INTRODUCTION

River restoration has become an important topic amongst conservationists, public policy makers, and water managers in recent years due to environmental problems that have resulted from over 150 years of water development, flood control, and hydroelectric generation in California. California relies on surface water to meet the demands of its growing population, flood control projects have been constructed to protect lives and property from flood damages, and hydroelectric generation has been an important sector of the state’s energy portfolio. Thus, hundreds of dams, diversions, levees, and other facilities have been constructed on California rivers and streams throughout the state to meet these demands.

However, these projects have not come without environmental costs, including loss of native fish populations, loss of riparian and wetland habitat, and loss of wildlife species dependent on these river-related habitats. To address these issues, several important federal and state programs have been created over the past 15 years, including the Anadromous Fish Restoration Program of the federal Central Valley Project Improvement Act of 1992, and the CALFED Bay-Delta Program, a joint federal-state initiative aimed at improving ecosystem health while ensuring water supply reliability. These programs and others have funneled millions of dollars of public funds to projects designed to improve the environmental health of the Sacramento-San Joaquin Bay-Delta Watershed, which includes the entire Central Valley of California, the west slope of Sierra Nevada, and the east slope of the coastal ranges.

Central to improving riverine and riparian health along California’s rivers and streams is a strong understanding of fluvial geomorphology, which is the study of channel and floodplain landform development as influenced by moving water, i.e. rivers and streams. Fluvial geomorphologists, working in concert with other scientists and engineers, have been at the forefront of prescribing recommendations for restoring ecological integrity and sustainability to the state’s streams.

This field guide is aimed at students, high school teachers, and community college and university instructors. The field trip features the lower Tuolumne River channel and floodplain restoration, as well as other points of interest, including Don Pedro Dam and the Tuolumne Gold Dredge. The trip begins at Don Pedro Dam and moves downstream to the west of Modesto (figure 1). Along the way, we will view different projects that were constructed using different strategies to restore the river channel, floodplains, and riparian areas of the Tuolumne River. The trip will also cover
Figure 1. Lower Tuolumne River Restoration field trip stops.
the fluvial geomorphological and human influences and the resulting river morphology. Watershed issues are also described on the drive to the first stop.

All of the stops, except the final stop, are on public land or viewable from public roadways. Most of the stops involve only short walks from vehicles, but one stop involves a ¼ mile walk on a dirt trail. Through this field trip, participants will gain an understanding of the processes that form rivers under natural conditions, human impacts on these processes, and strategies for rehabilitating stream health.

BACKGROUND

The Tuolumne River Watershed encompasses a 1,900 square-mile area of the central Sierra Nevada and northern San Joaquin Valley and includes the northern half of Yosemite National Park (figure 2). The Tuolumne is the largest tributary to the San Joaquin River, producing an average annual unimpaired yield of 1,906,000 acre-feet. The river flows for 150 miles from its headwaters at over 13,000 ft on Mt. Dana and Mt. Lyell to its confluence with the San Joaquin River at an elevation of 30 feet. The river provides drinking water to 85% of the San Francisco Public Utilities Commission’s (SFPUC) 2.4 million customers through the SFPUCs Hetch Hetchy Project. Through the Don Pedro Dam and Reservoir, the river also provides drinking water to Modesto, a city of nearly 200,000, irrigation water to over 250,000 acres of farmland in Stanislaus County, and hydroelectricity to over 194,000 home, farm, business, industrial, and municipal accounts.

While the river provides these critical socio-economic benefits, it also supports a weakened but important ecosystem that is habitat for several federal- and state-listed species, including fall-run chinook salmon (species of concern), Central Valley steelhead (Threatened), Valley Elderberry Longhorn Beetle (Threatened), riparian woodrat (Endangered), and riparian brush rabbit (Endangered).

