
Case Study 2

**Goode Road/Cottonwood Creek,
Hutchins, Texas**



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Cover photo: Panoramic view of the completed Cottonwood Creek,
Hutchins, Texas, project

Advisory Note

Techniques and approaches contained in this handbook are not all-inclusive, nor universally applicable. Designing stream restorations requires appropriate training and experience, especially to identify conditions where various approaches, tools, and techniques are most applicable, as well as their limitations for design. Note also that product names are included only to show type and availability and do not constitute endorsement for their specific use.

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Introduction

The Goode Road/Cottonwood Creek Project is the first streambank soil bioengineering project implemented by the Texas Department of Transportation (TxDOT). The significance of this case study is that it was implemented successfully in a hot climate area where five challenges were encountered:

- climatic constraint
- plant physiological limitation
- construction schedule conflicts
- shortage of qualified contractors
- insufficient technical guidance

Beginning in 1996, an existing TxDOT bridge on Goode Road in Hutchins, Texas, a few miles southeast of Dallas, was closed due to severe erosion on its abutment and a roadway embankment failure. The bridge, built in the 1960s, crosses Cottonwood Creek and is a single span timber plank structure (fig. CS2-1). In the 1990s,

Figure CS2-1 Original timber-plank bridge structure



Cottonwood Creek experienced large flows after some storm events, and these flows occasionally overtopped the bridge. Because Goode Road's west-facing embankment is also a streambank of Cottonwood Creek, the roadway embankment was severely eroded by the flow (fig. CS2-2). Specifically, a sewer and a water line crossing the creek caught large amounts of debris, which indirectly led to erosive currents downstream. In 1998, TxDOT sought to reopen Goode Road by replacing the old bridge and stabilizing the streambank. The Texas Transportation Institute (TTI) worked with TxDOT engineers and designed the streambank reinforcement using both soil bioengineering methods and traditional structures. Vegetated geogrids, dormant post plantings, turf reinforcement mats, and gabion mattresses were used to stabilize roadway embankments, creek banks, and bends.

Design methodology

Drainage study

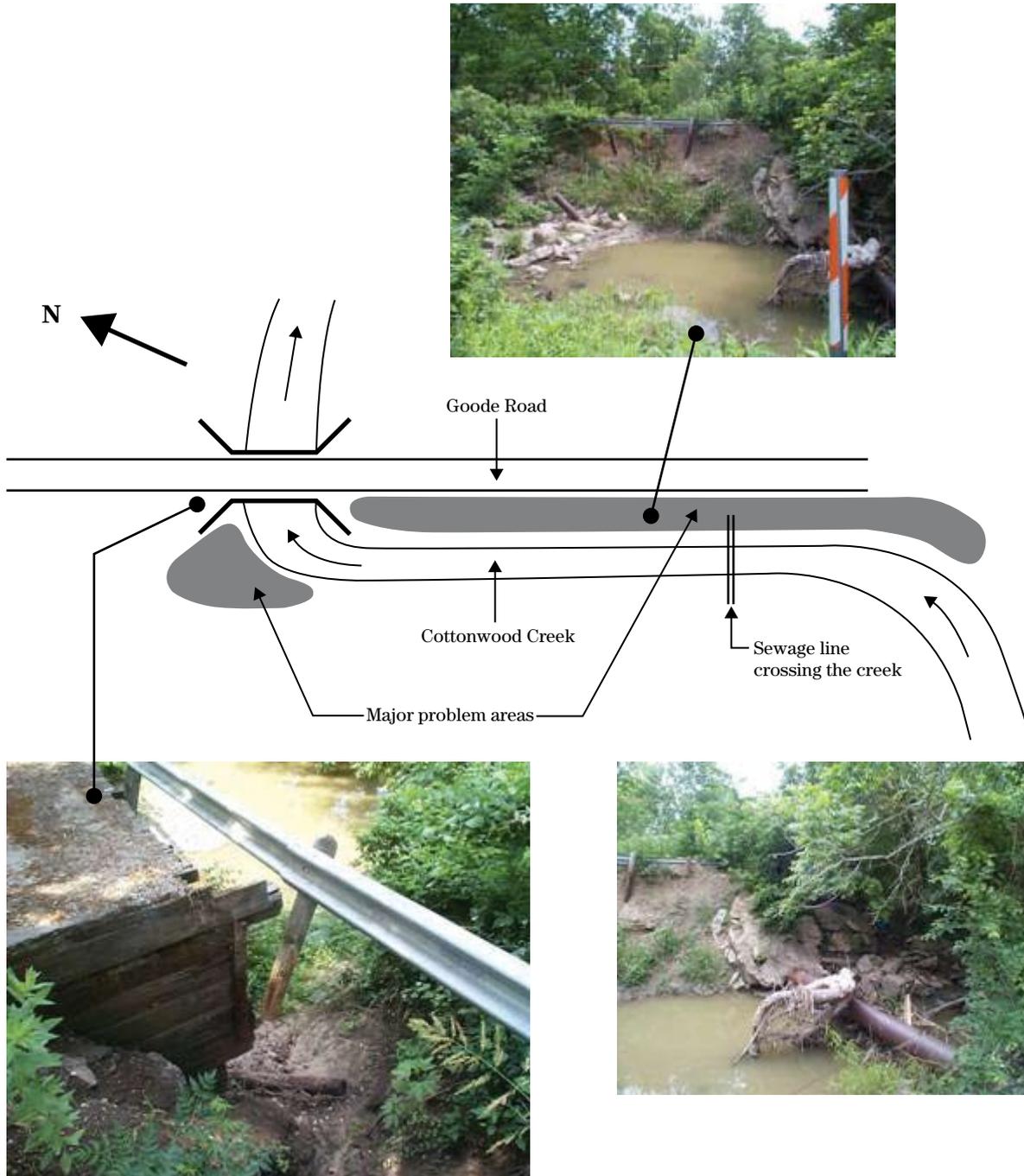
At the early design stage, TxDOT conducted a drainage study to determine the new bridge elevation. The proposed bridge was designed according to the following criteria:

