

Observations of Project Successes, Setbacks, and implications to Future Phases

Floodplain topographic diversity and drainage. Phase 2A incorporated a flat floodplain to ease implementation during the first construction phase. Additionally, scour channels intended to help guide juvenile salmonids back to the primary Clear Creek channel were flat bottomed. There were concerns that the flat floodplain and flat-bottomed scour channels could be improved to reduce potential stranding of juvenile salmonids on these surfaces. Phase 2B (implemented in summer 2001) has been designed to include "terraces" that are two feet higher than the floodplain surface, and modified the scour channel geometry to have a meandering and more defined thalweg. The additional topographic diversity provided by the new floodplains and terraces allows better association of riparian plantings with geomorphic surfaces (e.g., valley oaks and other upland species targeted on terraces, cottonwoods and willows on floodplains). Gentle side-slopes of at least 3% transition between terraces and floodplains to further reduce juvenile salmonid stranding risk.

Scour channel morphology. Observations during the winter and spring months show that fry and juvenile Chinook salmon migrate from the primary Clear Creek channel into these smaller channels, providing heavy rearing use during this time of year. These observations will be used to refine future designs to improve the value of the restoration project to juvenile salmon habitat. In addition, scour channels have been lowered so water will back into them at low flows, providing sheltered alcove habitats for salmonids and other species. Restoration of the primary Clear Creek channel in Phase 3 will incorporate more complexity by creating secondary low flow channels in some locations and complex bar features. These constructed surfaces, however, will evolve when; future high flows reshape the river channel as it migrates and avulses across the floodway.

Revegetation strategy. The Phase 2A constructed surface was nearly completely revegetated to increase vegetation success, and high survival of planted cuttings and natural regeneration was achieved. However, we anticipated a higher mortality to eventually result in more natural patchy revegetation patterns typical of the historical riparian morphology. Phase 2B has created areas of exposed gravel/cobble bar between planted riparian patches, and has incorporated more patch types and species, all of which will result in more complex riparian habitat.

Fill volume computations. A recurring problem of Phase 1 and 2A implementation has been under-predicting fill material volume needed to implement the project. Phase 1 required approximately 10% additional fill and Phase 2A required approximately 23% of additional fill. These "losses" appear to be due to three factors:

- 1) conversion of non-compacted dredger tailings from the borrow site to moderately compacted material at the fill site;
- 2) imprecise topography from photogrammetry (topographic bias plus inaccuracy due to vegetative cover); and
- 3) imprecise topography in ponded areas, where "muck" at the bottom of ponds under-predicts the functional depth of the pond.

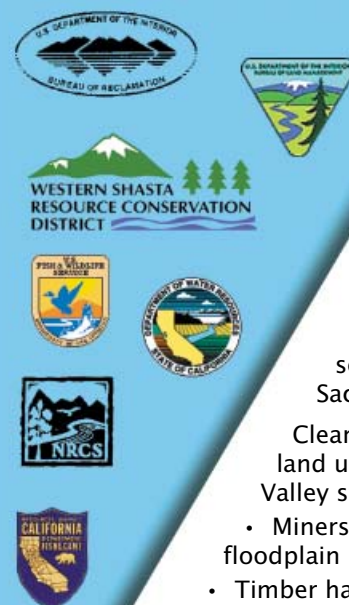
To improve these volume predictions, we recommend conducting high quality ground surveys of the site, making sure that surveyed topography in ponded areas reflects the functional bottom of the pond rather than the top of the muck layer. Photogrammetry and bathymetry are not recommended topographic techniques. Lastly, incorporate roughly 25% contingency volume to ensure that an adequate amount of fill is available to complete the project.



Chronology towards desired future conditions. Starting on the left, planted cuttings in their first year at Restoration Grove. The center photograph shows a maturing patch of willows (foreground) and cottonwood (background) adjacent to exposed cobble/gravel bar surface. Scour channels of varying depth and cover provide seasonal habitat for amphibians, mammals, birds, and salmonids. The right photo shows mature cottonwoods reaching senescence, which will provide habitat for raptors, cavity nesting birds and mammals, and if channel migration occurs, large woody debris to the stream. As we continue to implement, monitor, observe, and learn, each new phase of the Lower Clear Creek Floodway Rehabilitation Project will improve, providing valuable information for other restoration efforts on alluvial river ecosystems.