The lower Tuolumne River corridor is divisible as two distinct geomorphic zones. The gravel-bedded zone extends from river mile 52.2 to 24, and the sand-bedded zone extends from river mile 24 to 0. The river has been further subdivided into seven distinct reaches based on present and historical land uses, including placer mining for gold, dredger mining for gold, urban growth, livestock grazing, agriculture, streamflow regulation and diversion, and commercial aggregate (gravel) mining (table 1).
<table>
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<tr>
<th>Land Use</th>
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<th>Location</th>
<th>Disturbance</th>
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<tr>
<td>Placer Mining</td>
<td>1848-1880</td>
<td>La Grange and Upstream (RM 50)</td>
<td>Turned over floodplains; spoil placement on fertile areas</td>
<td>Destroyed natural channel morphology, increased sediment supply, destroyed instream habitat, removed riparian forests</td>
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<tr>
<td>Urban Growth</td>
<td>1850-present</td>
<td>Modesto to Waterford (RM 15 to 30)</td>
<td>Need for commercial lumber, space and aesthetic value</td>
<td>Confined river corridor (reduced width), constructed dikes, removed riparian vegetation, increased pollution loading into river</td>
</tr>
<tr>
<td>Grazing</td>
<td>1850-present</td>
<td>San Joaquin confluence to La Grange (RM 0 to 50)</td>
<td>Young riparian vegetation is grazed, water sources become feces conduits</td>
<td>Destabilized banks, discouraged natural riparian regeneration</td>
</tr>
<tr>
<td>Farming</td>
<td>1860-present</td>
<td>San Joaquin confluence to La Grange (RM 0 to 50)</td>
<td>Mature and establishing riparian vegetation is cleared. Channel is stabilized</td>
<td>Confined river corridor (reduced width), constructed dikes, removed riparian vegetation, increased pollution and fine sediment loading into river</td>
</tr>
<tr>
<td>Dredger Mining</td>
<td>1880-1952</td>
<td>Roberts Ferry to La Grange (RM 38 to 50)</td>
<td>Turned over entire riparian corridor valley-wall to valley-wall; spoil placement on fertile areas</td>
<td>Destroyed natural channel morphology, increased sediment supply, destroyed instream habitat, removed riparian habitat</td>
</tr>
<tr>
<td>Flow regulation</td>
<td>1890-present</td>
<td>Downstream of La Grange (RM 0 to 52)</td>
<td>Magnitude, duration, frequency, and timing of high flow regime is altered and reduced, reduced/eliminated sediment supply from upstream watershed</td>
<td>Bed coarsening and downcutting, fine sediments accumulated in channel, channel fossilized by encroaching riparian vegetation, channel migration and bar building virtually eliminated, floodplain construction and deposition reduced, quantity and quality of instream and riparian habitat greatly reduced</td>
</tr>
<tr>
<td>Aggregate Mining</td>
<td>1930-present</td>
<td>Hughson to La Grange (RM 24-50)</td>
<td>Large instream and off channel pits, dredger tailing removal</td>
<td>Historic floodplains are left as deep ponds, floodway narrowed by dikes separating ponds from river, riparian vegetation is cleared, regeneration is prevented and mature stands eliminated</td>
</tr>
</tbody>
</table>

Table 1. Land uses and effects on the lower Tuolumne River from 1848 to present. (McBain and Trush, 2000).
RESTORATION GOALS

In 1964, the Federal Energy Regulatory Commission (FERC – then called the Federal Power Commission) issued a license for the New Don Pedro Dam, which required the Turlock and Modesto Irrigation Districts (TID and MID), in cooperation with federal and state resources agencies, to conduct studies on the Tuolumne River “aimed at assuring continuation and maintenance of the salmon fishery in the most economical and feasible manner” (New Don Pedro License, Article 39). Additionally, FERC required a re-evaluation of minimum flow releases after the first 20 years of project operation. This re-evaluation led to a 1995 FERC Settlement Agreement (FSA) amongst stakeholder groups, including FERC, TID, MID, California Department of Fish and Game (DFG), US Fish and Wildlife Service (FWS), the City and County of San Francisco (CCSF), the Tuolumne River Trust, San Francisco Bay Area Water Users Association, Friends of the Tuolumne, Inc., Tuolumne River Expeditions, and the California Sports Fishing Protection Alliance. The FSA included four major provisions: 1) increased minimum flows, 2) an obligation of TID and MID to complete ten restoration projects to improve instream conditions for salmon, 3) a river-wide monitoring program, and 4) a $500,000 obligation upon CCSF towards restoration and land protection projects along the river.

The Tuolumne supports, on average, the largest run of wild-chinook salmon in the San Joaquin system, the southernmost system to support chinook salmon on the west coast of North America. Even though the Tuolumne and other San Joaquin tributaries have historically supported very large runs of both spring- and fall-run chinook salmon, presently only fall-run are found in the basin, and in wildly fluctuating numbers (figures 3 and 4).

Figure 3. Tuolumne River Salmon Run, 1973-2005. (DFG, 2006)
As outlined in the FSA, the goal of the restoration program on the Tuolumne River is to restore the declining salmon fishery, although many projects also include goals beyond salmon recovery, including steelhead recovery, riparian forest restoration, avian habitat restoration, and others.

**ROAD LOG TO STOP 1**

0.0 (0.0) This field trip begins at the corner of Columbia College Drive and Sawmill Flat Road. The Columbia College campus is located topographically on the divide between the Tuolumne Watershed, to the south, and the Stanislaus Watershed, to the north. In fact, the San Diego Reservoir on campus would naturally drain into the Stanislaus River. It is also fed by the San Diego Ditch, one leg of Tuolumne County’s historic Gold Rush era ditch system that is fed by water from the South Fork of the Stanislaus River through Lyons Dam. Woods Creek, a headwater stream in the Tuolumne Watershed, lies about 100 yards to the west of the intersection of Columbia College Drive and Sawmill Flat Road. From Columbia College Drive, turn right onto Sawmill Flat Road.

