard basis-of-design report:

1. Clearly links fish use (e.g., timing, life stage), vegetation (e.g., targeted community type), and hydrology (e.g., discharge, duration of inundation) to each design feature.
2. Documents connections between sediment data and morphodynamic modeling (for relevant design flows) and how these connections influence or ensure the desired geomorphic trajectory as well as the desired vegetative succession of a project site.
3. Links large wood availability to vegetative trajectory (i.e., will periodic large wood placements be required to mitigate for absence of large wood recruitment due to vegetative senescence on the site or lack of upstream sources?).

We also recommend that once programmatic-level success criteria are adopted, that standard design reporting includes how various design elements relate to these criteria. This will better ensure that the design meets the objectives for the programmatic goals.

Recommendation 8: Standardize and Adopt Post-Project Appraisals.
It is recommended that TRRP also adopt a standard post-project appraisal protocol and that those efforts are documented. Post-project appraisals should be tied directly to the objectives and design criteria articulated in the design report, as described above. The appraisal should allow reviewers to easily understand: "Have implemented changes responded to time and flow occurrences in a manner that is consistent with design expectations of project trajectory?" (Kondolf 1995, 2000). This would allow for designers to more easily document and distill "lessons learned" to guide the next

design. Post-project appraisals should be easily repeatable and focus on factors relevant to design. It is important that these appraisals do not become so onerous that they cannot be published with sufficient lead time to inform subsequent design efforts. Post-implementation monitoring programs implemented by organizations such as Sonoma Water on Dry Creek may provide examples of systematic approaches that are implemented with a standardized method that could be considered for adaptation to the specific needs of the TRRP (Porter et al. 2014).

The frequency between each post-project appraisal event should be tied to the anticipated design performance of various design components. For example, appraising desired vegetative colonization, growth or community successional maturation might be done annually while determining performance of desired changes in channel morphology might follow a specified sediment mobility event. This approach allows project performance to be tied to events that are appropriate to performance expectations, rather than a rigid schedule tied to a calendar, which may result in unnecessary and uninformative monitoring results. Additionally, if the design calls for adaptive measures to be used if project performance objectives are not being met, the post-project appraisal can serve as justification for future Adaptive Management (Downs and Kondolf 2002).

PROGRAMMATIC & OPERATIONAL

Recommendation 9. Facilitate Regular Integration between Science Work Group and Design Group.

The science and practices supporting each of the TRRP management actions, in particular Channel Rehabilitation, are inherently interdisciplinary. Effective management actions are reliant upon experience and expertise from many integrated disciplines, including fisheries biology, geology, fluvial geomorphology, riparian and aquatic ecology, hydrology, hydraulic and design engineering, and construction management. This multitude of necessary disciplines requires true interdisciplinary collaboration to inform the most effective and innovative actions. These fields should be effectively contributing to the work at each phase of the design and implementation program (assessment, conceptual design, preliminary design, final design, implementation).

During the retrospective evaluation, interviewees noted a growing disconnect between the Science Work Groups and the Design Group. This was partly attributed to the COVID-19 pandemic and partially attributed to differing timescales between deliverable work cycles between the design teams and Science Workgroup (e.g., 18 months vs. 3 to 5 years). In particular, Design Group members felt that useful information from the Science Work groups was offered too late or too infrequently to be useful in the design process. It was also noted in interviews that while some meetings can be effectively held virtually, meetings such as purpose-driven collaboration are less effective and less truly interdisciplinary when they occur virtually. Interviewees recalled that more frequent in-person design charrettes and field tours were highly beneficial for the exchange of ideas.

Given this feedback, it is recommended that TRRP host facilitated in-person interactions at established regular intervals (e.g., quarterly, semi-annually), or key increments of project design phases (e.g., conceptual design, preliminary design, draft final design). It is also recommended that each design team have input from most if not all of the relevant disciplines noted above. This would allow the TRRP to more effectively tap into the incredible depth and breadth of knowledge and experience across staff. Key to these collaboration opportunities is effective pre-meeting planning to make the in-person time most impactful. This includes pre-planning the meeting purpose, objectives, and creating a facilitation plan. This planning shouldn't be onerous but will allow the TRRP to more effectively capture input and expertise from participants who may have a range of communication styles. In the absence of facilitation, those who are more extraverted and/or those with longer standing in the program may dominate the conversation.

Recommendation 10. Formalize and Improve Mentorship in the Program to Mitigate the Potential Future Loss of Institutional Knowledge.

The depth and breadth of knowledge of the TRRP is bolstered by the long tenures of the staff who work under the TRRP umbrella. In many instances, staff have worked as part of the TRRP since the program's inception and/or completed their Masters and/or PhD work on the Program Reach. While this is a tremendous asset for the program, the potential loss of institutional knowledge can also pose an immense challenge and risk for the future of the program. This challenge is exacerbated by the fact that many skills required to effectively carry out the Program's management actions are nuanced and learned with experience, and not effectively taught in most educational programs (e.g., construction oversight, design surface iterations, and/or permitting strategies).

The depth and breadth of staff institutional knowledge in any restoration program/practice is tremendously difficult to effectively capture, even with the most diligent record keeping. In the worst case, once a person leaves the program, any knowledge not formally captured is effectively gone. Given this challenge, it is recommended that the TRRP formalize an apprenticeship-style mentorship program. This could be initiated with new staff, who are assigned a mentor based upon a shared discipline and then expanded to other recently hired staff in time. A formalized mentorship program can open up a two-way exchange of knowledge that can benefit the TRRP. Knowledge exchanged in this mentorship program between more tenured staff and newer staff. Tenured staff would be able to share applied skills learned on the job that are applicable to TRRP activities while newer staff could share advancements in tools, technology, and methods from outside academic or professional careers that may be incorporated into the TRRP. Transition planning may include, whenever possible, a minimum overlap of one project cycle (e.g., conceptual design through construction) for the outgoing and incoming staff.

Recommendation 11. Find Ways to Incorporate Lessons Learned From Other Regions to Improve Diversity of Thought.

While there are location-specific factors that inform the TRRP Management Actions, many of the tenets of the design and management practices that the TRRP is undertaking are similar to those being applied to restoration of other river systems along the West Coast. TRRP is fortunate in having long-tenured program staff with deep knowledge of the Trinity River system. This site-specific expertise could be augmented by exchanges with other restoration programs with some overlap in scope and objectives. While inviting external review (e.g., this report) is useful, regular peer-to-peer interaction with other external programs may provide effective knowledge growth and enable leveraging of lessons learned on a more frequent interval.

Given this, it is recommended that the TRRP consider identifying project sponsors or river restoration programs elsewhere with whom to regularly exchange ideas and lessons learned. This could invoke a "Sister City" type model. Ideas for exchanges include field tours or joint program symposia (e.g., short project presentations, pop-ups, discipline-specific breakout sessions), among others. Obvious examples of suitable analogue river restoration programs include programs on tributaries to the Columbia River—where similar salmonid species are the target for restoration) — and the Platte River restoration program—which involves restoration for very different species and habitats—but whose large scale and involvement of the U.S. Bureau of Reclamation could yield some valuable comparisons. Closer to home, the Clear Creek restoration program shares some goals and approaches with TRRP especially in the combination of gravel augmentation and physical interventions (though it is very limited in terms of flow releases possible), so exchanging experiences with the Clear Creek program would seem a logical step for TRRP.

PUBLIC ENGAGEMENT

Recommendation 12. Shift the program and public narrative to reflect that the severely managed flow regime and the magnitude of legacy impacts require a shift in the scale of program actions, along with the need for ongoing and future management of the landscape.