- cost-effectiveness
- passing the 50-year flood with a headwater elevation that is less than the water surface elevation encountered with the existing structure
- passing the 100-year flood at a water surface elevation that is no greater than that calculated using the existing conditions, thus theoretically not encroaching on the 100-year flood plain

Cottonwood Creek at Goode Road flows in an easterly direction and drains east to the Trinity River. The drainage basin affecting Cottonwood Creek is approximately 13.1 square kilometers. The Goode Road bridge drainage basin located in a suburban section of southeast Dallas currently has single-family parcel areas and some parcels with one to several hectares.

The U.S. Army Corps of Engineers (USACE) HEC-RAS computer program (USACE 1995a) was used to calculate water surface profiles of the proposed design condition. Results of the proposed design were compared

Figure CS2-2 Goode Road was closed due to scouring of the roadway embankment and abutment areas.



with the modeling results of the original bridge design conducted by the Federal Emergency Management Agency (FEMA). It was concluded that the proposed single-span bridge structure would decrease the water surface elevation from that of existing conditions. The bridge design and bridge deck elevation were determined on this basis.

Shear stress

The project team used the water surface profile and creek channel slope data to calculate the mean shear stresses on the creekbank and bottom during flood events. The 100-year flood was used to determine the flow depth at approximately 5.3 meters. The creek channel slope was 0.3 percent. The shear stress on the creek bottom approximately equals (water specific weight)×(depth of water)×(channel slope) = $9.81 \text{ kN/m}^3 \times 5.3 \text{ m} \times 0.003 = 156 \text{ Pa}$. This shear stress was considered in selecting streambank soil bioengineering techniques for eroded areas.

Soil data

Soil borings were conducted on the center of the existing roadway to investigate the soil type and profile. Clayey and sandy clay soils were under the road base and were considered *in situ* soil. Limestone was found 6 to 7 meters below the road surface and was also the creekbottom material.

Soil bioengineering measures

Gabion mattress

Streambank soil bioengineering methods are not applicable where there is little or no sunlight. Gabion was chosen to complement this weakness of soil bioengineering methods. Gabion mattress composed of wire cages and rocks was used to stabilize the bridge abutment (fig. CS2-3). The flexibility of installation on irregular areas, as well as shady spots, makes gabion mattress practical to this project.

Vegetated geogrids

Vegetated geogrids (U.S. Department of Agriculture (USDA) Natural Resources Conservation Service (NRCS) 1996b) were the primary stabilization measure for the west-facing roadway embankment, which is also the creek bank (fig. CS2-4).

This technique was chosen because the shear stress level that can be sustained by vegetated geogrids is intermediate from 145 to 290 pascal (Li and Eddleman 2002), which brackets the calculated 156 pascal shear stress from a 100-year flood. In addition, the sandy clay onsite can be protected from erosion by geotextiles used in this technique. Rocks of 0.15 to 0.3 meters, wrapped by geogrids, were used at the bottom layer as the foundation and to protect the toe area. This stabilization method provides immediate streambank protection at the early stage after installation.