0.4 (0.4) Woods Creek passes under Sawmill Flat Rd.

1.2 (0.8) Turn left onto Parrotts Ferry Rd.

1.5 (0.3) Turn left onto Highway 49, towards Sonora. Woods Creek parallels the highway to the east (left) of the highway, as both road and stream make their way towards Sonora. In Sonora, Highway 49 becomes Washington Street.
Woods Creek passes under Highway 49/Washington Street.

After flowing under two city blocks on the east side of Highway 49/Washington Street, Sonora Creek, a tributary to Woods Creek, passes under Highway 49. It daylights for about 150 yards, flows under a shopping center, and then daylights again. While we will view larger-scale manipulations of the Tuolumne River proper later in the field trip, human interventions are clearly visible on these small creeks higher in the watershed. Concrete walls have been constructed along Sonora Creek to prevent erosion, city blocks have been built over the creek, and the stream receives small amounts of Stanislaus River water from the Shaws Flat Ditch further up in the watershed through both leaks and managed spills.

Turn right at the stoplight in downtown Sonora onto Stockton Rd/Highway 49.

Sonora Creek daylights and then flows under the road. The creek parallels the southeast (left) side of the highway for about 500 yards.

Woods Creek passes under Highway 49 and then parallels the highway to the east (left). The confluence of Woods Creek and Sonora Creek are visible off to the left of the road. In early spring, vegetation is removed from both of these streams to reduce obstructions in the creek and thereby facilitate flowage of floodwaters away from downtown Sonora. During the mining era, both creeks were also subjected to gold mining, which would have caused varying degrees of alteration depending on the technique used. Unlike the mainstem of the lower Tuolumne River that we will visit downstream, which is characterized as an alluvial stream, the primary geomorphic control on these creeks is the bedrock itself.

Woods Creek disappears behind a hill, where it flows past the Sonora Wastewater Treatment Plant.

Turn right onto Highway 108/Highway 49 towards Jamestown. Woods Creek reappears on the south (left) side of the highway.

Woods Creek passes under the highway from the south side to the north side. It is periodically visible from the road for the next 1.9 miles.

Stoplight at Rawhide Road. Continue through the light to stay on Highway 108/Highway 49.

The first floor of the two story green house to the right of the highway along Woods Creek was inundated twice during March and April 2006 when spring storms pushed water onto the creek’s floodplain.
8.4 (0.7) Woods Creek passes under the highway for the last time, passing from the north (right) side of the highway to the south (left) side of the highway. From here it flows approximately 4.3 miles down to Don Pedro Reservoir.

8.8 (0.4) Table Mountain appears to the north and runs parallel to the highway. Table Mountain forms the divide between the Stanislaus River Watershed and the Tuolumne River Watershed in this area.

10.3 (0.8) Highway 49 bears left. Continue straight to stay on Highway 108.

12.3 (2.0) The highway crosses over a low divide and then through a gap in Table Mountain, and thus passes from the Tuolumne Watershed into the Stanislaus Watershed.

13.1 (0.8) Highway 120 joins Highway 108 from the south at Yosemite Junction. Continue straight to stay on Highway 108. Table Mountain now lies on both sides of the highway, recording its historical inundation of two Miocene paleochannels.

13.8 (0.7) O’Byrnes Ferry Road. Continue straight on Highway 108.

14.8 (1.0) Andrew Creek, an ephemeral headwater stream of the Stanislaus Watershed, flows under the highway.

15.6 (0.8) The highway runs along the west edge of the Red Hills, consisting of serpentine bearing rocks, altered from peridotite.

17.0 (1.4) Turn left onto La Grange Rd./J-59. Note the tombstone rocks in the area, which are metavolcanic rocks associated with a Jurassic island arc complex of the Foothills Terrane (Gopher Ridge Formation as described in Schweickert, et al, 1999). Extensive folding, exhumation, and subsequent differential erosion rates have created the features visible today.

19.4 (2.4) The road passes imperceptibly back into the Tuolumne Watershed. For the next 8.4 miles, the road crosses numerous arroyos and ephemeral streambeds. Initially, these streams flow towards Don Pedro Reservoir. Later, the streams are headwaters to Dry Creek, a tributary to the Tuolumne River. The confluence of the Tuolumne and Dry Creek is in downtown Modesto.

25.8 (6.6) The road crosses Gallup Creek, one of the larger tributaries to Dry Creek.