The science basis and understanding of the biogeomorphic processes of the Trinity River have evolved and deepened since the passage of the ROD. When the ROD was passed, the working hypothesis was that the river could "heal itself" following some small or moderate scale mechanical interventions. Today, as the understanding of the scale, extent, and nature of human alteration (and the associated past and perpetuating environmental responses along the Trinity River corridor has expanded) perspectives on this restoration hypothesis have evolved.

Based on the interviews and research supporting this review, it is evident that larger scale interventions are needed to achieve effective restoration. It is also expected that ongoing adaptive management will be required to attain long-term sustained restoration.

We recommend that the TRRP implement internal and external outreach to modernize the narrative regarding the scale and sustained requirements of effective restoration strategies. While altering the narrative to reflect the need for sustained adaptive management may be challenging, reframing the conversation towards sustained management due to ongoing alterations may help the Program move more closely towards its goals.

Recommendation 13. Incentivize Landowners to Participate in Projects.

The density and impacts related to private lands vary throughout the Program Reach, but the limitations imposed by working on and around these lands were noted as part of interviews. Providing incentives to private landowners has proven an effective mechanism to work on at least some private lands within the Reach but appears to be done on an ad-hoc basis.

While there are likely programmatic barriers related to a Federally sponsored landowner incentive program, developing this type of program may help motivate broader program participation by private landowners. Incentives for these types of programs can vary but most frequently include tax incentives and services provided to the landowner. Examples utilized by other programs include Channel Migration Zone Easements (e.g., Montana Freshwater Partners), forest health/fuels reduction thinning (wood/slash can then be incorporated into restoration projects), and flooding easements. It is acknowledged that the challenges to setting up a landowner incentive program are many, and include but are not limited to: financing, marketing to match demand with supply, knowledge of management gaps, standardized metrics, monitoring, and timing.

Related to landowner incentive programs, development of Safe Harbor Agreements for private landowners within the Trinity River basin may help encourage participation. This may help mediate some potential fear felt by private landowners related to participation in a Federal Program. A Safe Harbor Agreement (SHA) is "a voluntary agreement providing regulatory assurances to private property owners whose actions contribute to the recovery of species listed as threatened or endangered under the Endangered Species Act (ESA)" (NOAA 2019). This agreement provides an exchange where the landowner adopts conservation practices that contribute to the recovery of ESA-listed species on private lands but receives formal agreement that the agencies will not impose any additional land use restrictions without their consent. Additionally, at the end of the agreement term, the landowner may return their property to the pre-agreement condition if desired (NOAA 2019).

Recommendation 14: Continue Pursuing Incremental Progress on Engagement Spectrum.
Our observations suggest that staff under the TRRP umbrella are welcoming, collegial, and professional. We understand that proactive efforts are made to involve the public in the Program. The efforts include an open-door policy at the central office in Weaverville, "Science on Tap" events, convening the quarterly TMC meetings open to the public, convening public meetings and events (including targeted individual outreach to stakeholders to encourage attendance), and providing public comment periods for all permitted activities (Pickard et al. 2022).

However, when contemplating how to further instill public ownership and foster engagement in the TRRP, many of the existing engagement strategies put the onus on stakeholders, not the Program. It is also acknowledged that most TRRP staff have backgrounds focused on scientific and engineering, not outreach and engagement. The current approach to TRRP outreach asks the public to review lengthy technically-written scientific documents, outreach events may not reach all audiences due to timing, location, or type of event, and relative to science and engineering staff, there number of staff and budget resources focused on outreach and engagement appears small. Public investment and ownership of Program successes may be enhanced by striving to go further along the engagement spectrum (Figure 17). Strategies such as hiring a trained meeting facilitator for TMC meetings, providing more accessible and concise information to the public (e.g., visuals and graphics, short videos, graphically-illustrated project concepts), diversifying the location, time, and type of outreach activity to engage with varied public interests and abilities, and funding a position for outreach outside of Weaverville, may all help improve engagement. However, we acknowledge that the academic training of the authors of this document is focused on river science and engineering not outreach and engagement. As such, we recommend that the TRRP consider reflecting on the outreach and engagement strategy through an external review and subsequently implementing the recommendations of that review.

The Spectrum of Community Engagement to Ownership

>>>> INCREASED EFFICIENCY IN DECISION-MAKING & SOLUTIONS IMPLEMENTATION >>>> EQUITY

STANCE TOWARDS COMMUNITY	Ignore	Inform	Consult	Involve	Collaborate	Defer to
IMPACT	**Marginalization**	**Preparation or Placation**	**Limited Voice or Tokenization**	**Voice**	**Delegated Power**	**Community Ownership**
COMMUNITY ENGAGEMENT GOALS	Deny access to decision-making processes	Provide the community with relevant information	Gather input from the community	Ensure community needs and assets are integrated into process & inform planning	Ensure community capacity to play a leadership role in decision-making and the implementation of decisions.	Foster democratic participation and equity through communitydriven decisionmaking; Bridge divide between community & governance
Message to community	***Your voice, needs & interests do not matter***	***We will keep you informed***	***We care what you think***	***You are making us think, (and therefore act) differently about the issue***	***Your leadership and expertise are critical to how we address the issue***	***It's time to unlock collective power and capacity for transformative solutions***
Activities	Closed door meeting Misinformation Systematic Disenfranchisement Voter suppression	Fact sheets Open Houses Presentations Billboards Videos	Public Comment Focus Groups Community Forums Surveys	Community organizing & advocacy Interactive workshops Polling Community forums Open Planning Forums with Citizen Polling	MOU's with Community-based organizations Citizen advisory committees Collaborative Data Analysis Co-Design and Co-Implementation of Solutions Collaborative Decision-Making	Community-driven planning and governance Consensus building Participatory action research Participatory budgeting Cooperative models
Resource allocation rations	**100%** Systems Admin	**70-90%** Systems Admin **10-30%** Promotions and Publicity	**60-80%** Systems Admin **20-40%** Consultation Activities	**50-60%** Systems Admin **40-50%** Community Involvement	**20-50%** Systems Admin **50-70%** Community Partners	**80-100%** Community partners and community-driven processes ideally generate new value and resources that can be invested in solutions

Figure 17. Levels of community engagement to ownership. Currently, TRRP appears to operate mostly in "Inform" and "Consult" with opportunity to move towards "Involve" and "Collaborate" (Gonzalez 2022).

6. Recommendations for Channel Rehabilitation

The scope of this work included particular request for a focused review on the Channel Rehabilitation Process. Without being involved in an actual design process, information can be garnered only from design reports, interviews, and rapid site tours. Many of the recommendations provided above are relevant to Channel Rehabilitation and information provided below is intended to illustrate an overarching review of Channel Rehabilitation with specific actionable recommendations for design.

6.1 STRENGTHS AND WEAKNESSES OF THE DESIGN AND DESIGN REVIEW PROCESS

Based upon the methods described above, the following over-arching strengths and weaknesses of the Program's Overall Approach to Channel Rehabilitation are outlined below.

Design Process Strengths

- Design teams and the larger Design Group have a considerable body of knowledge and library of lessons-learned from implemented previous projects to draw from.
- Interdisciplinary and interagency collaboration on design development and refinement.
- Integration of state-of-the-science techniques in restoration design and engineering analysis.

Design Process Weaknesses

- Lack of updated programmatic guidance in Channel Rehabilitation designs.
- Potential lack of diversity of thought/input/lessons learned from other regions and a risk that institutional knowledge is not formally captured anywhere.
- Lack of uniform, regular integration and collaboration between the Science Work Groups and Design Group.