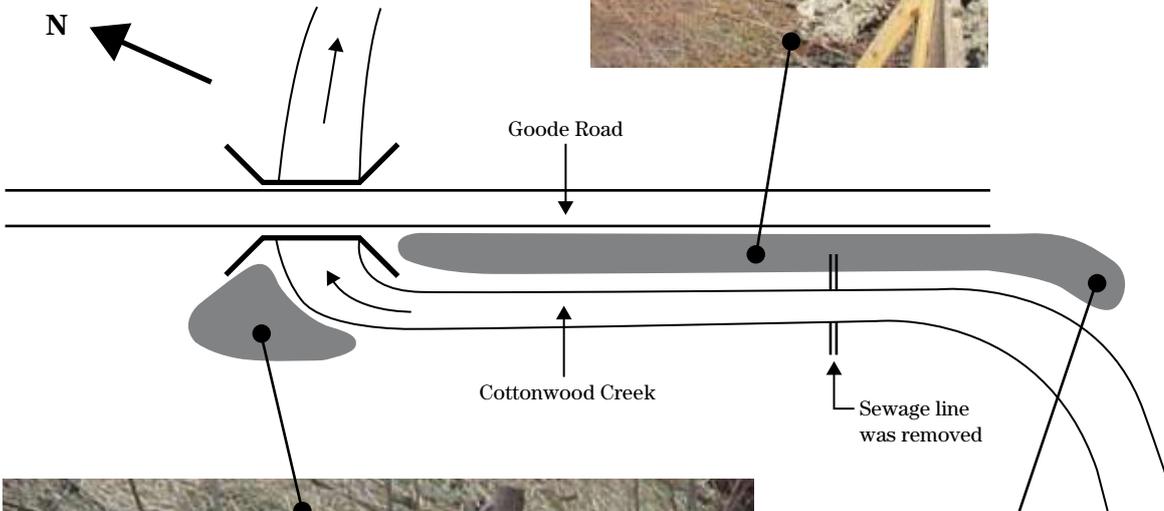
Black willow (*Salix nigra*) was used in this project because it is native and widely available in public rights-of-way. Cutting size ranged from 25 to 38 millimeters in diameter and from 1.5 to 2.7 meters in length. Approximately 33 to 40 cuttings were used per linear meter of streambank, and 3.65 meters of geogrid reinforcement were installed into the streambank for each layer. Roadway embankments and streambanks of 6 to 7 meters in height were built with this vegetative geogrid technique. No supplemental irrigation was provided after the installation.

Figure CS2-3 Gabion mattress was used for the bridge abutment area.



Figure CS2-4 Vegetated geogrids and dormant post plantings are the two primary streambank soil bioengineering measures.

Vegetated geogrids were used for stabilizing banks and roadway embankments.



Dormant posts were used in two creek bends.

Dormant post plantings

Dormant posts (USDA NRCS 1996b) of black willow (*Salix nigra*), 76 to 127 millimeters in diameter, were installed on two creek bend areas (fig. CS2-4). Boulders of 0.3 meters or larger were keyed into the toe of the bend areas to protect the streambank. In addition, turf reinforcement mats were installed along with the dormant posts to reduce the surface erosion.