27.5 (1.7) Turn left onto Bonds Flat Road.

28.9 (1.4) Don Pedro Dam Spillway to the west (left).
STOP 1 – DON PEDRO DAM VISITOR’S CENTER

The license for New Don Pedro Dam was issued in 1964 and the dam itself was completed in 1971. The Old Don Pedro Dam was completed in 1923 and still stands about 1.5 miles upstream of the new dam, although it is under about 250 feet of water. The New Don Pedro Dam is a 580-foot high earth-and-rock fill structure creating 2,030,000 acre-feet of storage in the reservoir behind it and 203 megawatt hydropower generation facilities.

New Don Pedro is one of 5 major dams on the Tuolumne River. Upstream, Eleanor Dam, Cherry Dam, and O’Shaughnessy Dam at Hetch Hetchy are owned by the City and County of San Francisco. Downstream, La Grange Dam acts as a diversion dam for TID and MID. La Grange Dam, built in 1893, at 130 feet high, was known at one time as the “Niagara Falls of the West.”

With regards to fluvial geomorphology, the two critical considerations about dams such as New Don Pedro are: 1) they impound water; and 2) they impound sediment. The impoundment of water drastically alters the river’s hydrology downstream of the reservoir by reducing baseflows and by reducing the frequency and magnitude of floodflows (figure 5).
Sediment retention is a less obvious outcome of dam construction. In an undammed system, sediment would be transported downstream with water, constantly resupplying gravel-beds and thereby rebuilding spawning beds for salmon and trout. However, sediment is not able to bypass a dam, and thus the water downstream is sediment-starved and much more erosive.

In addition to these two geomorphic considerations, dams also effectively block a fish’s upstream (or downstream) migration. Fisheries biologists estimate that salmon would have been able to migrate to the boundary of Yosemite National Park, some 55 miles upstream of the location of New Don Pedro Dam. This would eliminate not only 55 miles of mainstem habitat, but many miles of tributary habitat as well.

**ROAD LOG TO STOP 2**

At the exit from the parking lot, set the trip odometer to 0.0.

0.0 (0.0) Turn left onto Bonds Flat Road.

0.4 (0.4) New Don Pedro spillway. There are a couple of narrow pullouts just after the spillway itself.
STOP 2 – NEW DON PEDRO DAM SPILLWAY

The New Don Pedro Spillway is viewable from the road. When the dam was designed in the 1960’s, it was of sufficient size that the engineers thought that the spillway would never be used. However, the results of spilling during the January 1997 floods are evident here as approximately 45,000 cubic feet per second (cfs) flowed over the spillway, across the road, and down to the La Grange Reservoir in the canyon below. The spill completely washed out the road and completely removed topsoil down to the underlying bedrock and transported it downslope, effectively filling in the small reservoir. McBain and Trush (2000) estimated that approximately 500,000 cu yds of topsoil, mixed with crushed and scoured bedrock washed down Twin Gulch during that event.

ROAD LOG TO STOP 3

Reset the trip odometer to 0.0.

0.0 (0.0) Continue north on Bonds Flat Road.
1.3 (1.3) Turn left onto La Grange Rd/J-59.
5.2 (3.5) The MID main canal crosses under the road. Turn left onto Old La Grange Road.
5.5 (0.3) Pull over at the Gasburg Creek Bridge.

STOP 3 – GASBURG CREEK

As described above, coarse sediment supply is a critical issue in rehabilitating the Tuolumne salmon runs. Additionally, fine sediment management is also critical to improving egg survival on the Tuolumne. Fine sediments, particularly those between 8 mm and 0.125 mm fill interstitial spaces in spawning gravels, smothering eggs. Several small tributaries in the La Grange area have highly disturbed watersheds and provide a significant fine sediment load to the Tuolumne. Gasburg Creek in particular has a high potential to deliver sand because of a sand extraction operation a short distance upstream. The solution proposed for Gasburg Creek is a sedimentation pond near its mouth that would prevent harmful fine sediments from entering the Tuolumne River.

Other solutions for Gasburg and other creeks includes improving land use practices within the corridor to reduce soil erosion and delivery to the Tuolumne River; increasing the magnitude and frequency of high flows to deposit fine sediment onto the floodplain and to transport fine sediment downstream from primary spawning reaches; and excavation of sand stored in pools to reduce the volume available for affecting spawning gravels.
ROAD LOG TO STOP 4

Pull 0.1 mi up the road and turn around at the California Department of Fish and Game field office. Return to the bridge and reset the trip odometer to 0.0.