6.2 STRENGTHS AND WEAKNESSES OF THE PROGRAM'S OVERALL APPROACH TO CHANNEL REHABILITATION

Based upon the methods described above, the following over-arching strengths and weaknesses of the Program's overall approach to Channel Rehabilitation are outlined below.

Approach Strengths

- Robust data collection, remote sensing, survey, engineering and design capabilities.
- Programmatically thinking big and acting big where possible.
- Interdisciplinary and interagency collaboration on design development and refinement.
- Integration of state-of-the-science techniques in restoration design and engineering analysis.

Approach Weaknesses

- Inconsistent definition of success criteria.
- Inconsistent performance monitoring and design reporting (largely between the different design teams).
- Missing documentation that links fish life stage, flows, and vegetative community, and how these linkages inform design.
- Use of large wood structures that is more conservative (in some cases) than stream restoration industry standards (e.g., American Whitewater 2012) require.

6.3 RECOMMENDATIONS TO IMPROVE CHANNEL REHABILITATION DESIGN

Based upon the methods described above, and the strengths and weaknesses outlined in Sections 6.1 and 6.2, the authors of this report were asked to provide specific actionable feedback to improve Channel Rehabilitation design and the design process. It should be noted that our recommendations listed above Section 5 outline a number of recommendations that are relevant to channel rehabilitation. Most notably, these recommendations include:

1. Making clear linkages between geomorphic trajectory/setting and project objectives and design criteria,
2. More clearly linking fish use, hydrologic timing, and geomorphic trajectory to inform designs (As originally recommended by Buffington et al. 2014)

While it is our understanding that these items are discussed by the individual design teams and the Design Workgroup, more explicitly stating and describing them in design reporting will ensure that these disciplines are being connected throughout the design process and that management actions are clearly linked to design criteria.

In addition to these items, the area where we see the most significant opportunities for growth in Channel Rehabilitation design is related to the use of large woody material (LWM). Accordingly, we have provided the following detailed and actionable recommendations for how the TRRP can improve its use of LWM in project designs.

Recommendation 15: Increase Use of Large Wood Material in Projects.

The restoration practice of LWM restoration has evolved substantially over the same timeframe that TRRP channel rehabilitation projects have been implemented. In the late 1990s and early 2000s, placement of large wood in rivers was an emerging, novel restoration practice. By 2010, it had become a common technique in restoration of western rivers. Today, the importance of large wood in the river ecosystem, and in the field of river restoration, is well established in the literature. Numerous guidance documents are available that highlight the role and range of function of LWM in river restoration, as well as and provide extensive guidance on analysis, design, implementation, and monitoring procedures leading to successful LWM implementation. Restoration practitioners within the TRRP made significant contributions to one such document, the National Large Wood Manual (USBR & ERDC 2016).

On the Trinity River, Cardno Entrix & CH2MHill (2011) provided a comprehensive evaluation of the precedence and historical functions of LWM. That report also suggested goals, objectives, and criteria for increasing use of LWM in the Phase II channel rehabilitation projects. The use of LWM in TRRP projects appears to have been gaining prominence in recent years (Boyce and Goodman 2018). However, use of LWM has largely been focused on direct fish habitat creation in lateral habitats, with less emphasis on LWM implementation in mainstem locations and/or as geomorphic forcing features. LWM to drive geomorphic processes can enhance creation of, or provide stability to, complex aquatic and riparian habitats.

These observations, in combination with the literature review, interviews, and peer review conducted during development of this report, indicate the use of LWM elements within Channel Rehabilitation projects could be increased substantially. This may include increased quantities of LWM in future TRRP channel rehabilitation projects, supplemental LWM enhancement at the Phase I and early Phase II rehabilitation projects, LWM augmentation in sub-reaches that are outside of specific channel rehabilitation project boundaries, or LWM utilized in new ways to encourage greater geomorphic channel function.

Several constraints within the Trinity River and TRRP may have moderated past LWM utilization in Channel Rehabilitation designs. The high recreational utilization of Trinity River, FEMA floodplain considerations, landowner/access constraints, availability of source materials, availability of project funding, and willingness to implement this technique in deference to initial-established restoration strategies have all been identified as notable constraints. Other river systems in California, and the Pacific Northwest that have overcome similar challenges may provide valuable templates for the TRRP.

Based on our understanding regarding LWM utilization within the TRRP, we offer the following specific recommendations:

Programmatic Recommendations

1. Establish a Large Wood Workgroup
    a. Include practitioners and construction contractors from other basins/regions as external members of the workgroup.
    b. Conduct a focused review of LWM use in other regulated (flow and/or FEMA floodplain) recreational rivers.
    c. Evaluate novel uses and installation methods from other basins/regions, for utilization in the TRRP.
    d. Convene regular TRRP-specific LWM utilization workshop(s) to share and transfer knowledge gained and lessons learned.
    e. Over time, develop TRRP-specific LWM design guidelines.

2. Update and maintain a current LWM inventory. Include both restored and unrestored reaches for comparison using metrics developed by Cardno Entrix & CH2MHill (2011) and Boyce & Goodman (2018) for targets.
3. Establish a LWM procurement framework to guarantee reliable, high-quality LWM supply to use in Channel Rehabilitation projects, to either be implemented at the TRRP level or at the design program-level (e.g., Yurok, Hoopa).
4. Supplement LWM in Phase I and early Phase II channel rehabilitation projects to increase project effectiveness.
5. Integrate programming and practices to augment LWM loading in reaches where prior channel rehabilitation projects have been constructed
6. Clearly report how Channel Rehabilitation designs meet target metrics (such as target quantities or size classes of LWM).

Project-level Recommendations

1. Follow prior recommendations for LWM loading during Channel Rehabilitation project development (e.g., Cardno Entrix & CH2MHill 2011).
2. Reference existing design standards and guidelines, such as the National Large Wood Manual (USBR and ERDC 2016) and Integrating Recreational Boating Considerations into Stream Channel Modification & Design Projects (American Whitewater 2011), among others.
3. Collaborate with external practitioners for improvement and evolution of LWM implementation techniques.
4. Increase use of LWM to achieve geomorphic processes in the mainstem, in the floodplain, and in the lateral habitat junctions.
5. Increase scale of LWM utilization for both geomorphic forcing and direct habitat enhancement, to match loading recommendations in Cardno Entrix and Ch2MHill (2011).
6. Increase diversity of structure types, installation strategies, and placement locations to improve effectiveness of direct habitat placements.
7. Consider alternative LWM delivery or construction techniques to overcome access constraints, such as helicopter-assisted LWM delivery, helicopter-based construction, or paired helicopter and ground-based construction.
8. Integrate novel but established LWM installation techniques to support more diverse LWM utilization while maintaining adequate performance and stability. Techniques might include installation of timber piles via vibratory or vibrasonic pile driving equipment, extensive inclusion of slash into larger LWM structures, and integration of floodplain LWM as both a ground stabilization mechanism and geomorphic driver emulating mature forest conditions.

9. Selective clearing of even-aged stands of riparian alder to generate smaller LWM materials utilized as slash and create overbank complexity.
10. Follow LWM material procurement framework (recommended above) to guarantee reliable high-quality LWM supply.

7. Conclusion

The purpose of this review document is to summarize the TRRP's channel rehabilitation, site revegetation, watershed projects, flow management, and gravel augmentation activities through 2021, with an emphasis on the channel rehabilitation projects implemented during Phase 2 and to provide a review of how well the TRRP has incorporated the recommendations provided by the Phase 1 Review into Phase 2 projects, and finally to provide recommendations for Phase 3. The scope of this review is limited to findings from group interviews, restoration site tours, and existing available literature reviews.

This final version of the report has incorporated input and feedback from reviews by Reclamation, the TRRP IDT, and in-person feedback following a presentation to the TMC.