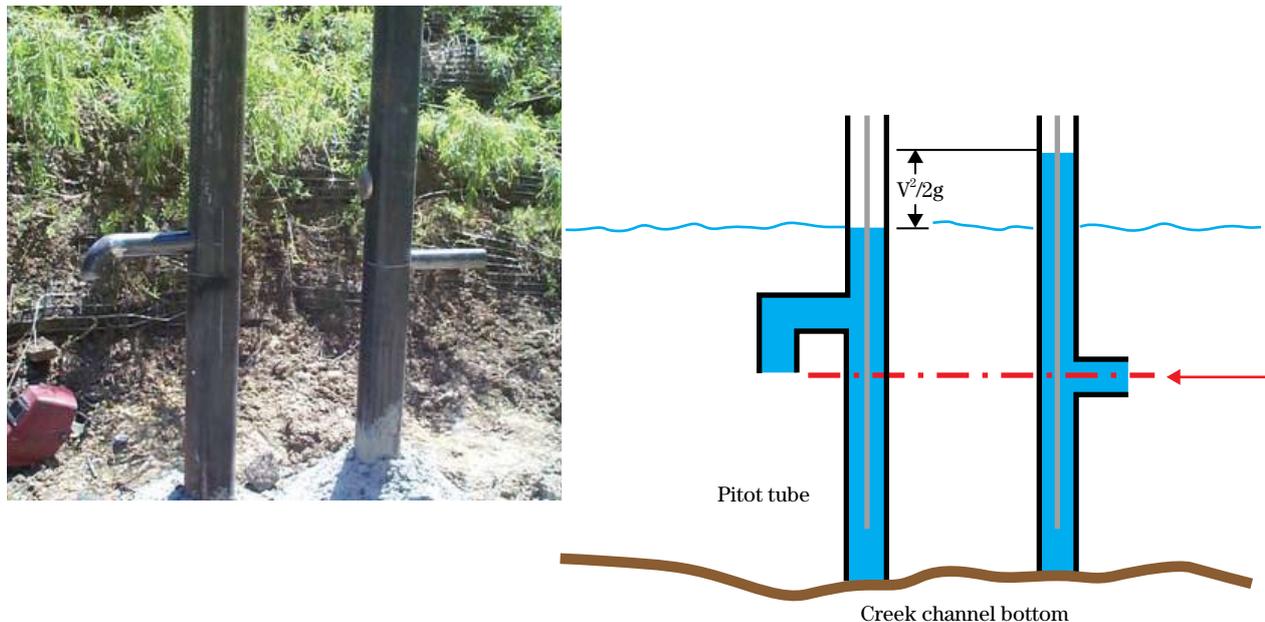
Project results

TxDOT spent approximately \$466,400 to replace the bridge, repave the road, and stabilize a streambank of 160 meters. Four layers of vegetated geogrids were installed. The construction activities and timing are listed in table CS2-1. The construction of streambank stabilization was completed in March 2001, followed by the postproject evaluation. Monitored variables include creek flow velocity (point measurement (fig. CS2-5)), flow elevation (point measurement), channel

Table CS2-1 Sequence of construction activities

Activity	Time
Relocation of utility lines (sewer line, drinking water line, and power line)	Jan. 2001
Earth grading	Feb. to May 2001
Harvest of dormant black willow cuttings	Feb. and Mar. 2001
Construction of vegetated geogrids	Mar. 2001
Construction of dormant post plantings	Mar. 2001
Construction of gabion mattresses	May 2001
Placement of bridge beams and decks	June 2001
Construction of road bed and paving	July and Aug. 2001

Figure CS2-5 Water level data loggers inserted in two standpipes to monitor water elevation and velocity



profiles, and survival rate of installed cuttings. Monitored cross sections and the standpipe location for velocity monitoring are presented in figure CS2-6.

Three years after the construction, the monitoring results of this project indicate that the streambank has sustained several high-flow events, the survival rate

of willow cuttings are above 90 percent even though no supplemental irrigation was provided, and channel deformation is within an acceptable range (figs. CS2-7, CS2-8, and CS2-9). In summary, this project demonstrates the successful use of soil bioengineering to complement traditional structural streambank stabilization techniques in hot climate areas.