0.0 (0.0) Head back up the Old La Grange Road towards J-59.
0.1 (0.1) DFG shop on right.
0.3 (0.2) Turn left onto J-59.
0.7 (0.4) The lower Tuolumne River crosses under the road.
1.0 (0.3) Turn left onto Yosemite Blvd/Hwy 132.
1.5 (0.5) Turn left onto the Old La Grange Rd. Drive less than 100 yards down to the end of the road and park in the large dirt areas on either side of the road.

STOP 4 – OLD LA GRANGE BRIDGE

Walk out onto the Old La Grange Bridge. From the bridge, the channel, the floodplain, and the condition of riparian habitat are visible upstream and downstream. Note that the river leaves the confinement of its canyon behind as it flows out of the foothills and into the Central Valley. The river is no longer a bedrock river, but rather has a channel of coarse sediment – the primary characteristic of an alluvial river.

To the casual observer, the channel, floodplain, and riparian vegetation are seemingly natural and healthy. However, in reality, over the past 150 years, this site has been subjected to dredger mining, gravel mining, flow regulation, loss of coarse sediment supply, and cattle grazing. These intensive activities have acted to severely alter the channel, its floodplain, and associated riparian habitat.

As described by Trush, et.al. (2000), unregulated (undammed) rivers are governed by a set of attributes critical to alluvial river integrity. These attributes arise from a river’s natural tendency to flood, move sediment, and migrate. These attributes include, amongst others:

- an alternate bar sequence creating spatially complex channel morphology,
- each hydrograph component accomplishes specific geomorphic and ecologic functions,
- balanced fine and coarse sediment budgets,
- floodplains are functioning and frequently inundated.

In the vicinity of the Old La Grange Bridge lies a single-thread channel with little complexity, floodplains, particularly on the north side of the river, are perched high above the river channel effectively disconnecting the floodplain from the channel, and
riparian vegetation is no more than a single tree wide and consists of only two or three willow species. These conditions are the result of historical impacts and the loss of several of the attributes listed above.

Beginning in the late 1800’s, dredger mining was used as an efficient technique for recovering gold. Through this technique, dredgers would work their way back and forth across the channel and floodplain, sorting out any valuable minerals, and leaving the aggregate behind in mounds called dredger tailings. In the process of dredger mining, the channel and floodplain would essentially be turned upside down with long linear piles of cobbles left behind and finer material either buried or washed downstream (figure 6). Subsequently, in the late 1960’s, many of the tailings were removed to build the New Don Pedro Dam, which in turn reduced and altered the stream’s hydrograph, and eliminated the coarse sediment supply to the river. Throughout this period, land use practices adjacent to the river, such as cattle grazing, prevented recovery of riparian habitat, which accelerated erosion rates in tributary creeks.

![Figure 6. 1950 aerial photo of dredger tailings in the La Grange area. Note the Old La Grange Bridge on the right side of the photo. (McBain and Trush, 2004).](image)

The result of these historical events was multifaceted: the river channel became essentially frozen in place between two tailing piles unable to meander and create alternate point bars and the related complex channel morphology; the hydrograph, in its highly regulated state, no longer included annual channel-forming flows; the coarse sediment supply was eliminated by the dams, while the fine sediment supply increased; and floodplains were elevated to such a level as to prevent regular inundation, thus completely disconnecting them from the channel.
One restoration project visible from the Old La Grange Bridge is designed to counteract the loss of coarse sediment supply. Adult chinook salmon, upon returning to the river after spending 2-5 years in the ocean, proceed to build a nest, or redd, where they will spawn. Considerable research indicates that Chinook salmon spawn in a wide range of sediment sizes, with suitable spawning substrate ranging in size from 0.1 to 5.9 inches. Sediment transfusion projects have been completed, with many more planned, to restore coarse sediment availability within the lower Tuolumne River. There are no tried-and-true methods available for placing gravel within the river, and much previous work has occurred on a trial-and-error basis.

Looking downstream from the bridge on the left side of the river, a newly constructed gravel bar was placed by the California Department of Fish and Game (DFG) in the summer of 2002. The method of placement employed by DFG was direct in-channel placement of gravel to mimic a point-bar. This method has the advantage of immediately increasing sediment supply to the river while providing usable habitat for salmonids. Potential drawbacks to this method are the channel work can be highly disturbing to any existing habitat and it is difficult to mimic the multiple microhabitats created through natural geomorphic processes.

**ROAD LOG TO STOP 5**

Return to Highway 132/Yosemite Blvd. Reset the trip odometer to 0.0.

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<tr>
<th>Mileage</th>
<th>Distance</th>
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<td>0.5</td>
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<td>0.9</td>
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<tr>
<td>2.5</td>
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</tbody>
</table>

- **0.0 (0.0)** Turn right onto Highway 132/Yosemite Blvd.
- **0.5 (0.5)** Turn left onto La Grange Rd/J-59.
- **1.4 (0.9)** La Grange Rd crosses Dawson Reservoir, out of which flows the TID Main Canal.
- **2.5 (1.1)** Pull out at the gate on the right side of the road just past the historical marker. The Tuolumne Gold Dredge is visible about ¼ mile south of the road down a dirt trail blocked by a gate marked no trespassing. However, the gold dredger is on county land and open to the public.

