

**Case Study 18. French Creek Embedded Concrete Box Vented Ford****Location**

North central California, Plumas National Forest, on French Creek. Three miles northwest of Brush Creek and 15 miles northeast of Oroville, CA. Forest Road 22N34.

**Crossing Description**

This structure, constructed in 1981, is located on a perennial stream where fish passage and woody debris jams are issues of high concern. The structure has a long, low profile. It is a 15-foot-wide, 240-foot-long concrete structure with five concrete boxes across about 50 feet of active stream channel (figure A114). The boxes are set just below the streambed elevation and native streambed material covers most of the floor. The top of the ford, about 5 feet above the channel, has a metal grating driving surface. The structure required minor repairs and lengthening of part of the armored driving surface after some large storm events when large amounts of debris accumulated behind and on top of the structure. Due to flow acceleration over the smooth concrete surface through the boxes, a large plunge pool has formed downstream of the ford. To prevent the ford from being undermined, a long gabion “mattress” has been placed across the channel at the downstream edge of the structure .



Figure A114. Looking upstream at the French Creek vented ford.

**Setting**

Sierra Nevada Section (M261-E). Elevation 2,100 feet, within a granite batholith on the west side of the Sierras. The site is located in a “west-side” forest area with mixed conifers and moderate hardwoods, particularly tan oak and madrone.

## Appendix A—Case Study 18

### Why Was This Structure Selected?

The large box culvert with grated top design was selected to fit the geomorphic and hydrologic characteristics of the site, and to avoid the expense of alternative structures. This is a wide stream (over 50 feet) and a very broad flood plain with large peak flows that carry substantial amounts of both bedload and debris. Normal culverts would likely clog or have insufficient capacity, and a bridge would need to have a high profile and span several hundred feet to cover the large flood plain and avoid constricting it. These factors led to a choice of a vented ford that could withstand overtopping and could be easily cleaned out.

### Crossing Site History

This box culvert ford replaced an old railroad-flatcar bridge with log abutments, which severely constricted the channel and had washed out on several occasions. The crossing site is actually a poor location, on a river bend with a point bar and a broad flood plain. The crossing could not be relocated because of its location at an intersection, as well as existing road alignment and private property constraints.

### Road Management Objectives

This is a maintenance level 2 road, alternately native or gravel surfaced, and maintained for passenger vehicles. It has an annual average daily traffic count of 50 vehicles, and provides access between two Sierra Nevada foothill areas, Brush Creek and Chino Ridge. This route is often closed during the winter due to other problems along the road. Traffic is a mix of occasional logging traffic during a timber sale, USDA Forest Service administrative traffic, and general recreational traffic. Traffic volume and type are such that occasional interruptions are acceptable. Traffic interruption due to flooding occurs only once every several years, lasting approximately a few days.

### Stream Environment

**Hydrology:** French Creek is a perennial tributary to the North Fork of the Feather River, with a drainage area of about 29 square miles. Average annual precipitation is 50 to 55 inches, falling as a mix of rain and snow. Summer low flows are 20 to 50 cubic feet per second. The bankfull flow ( $Q_2$ ) is 960 cubic feet per second, and the design flow ( $Q_{100}$ ) is approximately 7,100 cubic feet per second. During major storm events ( $Q_{20+}$ ) heavy debris deposited in the trees along the stream suggests that the entire ford is inundated several feet deep. Peak flow velocities of 7 to 9 feet per second are expected. The structure is designed to pass 800 cubic feet per second under the deck, so the structure is overtopped every 1 to 2 years.

**Channel Description:** French Creek is an unentrenched C4 channel; bankfull width and depth are about 55 feet and 2 feet respectively (figure A115). The substrate is a well-graded mixture of sands, gravels, and cobbles, and there is considerable bed movement during storms. Channel slope is less than 1 percent. The crossing is located on a broad bend, and the ford crosses French Creek from a low terrace on the east side across a point bar-flood plain sequence on the west side. Heavy riparian vegetation, including willow, alder, and blackberry vines stabilizes the high outside bank. The five boxes match the stream bed width so that low flows pass the structure freely. However, to keep vehicles out of the water during normal high flows and maintain a level driving surface across the point bar, the slab is raised 2 to 3 feet above the point bar. This induces some scour immediately downstream of the structure as water pours over the raised slab.



Figure A115. Looking upstream from the ford at French Creek.

