Case Study 15. Moonlight Crossing Concrete Box Vented Ford

Location

Northeastern California. Plumas National Forest. On Lights Creek, 8 miles north of Taylorsville, CA., Forest Road 29N46 near the intersection with Plumas County Road PC213.

Crossing Description

This large concrete box vented ford, reconstructed in 2000, is located on Lights Creek, a perennial fisheries stream. Previous crossing structures had caused upstreamaggradation and downstream degradation, and there was an 8-foot elevation drop at the site. The vented ford is designed to prevent lowcutting from progressing upstream.The structure is a trapezoidal shape over four reinforced-concrete box culverts, one containing a fish ladder (figure A97). The roadway surface across the ford, including the steel cattleguard and the 6-inch-thick reinforced concrete approach slab, is 15 feet wide and 109 feet long. The driving surface over the boxes (across the active channel) is 32 feet long.

Figure A97. Moonlight crossing with fish ladder 2001.

Water flowing over the smooth concrete surface of the apron, drops into a large plunge pool, approximately 50 feet across, which is lined with large stone riprap.

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Setting

Eastern Sierra Nevada, Section (M261-E). Elevation 3,700 feet, within a metamorphic unit of the northeastern Sierra Nevada. Mid-forest area of mixed conifer and oak hardwoods.

Why Was This Structure Selected?

After a preliminary evaluation of costs and alternatives by the U.S. Army Corps of Engineers, a ford structure was selected and designed by the Plumas National Forest. The structure was constructed under a Public Works Contract. This design was selected for four main reasons: 1) Fish passage is a key concern, so a fish ladder was incorporated into the design; 2) The structure needed to be massive and strong enough to withstand the power of the stream. A previous structure had been repaired and failed twice; 3) The cost of a bridge was prohibitive (twice as much); and 4) A grade control structure was needed to maintain the 8-foot difference in elevation between the upstream and downstream stream channel levels.

Crossing Site History

The previous, possibly original structure was a lightly constructed concrete slab over seven 24-inch culverts. The culverts exited onto a grouted rock apron that sloped down to the much lower streambed. During the major 1986 storm event part of the downstream apron was undermined and new large boulders and concrete grout (figure A98) were placed at that time. Also a small fish ladder was built on the east side of the structure below one culvert pipe. This structure again washed out in 1997, undermining the concrete slab (figure A99). Most likely the downstream depth of riprap was inadequate and the toe of the apron was undermined by scour, leading to progressive failure of the entire apron (figure A100). Also during the low-flow years the pipes tended to plug up because of their small size and the high sediment load in Lights Creek.

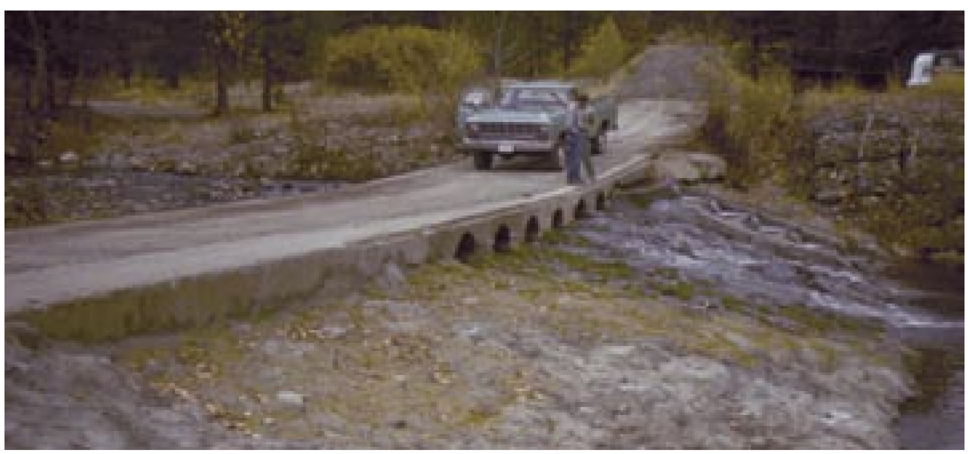

Figure A98. Moonlight Crossing prior to the 1997 flood. Note the weakly grouted small riprap armoring the downstream apron. There was no cutoff wall.

Figure A99. Damage to the Moonlight low-water crossing after the 1997 flood. The downstream rock armoring was undermined and washed away, partially undermining the concrete slab driving surface.

Figure A100. Moonlight crossing in 1999 prior to construction of new structure.