**STOP 5 – TUOLUMNE GOLD DREDGE**

Yuba-type gold dredges (or bucket-line dredges) were a popular tool for mining gold from river gravels on all California rivers, and were used extensively on the Tuolumne in the late 1800’s and first half of the 1900’s until about 1952, and until the late 1960’s on other rivers. The Yuba-type dredge is akin to a combine used for harvesting wheat. Built on pontoons or a shallow hull, these dredges only needed a small pond in which to float, and would essentially dig themselves a new pond as they moved forward across the floodplain.
Depending on the size of the dredge, they were capable of dredging up to 175 feet deep. They were built with up to 140 buckets, and the largest, digging 24 hours a day, would dredge and process up to 450,000 cubic yards each month. The buckets would excavate channel and floodplain deposits, transfer them to sluice and trammel, where gold would be sorted out, and then deposit it into long, cobble-armored tailings (figure 7).

![Figure 7. Yuba style dredge. (Ahnert, 1990).](image)

On the Tuolumne, gold dredges excavated the channel and floodplain to the depth of bedrock (up to 70 feet deep) which often realigned the river channel. The Tuolumne Gold Dredge used 120-4,000 lb buckets and was longer than a football field. It operated from 1938-1951. By the mid-1950’s, 12.5 miles of river and floodplain had been dredged and converted to tailings piles by this and other dredges.

Many of the tailings were subsequently removed to construct New Don Pedro Dam in the late 1960s creating flat floodplain surfaces armored with very coarse cobbles infrequently inundated by floods. Thus, much of the floodplain along the river in the upper 12 miles remains barren, vegetated primarily by exotic annual grasses.

**ROAD LOG TO STOP 6**

Turn around and reset the trip odometer to 0.0.

0.0 (0.0) Head north on La Grange Rd/J-59.

2.0 (2.0) At Highway 132/Yosemite Blvd, turn left (west) towards Modesto.
2.5 (0.5) Note the buff outcrops of Valley Springs Formation in the roadcut on the southside of the highway. The Valley Springs Formation is a rhyolitic tuff, approximately 25 Ma, erupted during a phase of Sierran volcanism. The Valley Springs Formation and Mehrten Formation form 100 foot cliffs along the lower Tuolumne River downstream of the present location. These rocks outcrop at several more locations along this leg of the field trip.

3.8 (1.3) The highway crosses the Tuolumne River at the “New” Basso Bridge. Note the Old Basso Bridge just downstream of the new bridge.

11.5 (7.7) Turn left (south) onto Roberts Ferry Road.

11.8 (0.3) Arrive at the Roberts Ferry Bridge. There are short, narrow pullouts on both sides and both ends of the bridge.

**STOP 6 – ROBERT’S FERRY BRIDGE AND 7/11 REACH CHANNEL RESTORATION**

The Robert’s Ferry Bridge before you was constructed in 1999 to replace the Old Robert’s Ferry Bridge that was washed out during the January 1997 floods. The 1997 floods caused many other problems for landowners along the Tuolumne, including the gravel mining operations downstream of this bridge. Levees separating the gravel pits in this reach failed in many locations causing damage to aggregate extraction facilities.

Aggregate extraction operations commenced in this reach in the 1960’s and still continue today. Many of the dikes separating aggregate pits from the channel severely constricted the channel, preventing channel migration and development of riffle pool sequences, while removing floodplains altogether.

The 2.6 mile reach of river channel (known as the 7/11 Segment) and low floodplain terraces was completely reconstructed in 2003. The restoration project had many goals, including, among others, restoration of the floodway width to safely convey floods while allowing the channel to migrate within the restored floodway; improving channel-floodplain connectivity; and improving salmon spawning and rearing habitats by restoring alternate bar morphology.

Construction of this restoration project required approximately 420,000 cubic yards of aggregate and topsoil to complete, while 21.8 acres of newly constructed floodplains were revegetated. (figure 8).
Figure 8. Design planform features for the 7/11 Reach Channel Restoration just below Roberts Ferry Bridge. (McBain & Trush and Jennifer Vick, 2004)
**ROAD LOG TO STOP 7**

Turn around and reset the trip odometer to 0.0.

0.0 (0.0)  Head back north on Roberts Ferry Road.

0.3 (0.3)  Turn left (west) onto Highway 132/Yosemite Blvd.