LOWER CLEAR CREEK FLOODWAY REHABILITATION PROJECT 2A FLOODPLAIN CONSTRUCTION AND REVEGETATION PROGRESS REPORT

September 2001



Historical Impacts and Site Description

Originating in the eastern side of the Trinity Mountains, Clear Creek flows southeast to its confluence with the Sacramento River just south of Redding.

Clear Creek has been degraded by human land uses in a similar manner as most Central Valley streams and rivers:

- Miners damaged natural channel and floodplain morphology in their search for gold
- Timber harvesting and road building increased fine sediment supply to the stream
- Gravel mining damaged channel morphology, riparian vegetation, and greatly reduced coarse sediment supply
- Dams reduced the flow regime and eliminated coarse sediment supply from the upper watershed

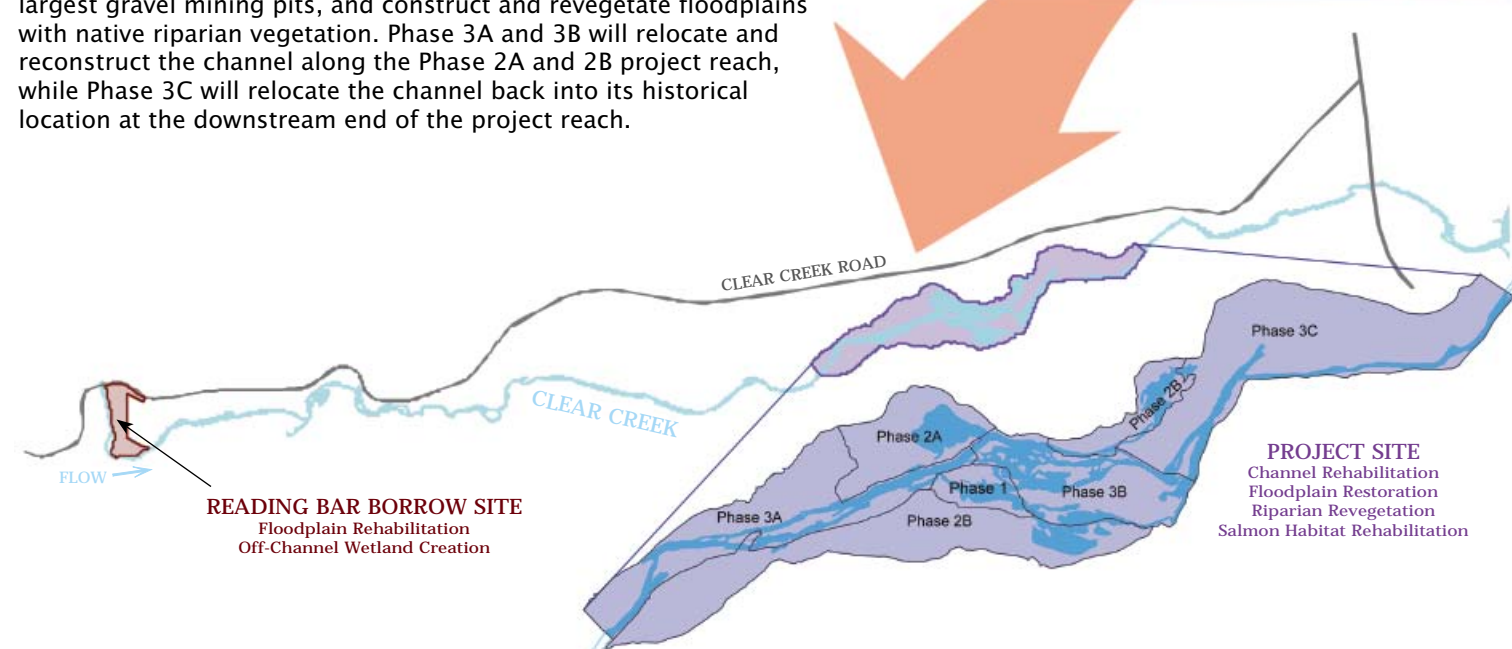
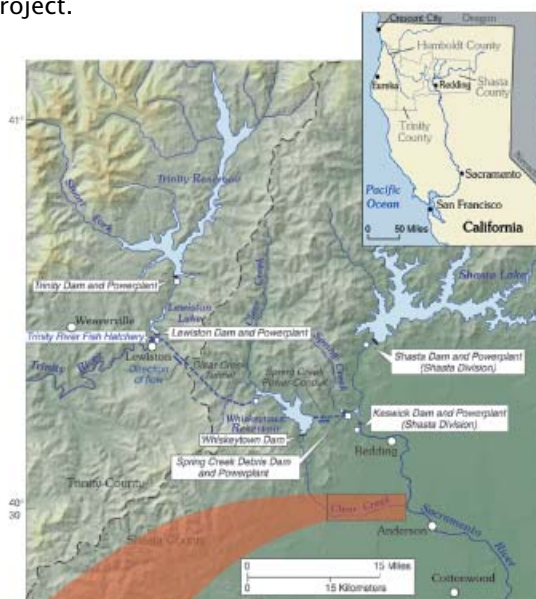
The lowermost section of Clear Creek has been degraded most severely by these land uses, particularly by instream gravel mining activities that removed several hundred thousand cubic yards of gravel in the 1970's and 1980's. Large instream pits were soon breached during high flows, and the cumulative effect of gravel extraction and upstream dams resulted in:

- Extensive channel incision down to the underlying clay hardpan;
- An unconfined and poorly defined inflow channel; and
- Extensive stranding of both adult and juvenile chinook salmon.

As a result, the Clear Creek Channel Rehabilitation Project was developed to reverse the impacts on the 1.6 mile reach most severely impacted (see map below). The large size of the project required multi-year construction, and the project was divided into five phases. Phase 1, completed in 1998, was an interim measure to isolate a severe Chinook salmon stranding area from flows less than 2,000 cfs. Phase 2A and 2B will fill the largest gravel mining pits, and construct and revegetate floodplains with native riparian vegetation. Phase 3A and 3B will relocate and reconstruct the channel along the Phase 2A and 2B project reach, while Phase 3C will relocate the channel back into its historical location at the downstream end of the project reach.

Most of the fill required to complete the project will be obtained from dredge tailing borrow sites approximately four miles upstream, and these borrow areas will also be restored and revegetated. The project and borrow sites for the restoration project are shown below.

This document will outline the overall restoration strategy of the project, describe the construction and revegetation approach used in Phase 2A, and highlight lessons learned from implementing Phase 2A that will be applied to future phases of the Lower Clear Creek Channel Rehabilitation Project.



Lower Clear Creek Restoration Strategy

Lower Clear Creek is unique among most regulated Central Valley streams: most of the floodway is under public ownership, there is no urban or agricultural encroachment into the floodway, there are no human structures in the floodway, and floods up to 19,000 cfs still occur even though Whiskeytown Dam regulates flow upstream. This uniqueness allows us to apply a restoration strategy that embraces the natural dynamic qualities of the stream, while reducing long term risk and maintenance of the project. This strategy allows the project to restore important natural ecosystem processes that are conducive to creating and maintaining high quality salmonid habitat, including:

- restore channel to historical meandering/semi-braided morphology;
- improve gravel transport, storage, and routing by reconstructing appropriately confined channel;
- reconstruct functional floodplains, and encourage natural floodplain creation, deposition, and inundation processes;
- encourage natural channel migration and avulsion processes;
- restore stream grade and reduce exposed clay hardpan by increasing gravel supply; and
- reduce salmonid stranding and mortality by filling gravel pits and creating well-drained floodplain surfaces.

Phase 2A Construction Activities: January - April 2000

Phase 2A consisted of the floodplain reconstruction site (12 acres named Restoration Grove) and the Reading Bar borrow site (6 acres). Approximately 70,000 yd³ of dredger tailings were removed from Reading Bar and used to fill remaining gravel mining pits (up to 10 ft deep) as functional floodplains at Restoration Grove. The borrow area at Reading Bar was

excavated to a functional floodplain elevation and revegetated in a similar manner to Restoration Grove. There was no manipulation of Clear Creek itself as part of Phase 2A. Construction occurred from January 28 - April 19, the material unit cost for excavating, hauling, and filling was \$3.90/yd³, and the total construction cost was \$502,000.



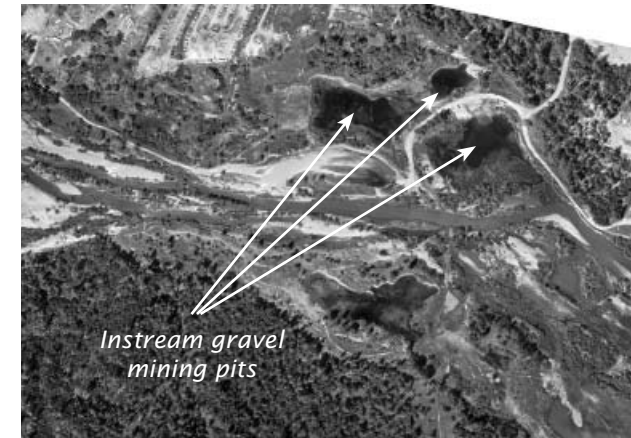
Panorama of Restoration Grove after construction was completed. The scour channel is saturated by groundwater soon after design completion.