Road Management Objectives: This is a maintenance level 3 road, gravel surfaced, and maintained for passenger vehicles. Road use is a mix of occasional logging traffic during a timber sale, USDA Forest Service administrative traffic, and general recreational traffic. One residence uses this crossing as access. This road has an annual average daily traffic count of 100 vehicles, and provides access from Indian Valley to the Westwood area on the Lassen National Forest. The through route is closed during the winter, though the section of road at the ford is rarely closed. Traffic volume and type is such that occasional interruptions are acceptable. Traffic interruption is considered likely to occur every few years and last several days each time.

Stream Environment

Hydrology: Lights Creek is a perennial stream draining about 47 square miles and is tributary to Indian Creek and thence to the North Fork of the Feather River. Average annual precipitation is approximately 40 inches. The upper reaches of the watershed are snow dominated, and rain-on-snow events produce large flows. Summer low flows are of the order of a few cubic feet per second. Flood debris deposited among the trees on the streambank suggests that the most recent 100-year flood in 1997 inundated the entire channel and was several feet deep above the streambanks. Bankfull flow is estimated at 380 cubic feet per second. The 100-year peak flood flow (Q_{100}) is estimated at 5,750 cubic feet per second.

Channel Description: Lights Creek underwent severe downcutting prior to the installation of this grade control structure, and some aggradation has occurred upstream. The upstream banks are about 3 feet high and stable, with riparian vegetation including willow, cottonwood, alder, and pine trees as well as some shrubs (figure A101a). The channel is narrow with easy access to a wide flood plain on the right-hand bank. Downstream, the banks are over 8 feet high, nearly vertical, and subject to scour and raveling. The channel is over 60 feet wide and widening, forming mid-channel bars, without flood-plain access (figure A101b). Channel slope was measured to be about 1 percent. The streambed is made of a well-graded mixture of sands, gravels, and cobbles. Occasional boulders exist to a maximum size of 8 inches.

Figures A101a and A101b. Lights Creek a) upstream and b) downstream of the ford.

Aquatic Organisms: Providing passage for fish is a key issue at this location. This section of stream provides habitat for nonthreatened native brown and rainbow trout, as well as nongame species. How effective the fish ladder is in providing passage for all fish and lifestages in the stream is unknown. The large pool downstream of the structure aids fish passage through the structure by providing a resting area and take off point for the jump into the ladder (figures A102 and A103).

Figure A102. Detail of the fish ladder built into the Moonlight Crossing.

Figure A103. Roadway across the Moonlight ford.

Water Quality: Sediment delivery and movement in this watershed is an important concern. The structure is being used as a grade-control structure to prevent the movement of massive amounts of fine and coarse sediments presently stored in the channel upstream of the ford. Water quality in the stream is relatively good.

Structure Details

Structure: The structure consists of four, 3.1-foot deep by 6.5-foot wide concrete boxes covered with a removable metal cattleguard-like grating (figures A104a and b). Massive concrete was used because of previous failures of grouted riprap. The roadway surface has a well defined dip to insure that flows stay over the structure and do not go around the structure. The vents have a capacity of about 500 cubic feet per second. A fish ladder with six step-pools is built into the eastern-most concrete box. This fish ladder design was developed in consultation with personnel from the California Department of Fish and Game.

The project took approximately 5 months to construct and required a total of 150 cubic yards of concrete. Because of the complexity of the site there was a 1-foot error in the elevations at the bottom of the structure, such that the downstream lip of the apron is 1-foot higher than designed. This causes a 6-inch drop to the downstream pool level. If this pool level drops, it may be a problem for access to the fish ladder and may require additional downstream work.

Bank and bed stabilization, and approaches: The immediate approaches are concrete and slope steeply into the drainage at 14 percent (figure A104a). Considerable Class VIII and Class XII riprap (4-foot-plus-diameter boulders) was placed along the approaches, along the downstream 6-foot-deep cutoff wall at the downstream edge of the concrete spillway, and at the downstream edge of the plunge pool to form a grade control structure (figure A104c).

Also a vortex weir structure made with 3-foot-diameter boulders was placed across the channel 130 feet upstream of the structure to direct the flow towards the vents.

Cost: The structure was totally reconstructed in 2000 for a cost of $240,000. Local materials were used as much as possible. The rock source for this project was a local on-forest quarry.

Safety: The structure has a low (8-inch high) steel curb along both sides of the road, with a low enough profile to prevent major accumulation of debris. The crossing is marked with object markers at each approach, and it is located on a tangent section of road, so safety appears adequate for its use. There are no safety warning signs or depth markers. The metal grating is reported to be “slippery when wet.”