4.8 (4.5)  Note active off-channel gravel mining to the left (south) of the road and the extensive gravel ponds created through this activity. The channel itself is separated from the gravel ponds by an extensive levee system and is given little room to meander or inundate the floodplain. Riparian habitat is almost non-existent.

8.0 (3.5)  Intersection of Highway 132 and Hickman Road in Waterford.

12.8 (4.8) Turn left (south) onto Geer Road.

13.1 (0.4) MID Lateral #1 crosses under the road.

14.2 (1.1) Geer Road crosses the Tuolumne River.

14.5 (0.3) Turn left into the Fox Grove County Park driveway.

14.9 (0.4) Drive down the driveway to the parking lot. The Special Run-Pool 9 is located on a dirt path about 100 yards downstream of the Fox Grove County Park parking lot, just west of the Geer Road Bridge.

**STOP 7 - SRP 9 CHANNEL RESTORATION**

Special-Run-Pools (SRPs) are former in-channel aggregate extractions pits. In-channel gravel mining dates back to the 1930’s on the Tuolumne and resulted in numerous unnaturally large and deep pools along the river. The unnaturally wide channel and deep water conditions offer suitable habitat to nonnative largemouth and smallmouth bass, and the native Sacramento pikeminnow, all of which prey on juvenile chinook salmon. Because a majority of chinook spawning in the Tuolumne River occurs upstream of this location, most juveniles must pass through this location during outmigration.

The Special Run-Pool 9 (SRP 9) Channel Restoration project was completed in 2001-2002. The goals of the project were to reduce predator habitat, restore channel geomorphology, and improve channel-floodplain connectivity. This was achieved through filling in the pit and reconstructing the mainstem channel and floodplain, both of which were scaled to contemporary flow conditions (figure 9). In total, approximately 169,000 cubic yards were required to construct the SRP 9 project.
Figure 9. Design planform features for the SRP 9 Channel Restoration just below Geer Road Bridge. (McBain & Trush and Jennifer Vick, 2004)
Pre- and post-project monitoring at the SRP 9 project and the downstream, uncompleted SRP 10 project, which provides a control for studies, has indicated that the SRP 9 project was not successful in reducing largemouth bass linear density during low flow years. Project effects on smallmouth bass are less clear, but monitoring did not identify any statistically significant trends in smallmouth bass linear density between project and control sites. The most important factors limiting the success of the SRP 9 project in reducing bass habitat and abundance may be channel slope and channel width. Channel slope at control sites where predator abundance is lower than at SRP 9 is an order of magnitude steeper than at SRP 9 while channel width is 24% narrower.

However, the project may reduce predator efficiency by creating a “safe-velocity corridor” within the low-flow channel. River 2D modeling indicates that the project increases habitat segregation between bass and juvenile chinook salmon by increasing flow velocities. However, this hypothesis has not been field-tested.

ROAD LOG TO STOP 8

Return to Geer Road at reset the trip odometer to 0.0.

0.0 (0.0) Turn left onto Geer Road.

0.3 (0.3) Geer Road crosses the Ceres Main Canal. Water is diverted from the Tuolumne River at La Grange Reservoir.

2.2 (1.9) Turn right (west) onto Service Road. TID Upper Lateral #2 parallels the road for the next 7 miles.

7.5 (5.3) Highway 99 overpass.

12.1 (4.6) Turn left (south) onto Carpenter Road.

13.1 (2.0) Turn right (west) onto Grayson Road.

17.5 (4.4) Turn right onto Broyle Road. Broyle Road is an unmarked, private, dirt driveway. Drive north on “Broyle Road”.

17.9 (0.4) TID Lower Lateral #2 crosses under “Broyle Road.”

18.1 (0.2) Pass to the left of the yellow shop and park under the eucalyptus trees.

STOP 8 – BIG BEND FLOODPLAIN AND RIPARIAN RESTORATION

The Big Bend project is a floodplain and riparian restoration project along the Tuolumne River west of the City of Modesto (figure 10). The project site includes approximately 49 acres of floodplain on the north side of the Tuolumne River and 186 acres of
floodplain on the south side of the Tuolumne River (figure 11). The site is a mix of cultivated farmland and riparian woodlands. Historically a portion of the property on the north side has been farmed in field crops while a portion on the south side has been planted in various orchards, row crops, or field crops. Both sides of the river contain significant amounts of riparian wetlands due to their topographically low elevation.

The project site is geomorphologically a part of the Tuolumne River floodplain and is subject to periodic damaging floods. The topography of the site varies from low floodplain terraces to high floodplain terraces with as much as a 12 foot difference between the lowest and highest areas on the site. The hydrology of the site has been altered by flow regulation at Don Pedro Dam, which has reduced the frequency, duration, and magnitude of high flows on the Tuolumne, thus reducing frequency, duration, and extent of inundation on the project site. Additionally, privately-constructed berms and levees further prevented inundation of agricultural areas, although under very high water and/or extended periods of high water, these levees were prone to fail. Over the past 25 years, the southern property has been inundated completely or in part in 1983, 1985, 1992, and 1997.