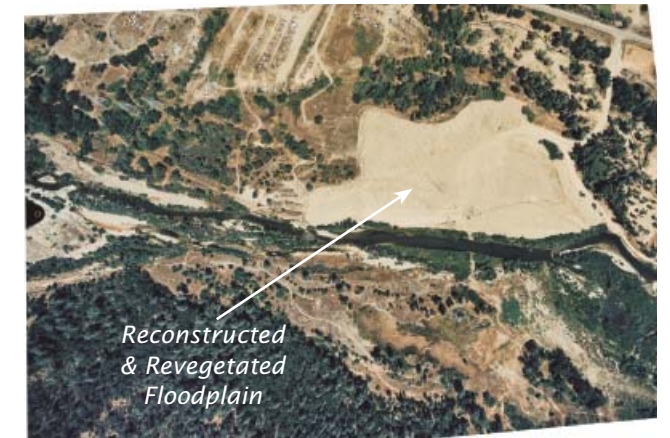
Panorama of Restoration Grove as of September 2001. The initial planting of Fremont cottonwood and mixed willow series is in its second year, and the natural revegetation of the scour channel with hardwoods and sedges can be seen in the photograph.

Phase 2A Design Specifics

- Floodplains were constructed to inundate at 3,000 cfs (2.0 year flood) under future constructed channel conditions (after completion of Phase 3 channel regrading).
- Terraces were not constructed, reducing fill requirements and lowering costs.
- Floodplains were constructed with zero lateral slope to simplify construction.
- Fill material was raw dredger tailings, with no topsoil used to improve riparian plantings and natural riparian recruitment.
- Floodplains revegetated with cuttings installed to the winter groundwater table (2-4 ft deep) with fertilizer tablets, plant protectors, and no irrigation. Installing cuttings to the winter water table was intended to encourage the cuttings



Aerial photograph of Restoration Grove prior to construction 1997 (1" = 950').



Aerial photograph of Restoration Grove after construction and planting, 2000 (1" = 950').

Phase 2A Riparian Revegetation Activities: April - May 2000

The riparian revegetation strategy for lower Clear Creek Restoration Project uses portions of the historical riparian morphology as a future restoration vision. This riparian vegetation morphology is characterized by interspersed patches of vegetation in lower elevation abandoned channels and high flow scour channels rather than a continuous riparian forest typical of lower gradient rivers. This riparian morphology is derived by the semi-braided channel morphology inherent with Clear Creek's natural flow and sediment regime. The Phase 2A revegetation strategy installed cottonwood and willow cuttings on floodplains, and avoided planting in scour channels to allow natural regeneration to occur there. We anticipated substantial plant mortality would result in a mosaic of vegetation patches. The revegetation cost using cuttings was \$7,000/acre. No irrigation was used.

Natural regeneration was also prolific in areas with a high water table and fine sands and silts. The scour channels quickly recruited thousands of Fremont cottonwood seedlings, but few willows. Additionally, natural sedge recruitment occurred over nearly the entire length of the scour channels.



Upper inset - natural cottonwood recruitment on constructed floodplains. Background photo - fine sediment deposits in scour channel at Reading Bar, showing subtle meandering. Lower inset - close-up of fine sand deposition at Reading Bar.

Patch/Series Type	Plant Make-Up
Fremont Cottonwood	40% Fremont Cottonwood, 40% Black Willow, 10% Shining Willow, 10% Valley Oak
Mixed Willow	30% Arroyo Willow, 30% Red Willow, 20% Shining Willow, 10% Fremont Cottonwood, 10% Black Willow
Arroyo Willow	80% Arroyo Willow, 10% Red Willow, 10% Fremont Cottonwood

Plant series used in Phase 2A

Species	Survival	
	Plug Site	Borrow Site
Fremont Cottonwood	52% (N=542)	38% (N=359)
Black Willow	83% (N=528)	67% (N=351)
Shining Willow	43% (N=255)	64% (N=206)
Red Willow	75% (N=178)	75% (N=266)
Arroyo Willow	56% (N=219)	54% (N=521)

Monitoring results of riparian plantings show higher than expected survival, largely due to installing cuttings to the shallow winter groundwater table.