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Appendix A – Phase 2 Projects Review Against Previous Recommendations

Project Details			***Buffington et al. (2014) Recommendations***						***CH2MHill & Entrix Recommendations (2010)***									
Year	**Project Name**	**River Mile**	Criteria: Design for dynamic alluvial processes	Rationale:	Criteria: Use models of channel morphodynamics, flow-habitat relationships, and fish production to inform designs	Rationale:	Criteria: Quantify response time for desired conditions	Rationale:	Criteria: Immediately create as much of the target habitat as possible	Rationale:	Criteria: Design/implement projects that are "self-sustaining"	Rationale:	Criteria: Design projects that trigger future restorative changes	Rationale:	Criteria: Actively engage the public to develop designs	Rationale:	Criteria: Revisit early TRRP projects	Notes:
2012	Lower Steiner Flat	90.1 - 91.1	**Considerable**	The design focusses on physical conditions / elements which drive morphologic changes with the aim to create / enhance channel and riparian habitats. The design considers geomorphic evolution of site under existing and proposed conditions to evaluate design.	**Average**	2D hydraulics were developed as part of the design but they were not explicitly related to habitat metrics or fish production. Sediment transport modeling was developed to evaluate sediment deposition in-side/off-channel features, but greater site morphodynamics are not discussed.	**Minimal**	The design discussion of the timing of response is limited to "immediately" and "long-term". Timing isn't related to hydrologic/biologic thresholds or conditions.	**Considerable**	Gravel augmentation is likely to enhance areas of spawning gravel upon installation and after initial reworking. Side channels and alcoves provide large areas which should deliver off channel rearing habitats.	**Average**	The longevity of features such as constructed point bars and hydraulic structures are not discussed. Features such as alcoves and side channels may fill in.	**Considerable**	Expanding wetted area via grading high valley bottom surfaces, enhancing probability of in-channel deposition and LW retention, forcing constriction and expansion of the channel, and enhancing riparian vegetation conditions are a part of the design. These aspects should produce a morphologically more dynamic setting which causes future habitat formation.	**Average**	Provides an overview of how the design changed throughout phases, feedback received about preliminary designs, and responses to review comments.	**N/A**	
2012	Upper Junction City	79.8 - 80.4	**Considerable**	Many project elements are designed to change over time to produce increased complexity and improve habitat quality. Primary anticipated responses are sediment erosion and deposition in the channel and riparian vegetation growth. Some off-channel features are unlikely to change.	**Considerable**	Design development is supported by extensive hydraulic, morphodynamic, and habitat modeling efforts. The results of the modeling are described and discussed for many of the project elements. The accuracy of modeling efforts can be validated by post-implementation monitoring efforts described in the report.	**Minimal**	The evolution of project elements is described, but quantitative estimates of timing and/or thresholds for response/change are lacking.	**Considerable**	Development of side channel and off channel habitat, an ecogeomorphically functioning floodplain, channel complexity, and improved in-channel sediment dynamics should effectively improve habitat at the project site following implementation.	**Considerable**	Due to designs that are anticipated to change and improve over time, and features that have mechanisms to flush sediment at high flows, self-maintenance of the project is likely to be successful.	**Average**	Vegetation regrowth will change flow and sediment dynamics across the floodplain and along channel and off-channel boundaries while providing shade. The skeletal bar design components are positioned to evolve over time and provide the greatest future restorative changes at the site.	**Average**	Design development interreacted with project partners concerns, and several design changes were made in response to concerns from project partners and stakeholders.	**N/A**	

2013	Lower Douglas City	93.6-94.6	Considerable	The primary design goal is to build a self-sustaining dynamic bar and riffle morphology that will increase channel complexity over time.	Average	Shields parameter analysis and a 2-D MDSWMS hydrodynamic model was used to estimate bed mobility under average and high discharge. A 2D model was used to predict existing and design habitat area at 450 and 1500 cfs. A FEMA no-rise model was also created for the project.	Minimal	The discussion of timing of response is limited to "short-term", "Immediately", and "over time".	Average	Wood placement will create areas that meet depth and velocity criteria for fry and pre-smolt habitat.	Considerable	Willow trenches added to a skeletal bar will promote fine sediment deposition, resulting in floodplain development. Alluvial bar features will recruit wood and be maintained through deposition and scour. Wood placements are expected to be self-sustaining by capturing wood transported from upstream.	Average	Vegetation regrowth will change flow and sediment dynamics across the floodplain and along channel and off-channel boundaries while providing shade. The skeletal bar design components are positioned to evolve over time and provide the greatest future restorative changes at the site.	Average	Project partners included tribes, landowners, Trinity River Guides Association, and Trinity County Board of Supervisors.	Considerable	This project includes a portion of the 2007 Indian Creek site due to a sharp decrease in fry and pre-smolt habitat as flows increased.
2013	Lorenz Gulch	89.4 - 90.2	Average	The design discusses the facilitation of deformation of the bed and banks to create geomorphic complexity and form habitat. Induced sediment sorting and transport are the morphologic processes identified to produce these results.	Minimal	No discussion of hydraulics, morphodynamics, or habitat modeling efforts are included in the body of the report. Hydraulics are included as an appendix but are not referenced explicitly. There is minor description of fish use at the site under existing conditions, but the connection between this information and the design is unclear.	Average	The trajectory of most design elements is discussed, and clear connections between hydrologic conditions/thresholds and the anticipated effect of each design element is included. Additional discussion of anticipated morphodynamic response in response to project elements, and more detailed descriptions of morphologic/habitat trajectory would be helpful.	Considerable	The design addresses the three overarching habitat enhancement goals and should deliver these habitat benefits immediately. Alcove, pond, and side channel construction will increase juvenile habitat following construction, and added wood loading will likely uplift habitat for all life stages. Berm removal and bank alteration will facilitate floodplain connectivity. Gravel addition, enhanced bank erosion, and LW-induced sediment sorting will help yield greater spawning gravel area.	Minimal	Side channel maintenance and sedimentation risk are not clear. Gravel addition suggests that gravel will be replenished from upstream with little discussion of the hydraulics and sediment transport conditions which would produce this response. Tipped large wood and other large wood structures may help to recruit riparian vegetation and bank erosion may contribute spawning gravel-sized sediment to the project.	Minimal	Wood structures, tipped trees, and changes to banks may enhance lateral channel processes. Changes in channel form, increased wood loading, and sediment grain size changes may continue to result.	Average	The design process included significant feedback from the project partners and other stakeholders, and the design report effectively described this feedback, the response, and how it was incorporated into designs.	Minimal	This project reworks a side channel created in the 1990s.