**Aquatic Organisms:** This section of stream provides habitat for rainbow trout and a variety of nongame fish and providing fish passage is a key issue. Stream-channel material that has filled in the bottom of most of the boxes shows that water velocity in the boxes is similar to the natural channel at moderate flows. This makes it likely most, if not all, swimming species can pass the structure.

**Water Quality:** Sediment delivery in this watershed is a moderate concern. Water quality in the stream is relatively good and should not be degraded.

## Appendix A—Case Study 18

### Structure Details

**Structure:** The structure was designed by the Plumas National Forest and constructed under a Public Works Contract. The project took 100 days to construct and required a total of 140 cubic yards of concrete, 190 cubic yards of gabions, and 77 cubic yards of Class VII riprap. The structure is made with five box culverts, with each concrete stem wall 1-foot thick. Each concrete box is 9 feet wide by 4 feet high, and they are embedded 6 to 12 inches below the natural stream channel bottom elevation to maintain streambed continuity through the structure (figure A116).

Four-foot deep concrete cutoff walls are located along the upstream and downstream edges of the structure (figure A116). Gabion mattresses protect both edges from scour. The raised concrete driving surface over the boxes and across the flood plain extends for a total of 240 feet.

The driving surface is 1 to 2 feet above bankfull elevation so as to pass bankfull flows and small debris. Across the active channel this capacity was good, but the raised concrete slab roadway across the flood plain has caused a “damming” effect which has led to upstream debris deposits and downstream scour.

During construction, water was bypassed around the west side of the structure while the concrete boxes were poured and backfilled. Then the removable metal deck grating was added, the flow returned to its natural channel location (through the boxes), and the ford approaches were constructed.

**Bank stabilization and approaches:** The ford slopes gently into the drainage at 5 percent on the west side and is nearly flat to the east across a broad flood plain. The approaches are not surfaced. Bank stabilization includes riprap of large boulders and willows (figure A118a). Both gabions and concrete blocks were placed along the downstream edge of the elevated driving surface across the flood plain areas (figure A118b).

**Cost:** Construction cost of this vented ford in 1981 was about \$155,500.

**Safety:** The structure has a 6-inch-high steel curb along both sides of the road as a traffic safety measure. The crossing is on a tangent section of road, near an intersection, so there is excellent sight distance and visibility. The structure is not signed, but road use is unlikely on this remote road during storms when the structure is overtopped.