The Soil Survey for East Stanislaus County (U.S. Soil Conservation Service 1964) identifies three soil series (Columbia, Foster, and Riverwash) within the project area. The Columbia soils are made up of five different soil mapping units varying in texture, permeability, and available water holding capacity. Columbia soils occupy all of the northern property and most of the southern property. Foster soils occur in relatively small areas on the Venn property, near the wetland on the southwest end, and north and west of the manmade pond on the southeast end. Foster soils typically occur in oxbow depressions, are very poorly drained, and are slightly saline-alkali. Riverwash soils occur in a narrow band along most of the river on the Venn property. Riparian vegetation already exists in most of these areas. Additionally, soil pits revealed clay to sandy loams interbedded with strata of fine to coarse sand.

The goals of the restoration project are to improve the functionality of the floodplain to support riparian plant species, juvenile chinook salmon and steelhead. The objectives for the restoration project are:

- Improve channel-floodplain connectivity by increasing the frequency of floodplain inundation on the project site, improve natural regeneration of native riparian plant species, improve migratory and rearing habitat for juvenile chinook and steelhead and improve spawning, rearing, and migratory habitat of other native fishes;
- Preserve existing riparian vegetation and plant native riparian species on floodway surfaces appropriate for each species' life history;
- Remove invasive exotic vegetation;
- Provide for public education and involvement in the restoration activities on the northern property.
Figure 10. Tuolumne River Big Bend Floodplain and Riparian Restoration Project Location. (River Partners, 2004)
Figure 11. Aerial photography and field designation of the Big Bend Project. (River Partners, 2004)
Breaching the levees surrounding the properties was the key strategy employed for improving channel-floodplain connectivity. Through strategically located breaches, high flows would once again inundate historic floodplain surfaces; thus, reestablishing fluvial processes. In the autumn of 2004, fifteen notches were created on both properties, totaling 7,970 cubic yards of material.

The winters of 2005 and 2006 were both very wet years, and extended high flows were experienced on the Tuolumne in both years. As a result of the notches, the lowest areas on the southern property were flooded for about 3½ months in 2005, while moderately low surfaces were flooded for about 4 weeks. Even higher flows kept most surfaces inundated for 3 months in 2006.

Planting of the project site began in the autumn of 2004 and continues to the present. The vegetation mix has been prescribed based on soil type, depth to groundwater, and expected inundation frequency. Three forest types are planned, including Fremont cottonwood forest, valley oak forest, and valley oak savannah (figure 12).

**ROAD LOG TO RETURN TO COLUMBIA COLLEGE**

Drive south on “Broyle Rd” back to Grayson Rd. At Grayson Rd, reset the trip odometer to 0.0.

0.0 (0.0) Turn right onto Grayson Rd.

1.6 (1.6) Turn right onto Shiloh Rd.

4.5 (2.9) Shiloh Rd crosses the Tuolumne River. The confluence of the Tuolumne and the San Joaquin River is approximately 3.7 river miles downstream.

5.0 (0.5) Turn right onto Paradise Rd.

5.5 (0.5) Turn left onto Hart Rd.

7.5 (2.0) Hwy 132/Maze Blvd. Head straight through light.

9.5 (2.0) Straight through the Shoemake Rd 4-way stop.

11.5 (2.0) Turn right onto Bacon Rd.

13.0 (1.5) Bacon Rd jogs left at Toomes Rd. Stay straight on Bacon.

13.5 (0.5) Turn left onto Finney Rd.

14.0 (0.5) Take a “soft” right onto Broadway Ave into downtown Salida.
Figure 12. Big Bend Planting Design (River Partners, 2004).
14.4 (0.4) Cross Hwy 99.

14.5 (0.1) Broadway becomes Hwy 219/Kiernan Ave. Continue east on Kiernan Ave.

19.1 (4.6) Turn left on McHenry Ave/Hwy 108.

20.6 (1.5) Follow Hwy 108 as it bends to the right (east). Continue on Hwy 108 through Riverbank, Oakdale, and Jamestown to Sonora.

References


McBain & Trush and Vick, 2004. Tuolumne River Floodway Restoration, Project Design Approach and Rationale for Gravel Mining Reach (River Mile 34.3 to 40.3) and Special Run Pools 9/10 (River Mile 25.0 to 25.9)

River Partners, 2004. Riparian Restoration Plan for the Big Bend Project – Tuolumne River, River Miles 5.7 to 6.6, Stanislaus County, California.