2014	Lower Junction City	78.8 - 79.8	Average	The design aims to facilitate lateral channel processes to change form and contribute sediment to the channel. Vegetation establishment and planting will change floodplain hydraulics and sediment transport conditions outside of the active channel.	Average	Hydraulic and fish habitat modeling was performed as part of the study and inform design decisions. A discussion of shear stress calculated from the hydraulic model qualitatively addresses some aspects of sediment transport and morphodynamics.	Minimal	The evolution of project elements is described, but 113quantitative estimates of timing and/or thresholds for response/change are not clear.	Average	The primary emphasis of the design is creating more floodplain connection and reducing anthropogenic impacts on habitats at the site. Some in-channel changes are proposed to create in-channel habitat and complexity. The riparian emphasis of the design limits the timing and duration of habitat uplift following implementation.	Considerable	In-channel project elements are designed to produce progressive changes in the channel and enhance channel-floodplain connectivity. Floodplain elements are designed to flush sediments at high flows. Floodplain and riparian project element success largely depends on the success of revegetation and reduced human use at the site.	Average	Future restorative changes are primarily associated with morphological changes associated with the meander complex elements and riparian revegetation efforts.	Considerable	Design development considered comment from project partners and the general public at 10% design stages, project partners at the 30% design, and comment from public and project team at 50% design prior to final design development. Many changes resulted from multiple opportunities for external input on the design.	N/A	
2015	Upper Douglas City	93.6 – 94.6	Average	Design elements are proposed to enhance sediment transport through the reach, promoting areas of preferential erosion and deposition. This is anticipated to promote morphologic complexity and habitat formation.	Minimal	2D hydraulic modelling was performed to evaluate velocity and shear stress at designed element locations under proposed conditions. No habitat or morphodynamic models were discussed.	Minimal	We were unable to determine how comments were incorporated into final design and what the proposed trajectory is for the site.	Minimal	The benefits of an aggressive design and promoting dynamic processes were balanced with the desire to reduce the risk of failure of designed features. We were unable to determine how comments were incorporated into final design and how this affected the amount of habitat created post-construction.	Minimal	Expected evolution and concerns of project elements was described, but we were unable to determine how comments were incorporated into final design and what the likely trajectory is for the site. 2d hydraulic modelling was used to evaluate bed mobility and determine the size of placed coarse sediment and reduce the likelihood of unintended mobilization of placed material.	Minimal	Expected evolution and concerns of project elements was described, but we were unable to determine how comments were incorporated into final design and what the likely trajectory is for the site.	Average	The design was revised based on technical recommendations for the design team. Boater safety was considered for instream features. The project design meets federal flood regulations. No discussion of input from the public was included.	N/A	
2015	Limekiln Gulch	99.7 - 100.6	Average	Wood placement and grading in the design is intended to increase scour and sedimentation. The design of constructed side channels does not discuss dynamic or deformable features.	Considerable	A 2D hydraulic model was used to evaluate rearing habitat for the design and existing conditions at a range of discharges. Habitat availability for fry and pre-smolt salmonids was evaluated for existing and design conditions using 2D-HBLM.	Minimal	The expected geomorphic evolution is described but lacks timing other than "immediate" or "over time".	Considerable	The design creates a large amount of low velocity rearing habitat at a range of flows.	Average	Project elements are designed to evolve over time as vegetation matures and additional wood is recruited.	Average	Grading, wood placement, and vegetation may enhance sedimentation and create additional shallow-water habitat. Additional woody material is expected to accumulate and add to habitat complexity.	Minimal	The expected geomorphic evolution is described but lacks timing other than "immediate" or "over time".	N/A	

2016	Bucktail	105.3 - 106.4	Considerable	Sediment source areas are designed to be activated at design flows, mobilizing material and enhancing downstream alluvial features. Project elements are intended to increase bank erosion in select locations. Geomorphic goals for each project element are clearly stated.	Average	Habitat rating curves were developed to estimate the amount of salmonid rearing habitat under existing and proposed conditions using a 2D hydraulic model, identifying areas with suitable depth, velocity and proximity to cover. No morphodynamic modelling was described.	Considerable	A matrix is provided describing expected response over time for each project element.	Considerable	The aggressive nature of floodplain excavation in this project will create a significant amount of juvenile salmonid rearing habitat immediately post-construction. The variety of design features provides habitat for fish at all life-stages and through a variety of flows.	Average	The design indicates that sediment transport may not be balanced in this reach. Excavated material derived from floodplain lowering will be stockpiled and is intended for future gravel augmentation. Revegetation plantings reduce the risk of establishment of invasive or weedy species. Side channel features reduce the risk of inlet deposition.	Considerable	Design elements are expected to evolve over time, increasing complexity and quality of habitat as channel and bank substrate is mobilized and riparian vegetation establishes.	Considerable	Conceptual alternatives were reviewed by the TRRP Design team, program partners and stakeholder groups. Flooding concerns were mitigated by replacement of the bridge. 50% designs were presented to the public for review. Public meetings were also held, and a revised 50% design incorporated this feedback.	Considerable	The Bucktail reach occupies a portion of the Dark Gulch rehabilitation site which was constructed in 2008. Off-channel elements were not included in the previous project due to flooding concerns. Replacement of the Bucktail Bridge eliminated these concerns and created an opportunity to create a significant amount of off-channel juvenile rearing habitat in this reach. A bank rehabilitation project was also constructed in this reach in 1993.
2017	Deep Gulch	82.4 - 82.9	Considerable	Project elements introduce increased potential for floodplain accretion and scour, and channel avulsion, bed scour, bank erosion and channel expansion, and bar growth to the project area.	Average	The amount of salmonid rearing habitat under existing and proposed conditions was estimated using a 2D hydraulic model assessment module and by identifying areas with suitable depth, velocity and proximity to cover. WUA curves were developed. A 1D hydraulic model was used to develop stage-discharge relationships throughout the reach. 2D hydraulic model was used iteratively to determine design elevations for inundation at target discharges. Morphodynamic modeling was not included.	Considerable	The immediate habitat benefits provided by design elements including lowered floodplain surfaces, bar complex and side channel will increase over time as vegetation establishes and fluvial processes introduce topographic and ecological complexity. The expected lifespan of large wood structures is stated.	Considerable	Implementation of this project provides a large increase in the amount of low velocity rearing habitat available to juvenile salmonids at a range of flows immediately post-construction.	Considerable	Overbank flow is directed towards the alcove to provide flushing flows. The wood structure at the side channel inlet is intended to reduce the risk of sediment deposition and maintain flow through the channel.	Considerable	The habitat value of constructed features is expected to increase over time as riparian vegetation establishes and fluvial processes introduce topographic and ecological complexity to the floodplains, bars, bed and banks.	Minimal	No discussion of engaging with the public or other stakeholders or describing the evolution of the design was included. The project design meets federal flood regulations.	N/A	

2017	Sheridan Creek	81.6 - 82.4	Average	Increasing channel complexity and dynamism is a secondary objective in this reach. The meander complex is intended to promote bank erosion to supply sediment downstream. Maintenance of the existing spawning riffle is key to the design.	Average	Salmonid rearing habitat under existing and proposed conditions was modeled using 2D hydraulic model and WUA curves were created. Habitat estimates were also created using categorical mapping criteria. It is not clear whether this data was used to inform the design, or simply to document habitat creation.	Average	Rearing habitat will be available year-round immediately post-construction. The meander complex is expected to be relatively stable over time. Cool groundwater inputs to the ponds are expected to diminish over time, but this is expected to be balanced by increased shading of newly established riparian vegetation.	Considerable	The project creates a significant amount of rearing habitat, protects existing spawning habitat, and creates additional amphibian habitat.	Considerable	The meander design includes several measures to promote self-maintenance including features to maintain appropriate shear stress through the bar and appropriately sized bar substrate. The radius of curvature of the meander is designed to minimize flanking as is the elevation of the adjacent floodplains. Incorporation of large wood and woody plantings provide roughness. The pond features are protected from sediment input. The daylighting of Sheridan Creek is designed to protect the existing elevated water table and as a spring-fed channel is expected to be stable.	Average	Expected evolution and the effect of the design on existing and future habitat is clearly defined. The project is designed to raise local groundwater levels to support riparian forest development. Maintenance of the existing spawning riffle is a key component of restoration in this reach and has been prioritized over the introduction of dynamic river processes.	Considerable	The design process included alternatives that were refined with public input and external technical review. Additional public meetings were included in the permitting process. The project design meets flood regulations and protects structures in the area.	Minimal	Two previous "feather edge" riparian projects were constructed in this reach in the 1990's which included bank laybacks. Subsequent flooding reshaped the channel in these areas.
2019	Chapman Ranch Phase A	82.8 - 83.8	Considerable	Physical design objectives include promoting dynamic river processes and preserving alluvial potential. Forced meanders are intended to promote entrainment of spawning gravel from dredge tailings along the bank. Design favors increased dynamism over certainty in performance and channel evolution.	Considerable	Flow duration curves were used to develop design channel and floodplain elevations that meet target inundation durations and provide off-channel rearing habitat for juvenile chinook salmon during winter months. 2D hydraulic modelling was used to evaluate areas of velocity refugia and available habitat for juvenile chinook under existing and proposed conditions by developing WUA curves. Sediment transport modelling was used to design channel features.	Considerable	The aggressive nature of excavation at the site will create immediate habitat benefits. All design features are described including the goals of the feature, lifespan, and expected evolution, as well as risks and uncertainties.	Considerable	The aggressive approach allows for immediate and notable improvements in salmonid habitat for all life stages, including in-channel habitat and improved riparian ecosystem health and floodplain connectivity.	Considerable	Design objectives include developing floodplains suitable for natural riparian regeneration. Target elevations were developed based on groundwater monitoring data. Alcoves were placed in areas adjacent to hillslope drainage channels, providing sufficient flows to maintain the inlet. The risk of channel scour is designed to be offset by the influx of sediment from bank scour into dredge tailings.	Considerable	Expected evolution of each design feature is described. The sharply meandering planform creates opportunities for future entrainment of spawning gravel, lateral channel migration, and increased hydraulic complexity in the short-term, and channel avulsion in the long-term. Sinuous riffle-pool morphology is expected to develop in the designed channel.	Average	A Historic Dredger Tailing Viewshed was established in the project area to mitigate cultural resource impacts. Infrastructure related to nearby homes will be protected. Q100 water surface elevation will not be increased.	N/A	