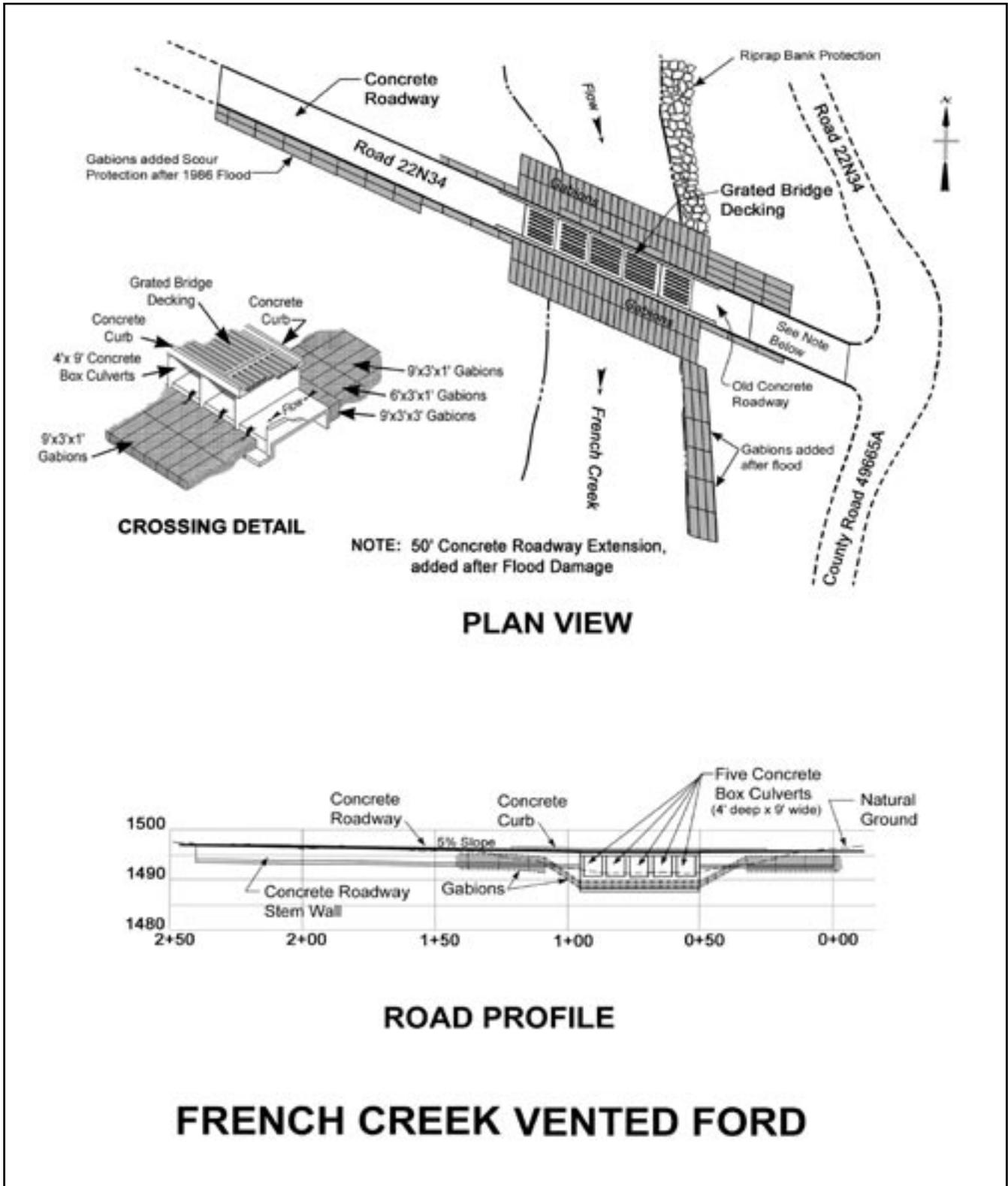


Figure A116. Site plan view with valley and road profile sketches.

## Appendix A—Case Study 18

### Flood and Maintenance History

The vented ford was slightly damaged by scour in 1982, the year after it was constructed, and again during a flood in 1986. In 1986, the structure was overtopped and a scour hole formed in the roadway where the original concrete armoring ended (figure A117). The concrete roadway surface with 3-foot deep cutoff walls was extended 50 feet on the east side, covering the area of scour. Also some energy dissipation measures were added along the downstream edge of the structure where the water flows over the concrete slab roadway. Large articulated concrete blocks were used, as well as some additional large riprap (figure A118b).



Figure A117. Scour around the east end of the structure after the 1986 flood. The concrete driving surface was then extended 50 feet.

In the 100-year event of 1997 the entire structure was plugged with debris, as seen in figure A119, causing the channel to move to the west side of the structure, in the flood plain area. The original channel was cleared and flow returned to the main channel. The structure itself was not damaged.



Figures A118a and A118b. Scour protection measures a) using riprap with vegetation along the channel (left) and b) concrete blocks and gabions along the elevated roadway (right).



Figure A119. Debris dammed the structure during the 1997 flood event. The main thread of flow shifted to the west and is spilling over the elevated roadway. The white sand deposited everywhere except the higher forested ground in the upper left and lower right of the photo shows that almost the entire area was flooded in 1997. The area that was scoured east of the ford in 1986 is also delineated.

## Summary and Recommendations

The French Creek crossing is a relatively massive integral concrete box structure with a steel grating driving surface (figure A120). It is designed to withstand major storm flows and major sediment movement, and to resist significant scour. The site is poor because it has a broad flood plain where channel processes can be disrupted by a blockage such as the raised slab. In addition, the stream can shift its location during floods when the structure plugs with debris. A narrower, more entrenched channel location would have been a better site for a crossing. A few hundred feet above the crossing site is a straight and more confined reach of French Creek. Both banks at that location are 8-foot high, and there is no flood plain. A bridge at this site would have had less site problems, but would have been a much more expensive structure. Also other site constraints prevented relocating the road.

A ford is an appropriate structure compared to culverts which would plug and overtop more frequently, or a much more expensive bridge at a location unlikely to be used during major storm events anyway. The heavy debris load in the watershed requires maintenance of the structure after each major flow. The original structure should have been made

longer to protect the entire wetted perimeter, and the boxes should have been set slightly deeper to ensure full coverage of the box floors with natural streambed material. However, the floors are already approximately 90-percent covered and subsequent repairs have added the necessary downstream scour protection. Also the roadway elevation should have been set a couple feet lower across the flood plain to prevent the water drop over the roadway and subsequent scour in this area.



Figure A120. Looking downstream at the vented ford with point bar on right.

Gordon Keller, geotechnical engineer on the Plumas National Forest, provided information and photos for this case study.