Figure CS2-6 Project plan

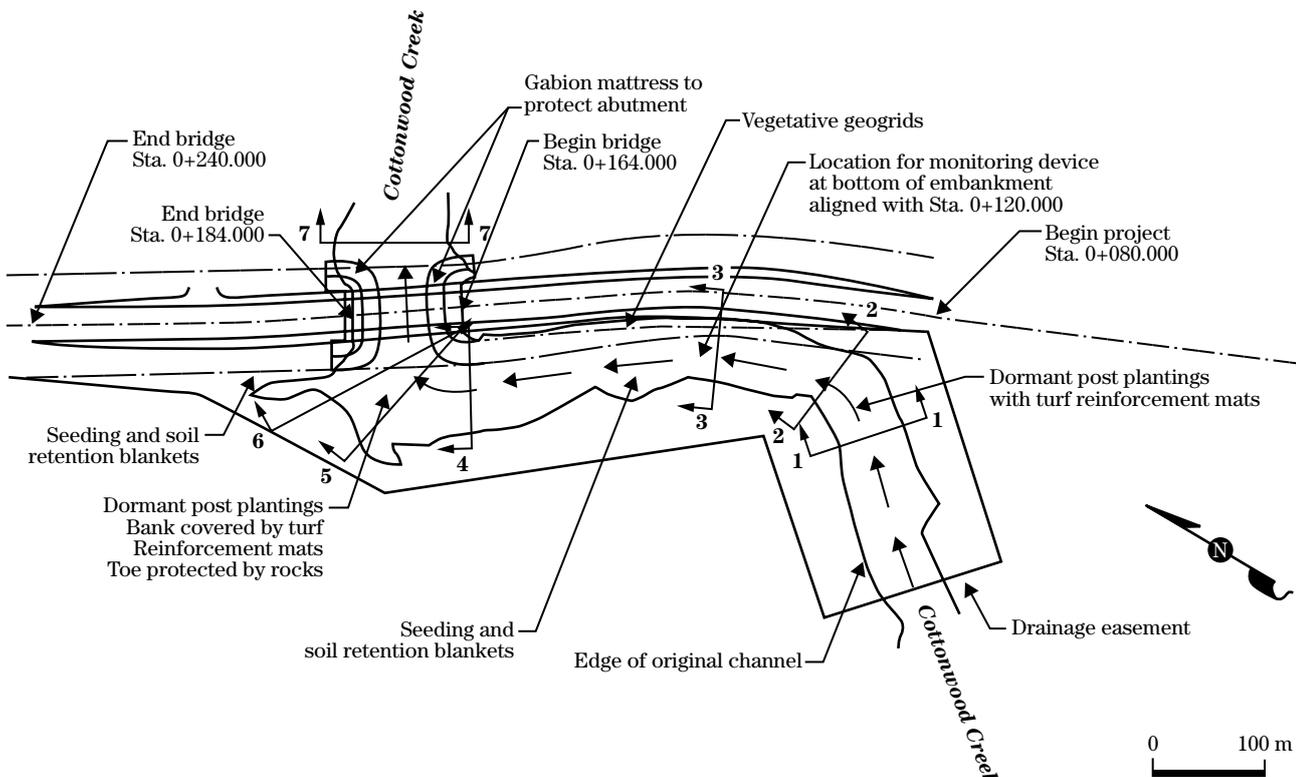


Figure CS2-7 (a) Mar. 2001—Goode Road embankment was stabilized with vegetated geogrids. The opposite bank on the left was protected with soil erosion blankets; (b) Apr. 2003—biomass increases with time; (c) May 2002—black willow covered the entire bank 1 year after construction.

(a)



(b)



(c)



Figure CS2-8 (a) May 2001—dormant black willow posts installed on the first creek bend. Rocks were used to protect the toe area; (b) Nov. 2002—black willow covered the bend 1 year after construction.

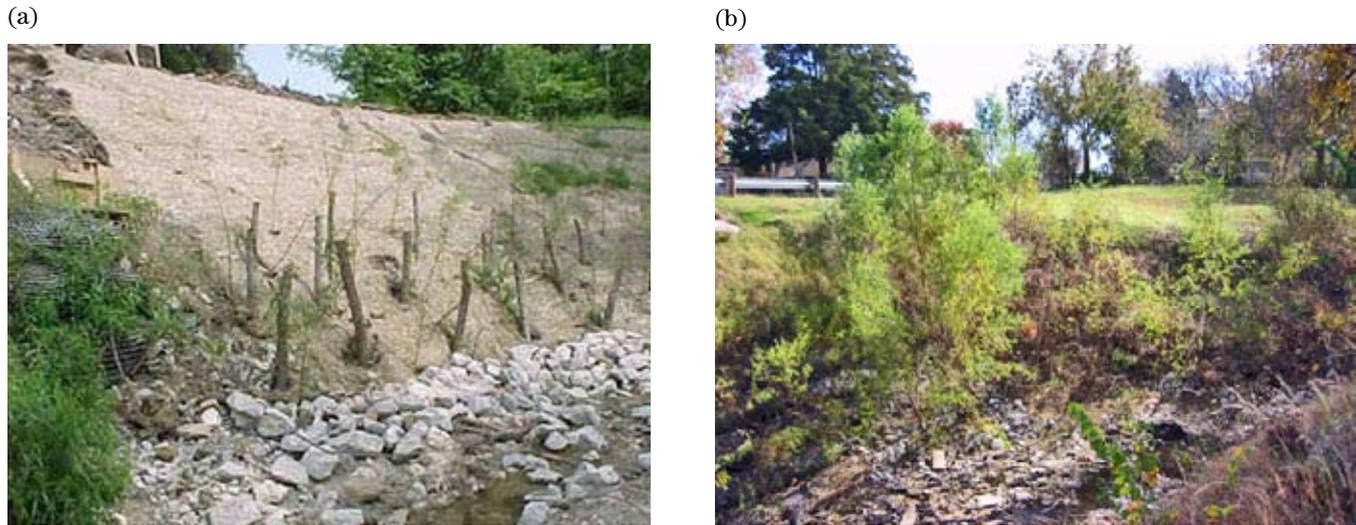


Figure CS2-9 (a) May 2002—panoramic view of the project; (b) Sept. 2003—postproject conditions (view from the top of the bridge to the creek)

(a)



(b)