2020	Dutch Creek	85.0 - 86.6	Average	Terrace excavation is intended to increase scour, channel avulsion through the floodplain and accretion in the channel. Forced meander is intended to promote bank erosion and channel deposition, though lateral migration will be limited as it is being constructed adjacent to bedrock along the valley wall.	Minimal	Discussion of the use of these types of models to inform design is limited. A portion of the lowered floodplain is designed to be inundated at a variety of winter flows. Modelled water velocity and depth in this area are intended to meet habitat needs of juvenile salmonids and promote establishment of riparian vegetation. Habitat capacity under existing and design conditions were modelled using 2D hydraulic modeling software and GIS data and show an increase in habitat in the project area, though proposed habitat cover data was not created for this modelling effort. 2D morphodynamic modelling was not performed, though relative channel bed mobility was estimated.	Average	Habitat quantity is expected to be greatest immediately post-construction. Sediment deposition is expected to raise lowered floodplain surface over time, reducing habitat availability for juvenile salmonids. Riparian vegetation is expected to establish and persist once the elevation of this floodplain surface reaches equilibrium. The side channel and alcove are expected to persist, but this is not well defended.	Average	Habitat quantity is expected to be greatest immediately post-construction. One floodplain lowering area is designed to provide habitat at a large range of winter flows. The second floodplain lowering area will remain higher and activate at higher flows.	Average	It is stated that design features are intended to be self-perpetuating, but this statement is not well defended. Constructed point bar is expected to self-adjust as coarse sediments transport through the site. Large wood placed at the side channel inlet is expected to decrease the risk of this inlet clogging. Discussion of risks and uncertainties of the design features is discussed generally.	Minimal	Lowering floodplain terraces will increase fluvial processes on the floodplain, increase available habitat for salmonids and increase extent of riparian vegetation but the expected evolution of the designed features is not well described, and it is not clear that the trajectory of the site will allow these features to persist.	Minimal	No discussion of engaging with the public or other stakeholders or describing the evolution of the design was included.	N/A	

2021	Chapman Ranch Phase B	82.9 - 83.8	**Considerable**	Physical design objectives include promoting dynamic river processes and preserving alluvial potential. Bed and bank scour is expected, including scour of alluvial deposits on the right bank. Design favors increased dynamism over certainty in performance and channel evolution.	**Considerable**	Flow duration curves were used to develop design channel and floodplain elevations that meet target inundation durations and provide off-channel rearing habitat for juvenile chinook salmon during winter months. 2D hydraulic modelling was used to evaluate areas of velocity refugia and available habitat for juvenile chinook under existing and proposed conditions by developing WUA curves and carrying capacity estimates. Sediment transport modelling was used to design channel features.	**Considerable**	The aggressive nature of excavation at the site will create immediate habitat benefits. All design features are described including the goals of the feature, lifespan and expected evolution, as well as risks and uncertainties.	**Considerable**	The aggressive approach allows for immediate and notable improvements in salmonid habitat for all life stages, including in-channel habitat and improved riparian ecosystem health and floodplain connectivity.	**Considerable**	Design objectives include a focus on functional improvements including improving floodplain connectivity and function with target elevations based on groundwater monitoring data. Increasing geofluvial function and expanding riparian and upland vegetation diversity and extent will create a more resilient river corridor. Sediment transport modelling was used to design channels which balance sediment supply and transport through the reach. Riparian areas are designed to encourage natural recruitment of riparian vegetation. Beaver dam analogues are included to increase water surface elevation and the success of riparian vegetation. The side channel complex is designed to minimize filling risk.	**Considerable**	The design aims to restore linkages between fish habitat and riverine processes. Expected evolution of each design feature is described. The sharply meandering planform creates opportunities for future entrainment of spawning gravel, lateral channel migration, and increased hydraulic complexity in the short-term and channel avulsion in the long-term.	**Average**	Infrastructure related to nearby homes will be protected, including coordination with the local utility provider to protect an existing utility pole that may be impacted by the project. Q100 water surface elevation will not be increased.	**N/A**	

2022-2024	Oregon Gulch	81.0 - 81.9	**Considerable**	The stated physical objective is to promote fluvial processes, such as bedform dynamics and channel planform change. The design is intended to stimulate geomorphic processes that will drive the evolution of a structurally diverse floodplain including mobilization and deposition of sediment, and wood at select locations on the floodplain and localized scour, aggradation, avulsion and incision in channels.	**Considerable**	Design development used 2D hydraulic model results and GIS data to estimate rearing habitat under existing conditions based on fish capacity as recommended by the Fish Work Group. Results determined that fry habitat capacity decreased with increases in flow, and defined a primary design objective to increase this habitat availability as flows increase. Used morphodynamic models results to predict erosion and deposition.	**Considerable**	The site is expected to evolve quickly, as constructed channels are designed to overtop during typical winter flows. Aggressive floodplain excavation will drastically increase available salmonid habitat.	**Considerable**	A large volume of material is excavated for this project. The as-built condition will create 16-acres of new, frequently wetted floodplain.	**Average**	Deposition is expected within the IC-1 channel and could reduce channel capacity, creating a condition where boat passage is difficult for a period of years. Habitat created is expected to sustain.	**Considerable**	The expected evolution of each design feature is described and is intended to create a dynamic and complex floodplain. The constructed features are expected to change and may be replaced by naturally created features that provide the same functions.	**Average**	Boat-based fishing is by far the most popular recreational use of the site. The proposed design may make passage by boat difficult during some years. Large wood is designed to minimize the risk to the public. Project-specific public meetings were held throughout the design process to educate the public and receive input. At the conceptual design phase, input was solicited from other design groups.	**N/A**	Reviewed conceptual designs for the reach from 2010.