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Flood and Maintenance History

The structure suffered no damage from moderate flood flows in January 2006. However, because of the large amount of large woody debris moving through this channel and the relatively small size of the vents, the vents have plugged up with debris several times. They require annual cleaning, making the structure a maintenance headache.

Summary and Recommendations

Moonlight Crossing on Lights Creek is a relatively massive integral concrete box structure with a cattleguard driving surface designed to withstand major storm flows, major sediment movement, and to resist significant scour potential. The cost and effort were large but necessary to prevent the structure from failing, to keep the road open most of the time, and to prevent both the upstream migration of a headcut and the downstream movement of the large volume of sediment accumulated above the crossing. Repairs may someday be needed downstream of the structure to hold or raise the elevation of the downstream plunge pool, prevent a waterfall, and keep the fish ladder functioning.

Had the amount of debris moving through the drainage been better understood, several alternative designs would have been considered, such as: larger vents, tapering concrete wings in front of the boxes to help the debris float up over the structure, or a short span, low-water bridge. The structure is functioning well, but does cause excessive annual maintenance work cleaning the concrete vents.

More communication and a more careful review of the design during construction might have prevented the 1-foot elevation error. Approaches leading to the structure should be paved as the gravel roadway surface constantly ravels onto the concrete approach slabs.

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

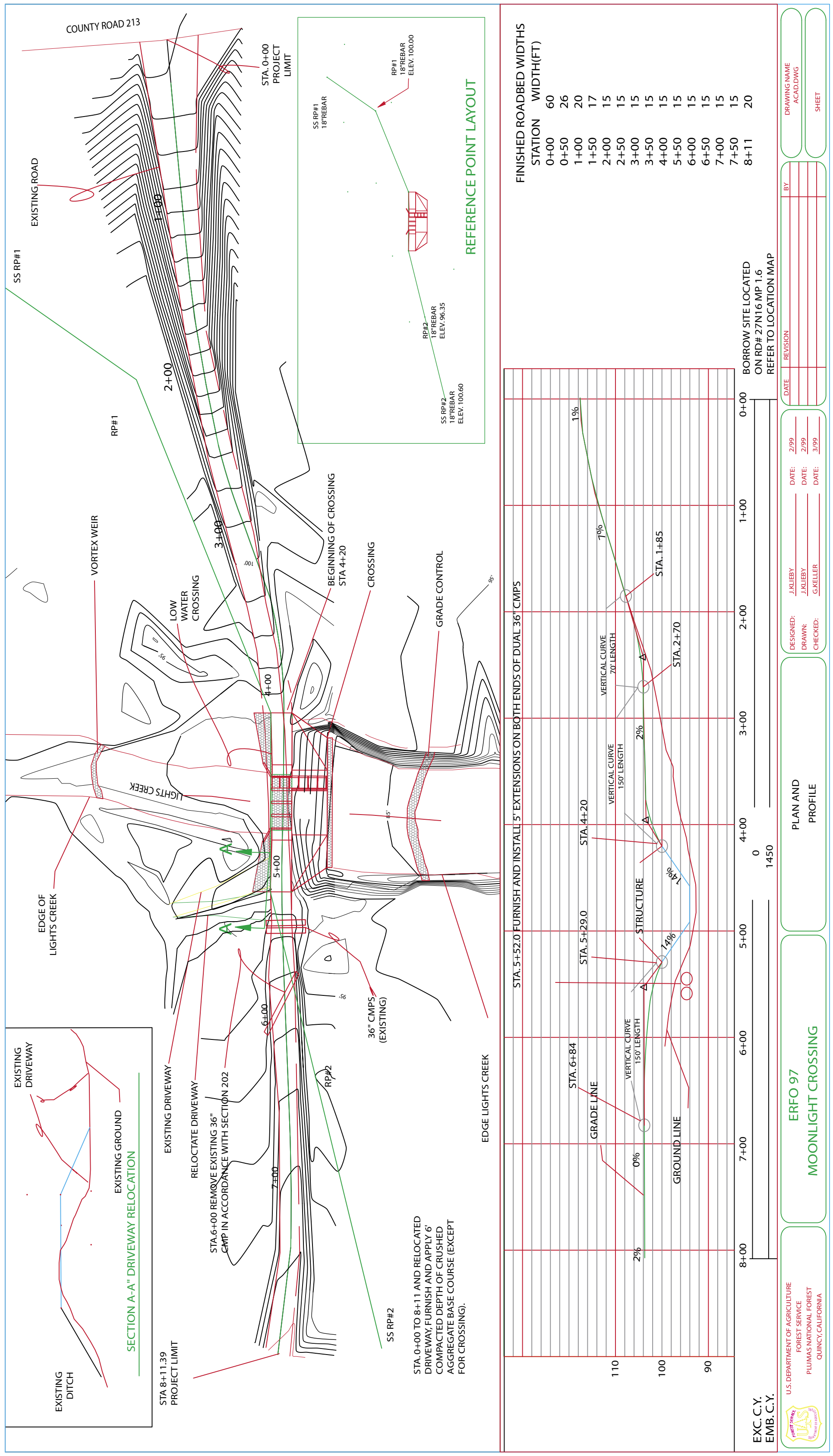

Figure A104a—Contract drawings; (a) site plan and profile. A full size drawing may be found on the CD included in the back of this publication.

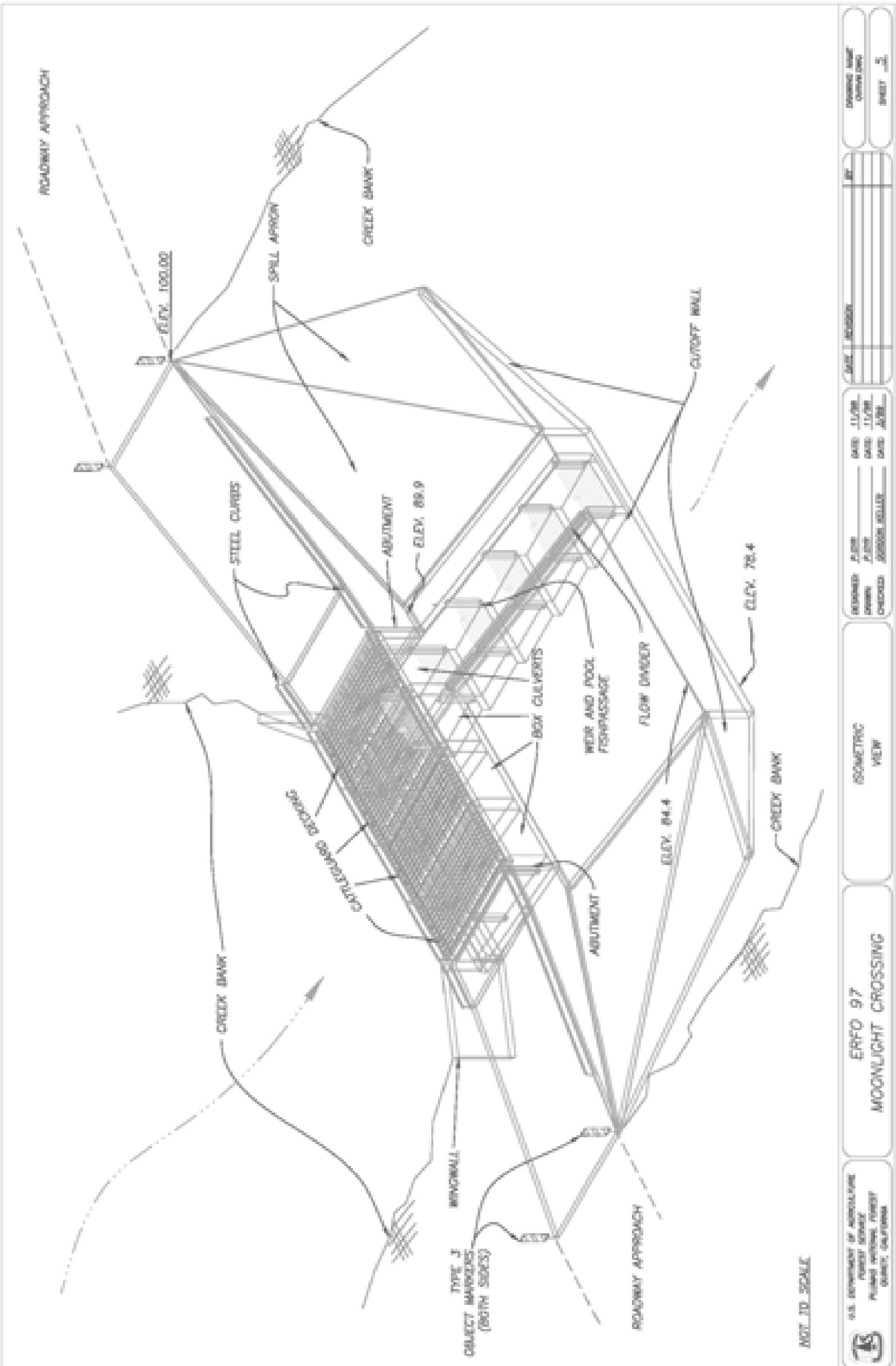

Figure A104b—Contract drawings; (b) isometric view. A full size drawing may be found on the CD included in the back of this publication.