Appendix B – Interview Summaries

U.S. Forest Service	
Noted Program or Design Strengths	- Channel rehabilitation design/new approaches in recent years are moving in the right direction; Oregon Gulch as an example is an excellent project – the size in particular. Should have been goal from Day 1 (let river be freer and removal of mine tailings). - Program has learned a lot over the past decades and has a bigger appetite for large-scale projects and actions. - Mine tailings are being processed and good-sized sediment is being put back in the river. - Many smart people working towards goals; willingness of the program to spend money and take action. - Barrier removals in the tributaries have made a huge difference. - Individuals designing and constructing channel rehabilitation projects have learned what works, what doesn't and are/have been adaptively managing designs/implementation. - There is a lot of institutional knowledge in the long-term staff and partners, but if and when these people leave, or as new folks come in, this will be lost because there has been no formal documentation of that adaptive management and lessons learned.
Noted Program or Design Weaknesses	- Recent winter flow proposal was good baby step but didn't go far enough. - The long timeline for flow management group to make decisions, and then those decisions get enacted, is a major issue. Flow problems are political issue, not science issue. The actual volumes of water are not the problem, instead the trends are the problem. - Not enough gravel has been added – need to do more of it. - Watershed actions are never fully funded and are usually not the focus of the TRRP, but would like there to be more focus on the good work that is happening by the nonprofit partners and full funding of their projects. Benefits steelhead the most. - There has been a lot of lessons learned/adaptive management in the people building the projects, but looping that info back to the science group has not been happening as much/at all. No formal review or recognition of how projects are adapting to new science/information. It just happens. - There is a lot of institutional knowledge in the long-term staff and partners, but if and when these people leave, or as new folks come in, this will be lost because there has been no formal documentation of that adaptive management and lessons learned.
U.S. Bureau of Reclamation	
Noted Program or Design Strengths	- Our knowledge has changed and understanding of the river is more nuanced now, which has influenced TRRP actions and goals. This is learning and evolving, and an example of adaptive management. - Good at conducting research, answering scientific questions. - Anecdotal information/lessons learned is a start at successful adaptive management, and help bridge the gap between science reports and designers of the projects.

	- Fewer fines in the channel now, channel is widening, and transverse bars are increasing (meaning sediments/fines are mobilizing). - Outgoing juvenile numbers has increased since TRRP started. - TRRP has implemented many channel rehab projects which will be even more beneficial once we get the flow management set up better. - No fishing closures on the mainstem Trinity and a relatively consistent fishery is a success.
Noted Program or Design Weaknesses	- The fact that goals/methods have changed over time makes some people think that the program itself is a "failure". - Adoption of science lags significantly behind the findings. Have a problem taking science and making decisions off of that, as by the time we have defendable science findings we've moved on several steps in design based on anecdotal findings. - Science doesn't create decision making; politics and social aspects mostly, plus some of the science, inform the policymakers. - Everyone has different definitions of adaptive management which makes it hard to do anything productive. - Rigorous, formal adaptive management documentation is lacking. - Push for action overwhelms careful analysis and adjustment. Emphasis is on short-term results, especially for rearing habitat. - Disconnect between projects built and program goals/objectives. Questions about "did we build what was actually needed?" - No follow-up/reviews for project performance. Does the project response to time or flows match the design expectations? - No clear definition of what can and can't be "fit in the field" or when fit in the field is reasonable or not. Need guidelines. - No documentation of fit in the field changes or design adjustments that were made. - Lack of overall strategy for watershed projects right now is a detriment. We don't know what the tributaries need right now and need a strategic plan for the watershed. - Hard to focus on longer-scale timeframes, e.g., beyond 10 years. Results important in near term and less thought about longer timelines. - Gravel augmentation has recently lost attention, funding.
National Marine Fisheries Service	
Noted Program or Design Strengths	- New science document (currently in prep) provides a really good proposal for moving forward. - Goals, metrics and objectives have been more well-defined in recent years. - Decision Support System developed to document decisions more clearly and has been super helpful.
Noted Program or Design Weaknesses	- Despite lots of consensus on changes to flow management, administrative hurdles and conflicts in the TMC made it hard to enact those changes. - Non-scientists on TMC are decision-makers for science-based actions & questions, etc. Voting shouldn't be required to implement scientific findings. - Varied interests among partners, or even varied ideas on how to implement shared interests, can be an impediment to action.

	- Need to do some restructuring to successfully do adaptive management and create a place for learning, bringing in literature from other basins, etc. - Don't have a LWM program and budget (wasn't included in original ROD), but it's really needed in the reach.
U.S. Fish and Wildlife Service	
Noted Program or Design Strengths	- Program has done a good job of increasing juvenile rearing fish habitat. - In the beginning, we didn't have super clear metrics (just "increase juvenile habitat") but now we have more specific targets where it's easier to show yes or no success. - Capacity or habitat gain has been a driving factor for selecting the design - the design that (at the time of construction) gives the most uplift to capacity or habitat are selected. - More recently we have been using hydraulic modeling to evaluate habitat projects, but results aren't fully available yet. Intent was to align design methods with monitoring methods (hydraulic models).
Noted Program or Design Weaknesses	- Don't have a formal structure to do a post project look back and see if the project actually met the objectives or what project elements worked or didn't or were able to persist over time. Some of that info is available from monitoring but haven't taken a comprehensive look at it to inform new rehab site designs and it is not clear how the designers are using that info, if at all. - Missing a project level post-evaluation - need to understand how specific elements are performing. If we're going to lose habitat value over time, maybe we should be using different tools to select the preferred alternative (instead of just capacity or habitat). - Also need to consider the evolution of the sites - we focus on building it now, rather than the longer term. - I don't have a true idea of the reach's limiting factors – a limiting factors analysis is missing and is needed. - Outreach to the community to explain the work the program is doing hasn't been very good, though it has improved slightly in recent years. - project scale metrics might need work because we're not seeing the fish population responses like the ROD/flow evaluation study just assumed would happen. - Program has not done a good job of completing the loop and formally documenting adaptive management or learning from success/failures that's happening. Adaptive management is happening implicitly but not explicitly or easily for others to follow. - There's push back on external, peer review, or science advisory board opinions and advice. Some in the program see that as unwanted advice. That structure of who's driving the ship and making the decisions (TMC structure) ends up promoting the status quo going forward. - Everyone is working for individual agencies first and TRRP second, which can create competition and interfere with collaboration. - The funding structure makes it very challenging to collaborate and keep track of who is responsible for what in terms of reporting. Annual funding agreements are hard to negotiate.

Trinity County	
Noted Program or Design Strengths	- TMC voting structure is good because it requires strength in numbers. The current voting structure allows voices from all partners to have equal power, especially when a majority of the partners are federal agencies with alignment in their interests/perspectives. The TMC has an important role to play to allow the voices on it to be heard and provide oversight. If voting structure changes, the county would essentially not have a say in any of the decisions because it would get out voted by federal interests. - Program accommodates varied interests/needs to some degree, for instance the folks served by the PUD have gained benefit of some of the cheapest power in the state. - We have a lot of science data; scientists do a lot of work. But getting science to go full circle and answer questions of how the projects are working, what could be tweaked, that isn't happening - A new dedicated technical staff person from the County on the TRRP is a new, good change.
Noted Program or Design Weaknesses	- Success can be hard to achieve when many things influencing success are out of the projects or program's control, and the restoration program works within a narrow breadth. - Tributary work has not been very well funded, even though they are major opportunities with less expensive, less complex projects. - The communication between restoration and the public is not good at best. Success for some people seems to be to just get projects in the ground. Involving the public may introduce uncertainty into getting projects in the ground or meeting timelines, which may be part of it. - No longer enough fish to maintain the economic support of the county the way it used to. - Changes to the program could influence community/economic interests - We have a lot of science data; scientists do a lot of work. But getting science to go full circle and answer questions of how the projects are working, what could be tweaked, that isn't happening. - Agree with some of the general thoughts from others about how the TMC doesn't need to be deciding on science matters and could stick to more programmatic decisions.
Yurok Tribe (both interviews)	
Noted Program or Design Strengths	- Currently we have leeway in the design process and implementation process that works well. We need to have flexibility to change to fit the conditions in the field. - Flexibility on site during construction works for us as construction is done in-house. Waste of time in the office to get too prescriptive. Requires some more communication once we get on the ground to figure out what to do. But is that adaptive management - not just in the design, but in the procedures and construction as well. - Have designers and implementers all as part of the team. - Before the designs were over complicated and overdesigned, now we're doing bigger things on a bigger scale, and can see those responses much better than smaller but more complicated projects from the past.