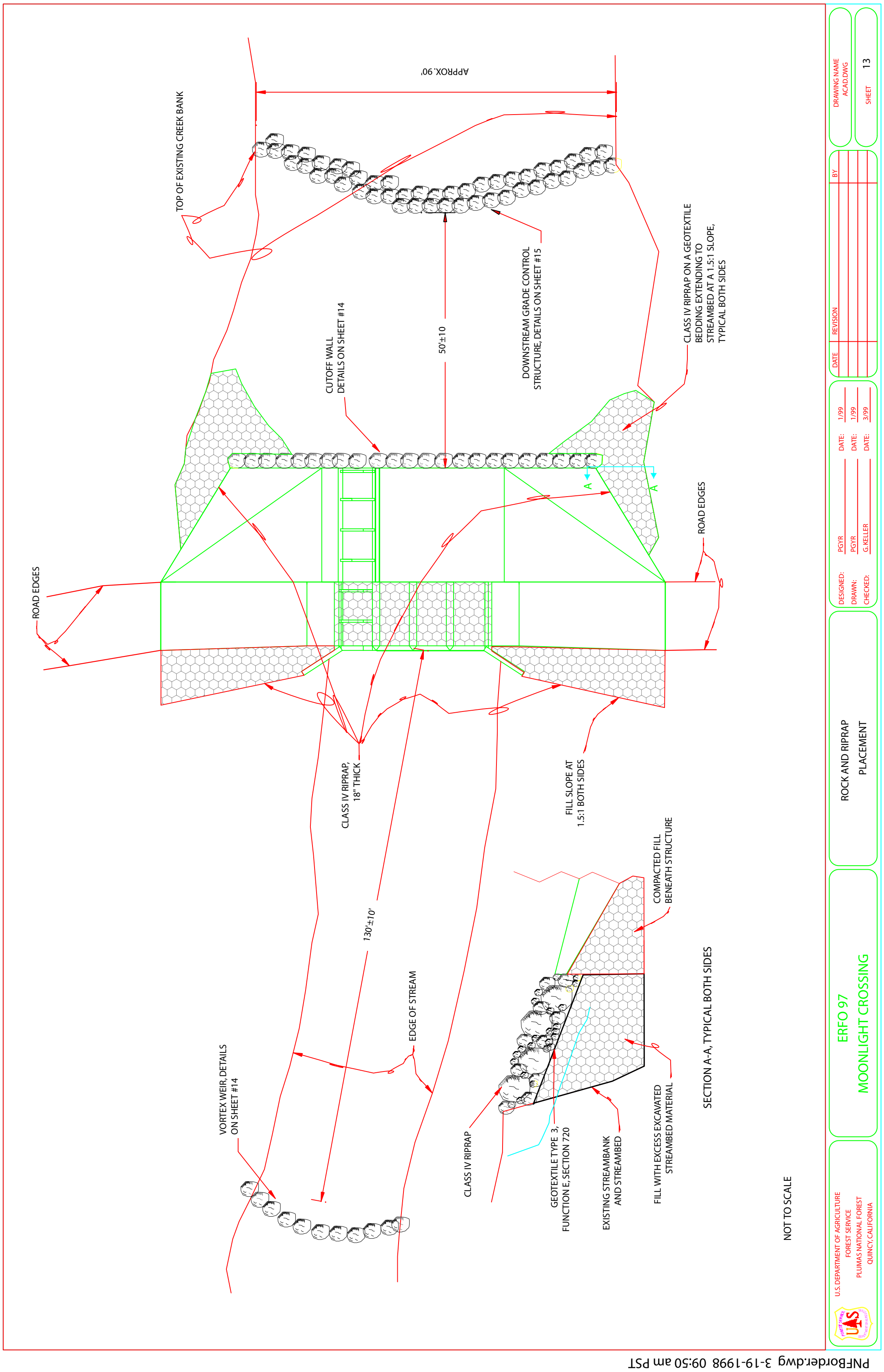

Figure A104c—Contract drawings; (c) rock placement. A full size drawing may be found on the CD included in the back of this publication.