	- There is room in the program for different approaches to design, which is a good thing. - Things are a lot different than when we started too, which maybe has not been formally documented as adaptive management but we are changing, evolving, etc. and are absolutely getting better at restoration, gravel augmentation, etc. - Most of our actions on the science side are answering the implementation groups questions they are asking us; they are relying on us. - Learning and are trying to shift from the metric of fish population response which has a lot of noise and doesn't respond very quickly, to some other metrics which can have a major influence on fish populations but give a signal on a much shorter time cycle. - Adaptive management is not necessary as it's been utilized by TRRP for a long time. - Design and implementation have been using adaptive management, the ongoing evolution of what has been constructed is an obvious outcome of that. - Monitoring and science findings feed and influence the design and implementation, but this happens mostly verbally in meetings. It reduced the time between publishing findings and design refinements.
Noted Program or Design Weaknesses	- Huge limitation is that so much of critically dry water year water is tied up in the summer, so if you could scale the baseflows based on the water year type you could free up so much of it and create a more natural regime - The current summer flows create the unnatural riparian dense fringe that are a problem, but also hate to see the water get too low because then it hurts the commercial rafting downstream. - The focus on models or as-built modeling of capacity: when projects are different from the design it doesn't matter as much because projects are supposed to change, and the capacity modeling is more sensitive to flow/temp than the physical habitat. - Before the designs were over complicated and overdesigned, now we're doing bigger things on a bigger scale, and can see those responses much better than smaller but more complicated projects from the past. - Need to see more recognition of the significance of the mining legacy. - Fish response time is much longer than even the time frame or decision-making schedules for adaptive management considerations. - The problem with the science group is sometimes the response variables are too long of a response or are just not the quite right variable. - Flow management, however, is not adapting at a similar pace and that needs to change. - Sites need flood flows to respond so it's hard to learn how design works if elevated flows do not occur. Yet the pressure to get things designed and implemented means things march on, the feedback loop between flows and design is broken.

	- Post implementation monitoring should occur but only happens infrequently and then just anecdotally. It would be nice to do annual field trips to project sites with all the design folks attending. - Flow is the biggest "dial" we can turn, and we have not been able to turn it. Flow affects every inch of the river, and we need to change that part of the system. - Placer mining impacts have been greatly underestimated in terms of the ability of the river to move its bed.
Hoopa Valley Tribe and McBain	
Noted Program or Design Strengths	- New science document will allow TMC to fund these adaptive management/monitoring studies that are 2-yr chunks or so of funding/planning separate from the standard status and trends monitoring that is funded every year. - Modeling of rearing habitat/capacity is providing an accurate picture of the work that is being done, even if there are other things it isn't able to include. - Design teams have gotten better recently about what the actual goals of the project are, so you have a better metric to evaluate the project for success, previously it was vaguer and harder to evaluate. - With more recent projects, we are creating enough of a geomorphic response out of the river that is in turn creating habitat.
Noted Program or Design Weaknesses	- In the past we haven't been very good at doing actual adaptive management, we've been good at trial and error and then ad hoc post project evaluations. Haven't done a good hypothesis, test, evaluate true adaptive management process. This is fairly well acknowledged in the TRRP, and the science document that is being developed now is hopefully going to address some of this. - One of the basic hurdles the program faces with respect to adaptive management is buy-in from managers to implement it in a structured way as well as the scientists themselves. - Do lots of experiments with individual projects but not a holistic structured evaluation of all the implemented projects in a thorough way. Not planned out and don't have funding to evaluate those experiments usually, instead the evaluation is a simple kick the tires and little to no documentation is made to document the findings of how the experiments worked. - Need an adaptive management structure, and it needs to be built into the funding structure in order to really complete the feedback loop. - Older projects had too light of a touch to be able to evaluate effectiveness. - Program is missing a comprehensive qualitative riparian revegetation assessment because that is limited, and a better understanding could contribute more to our project successes. - When each project has differing goals for success then it's hard to measure overall success. - We need a programmatic document to guide watershed projects - We don't take advantage of the inputs from tributaries or upstream as much as we could, and we should do more of that.

	- Need more gravel augmentation. - Need to figure out what is limiting adult escapement on the Trinity River (is it an in-river issue, a lower Klamath River issue, or an ocean issue?). - Need to update Channel Design Guide and Coarse Sediment Management Plan. - Need to consider a long-term perspective of the valley bottomlands, including land purchases/easements for river processes, relocating houses if needed, etc. Look at Clear Creek example. - Need to finish Large Wood Strategy document, and update as we learn.
California Dept. of Fish and Wildlife & Dept. of Water	
Noted Program or Design Strengths	- We have done good work, but a lot of our projects are usually based on fish potential, and fish may not actually exist there at this time (there is intrinsic value only). - Most of the road decommissioning, culvert replacements, and reduction of sediments projects have been done already. - We've learned a lot in the last 10-15 years, plus we have new techniques, new modeling that can inform us now. - The program has a clear goal, which is focused on adult escapement (whether or not that needs to be revisited is another matter). - We've increased the number of juveniles per adult. - We've found we often get a big increase in habitat right after construction, then lose a little over the next few years, but amount of habitat still remains above baseline habitat conditions. - TMC hasn't really concerned themselves with details of the designs - typically, we just present the final designs to them at the end of the process. This has allowed for a good evolution of the design philosophy in the TRRP and is a little different than the other management actions we have in the TRRP and the level of oversight the TMC provides for those (such as flow). - At the construction and design level is where the most AM has occurred. - Gravel augmentation program changes have occurred based on new approach and philosophy from science folks.
Noted Program or Design Weaknesses	- Money is associated with the dam, so trying to figure out projects where this money applies to the tributaries is really hard. Lots of good projects out there, but not for us to fund because of where the money is coming from. - The problem is we fund projects, but we don't go full circle and hear how the projects are working and how they were implemented. So, the locals see that, but we don't get that formally documented on our end. - Need to develop some sort of objective way to approach and determine if a revisit to a previous project should be done and what the level of investment should be. - It is a bit pie in the sky and unrealistic/unfair to be so focused on adult escapement as overall goal and measure of success when there are a number of factors outside of our control that influence those numbers. - We aren't, but should be, looking at out-migrating numbers of juveniles or productivity in terms of fish size.

	- We've found we often get a big increase in habitat right after construction, then lose a little over the next few years, but amount of habitat still remains above baseline habitat conditions. So, we should consider this "settling" of the project when we come up with our project objectives. - Interaction between planform/hydrology and habitat is not well thought out at design level - projects as implemented don't often appear to interact with flows in an optimum way. - The biggest thing is they have failed at creating an adaptive management program, though some important AM has occurred in the program. Those are not the same thing. - The integration of all management tools is not happening, for example new river habitats are being constructed but flows haven't been changed at all. Huge missing piece that needs to be addressed is the interaction of all our tools and actions. - Politics are getting in the way of the implementation of science.