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**Cover photo:** Treated section of Coffee Creek in Edmond, Oklahoma

### **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.

## Case Study 16

## Coffee Creek, Edmond, Oklahoma

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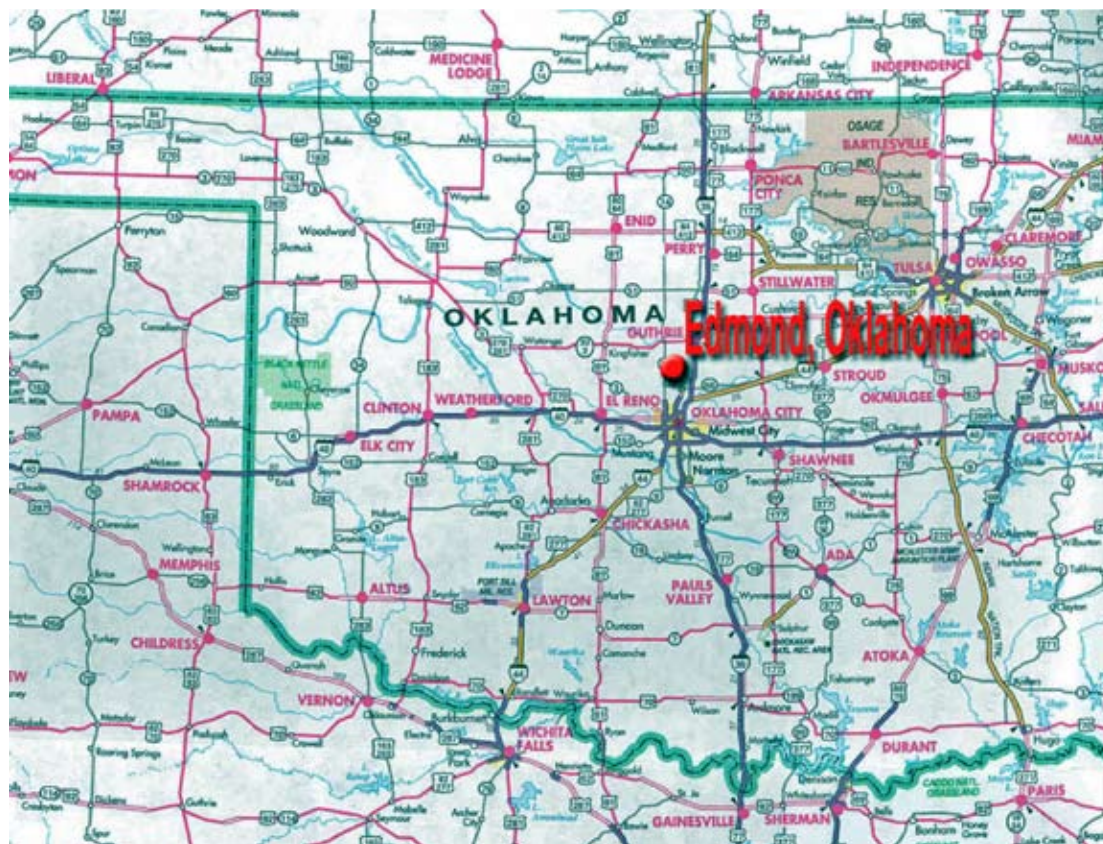
Steeplechase subdivision in Edmond, Oklahoma (fig. CS16-1).

The U.S. Department of Agriculture (USDA) Natural Resources Conservation Service (NRCS) provided grant funding through the Emergency Watershed Protection (EWP) program, covering 75 percent of the costs for the design and construction of channel improvements to protect nearby homes and public utilities. The project area is comprised of the reach of Coffee Creek that begins upstream of Coltrane Road at the confluence between Coffee Creek and Coffee Creek Tributary No. 3 and extends upstream approximately 2,300 feet (fig. CS16-2). Coffee Creek lies within a Federal Emergency Management Agency (FEMA)-regulated Zone AE flood plain.

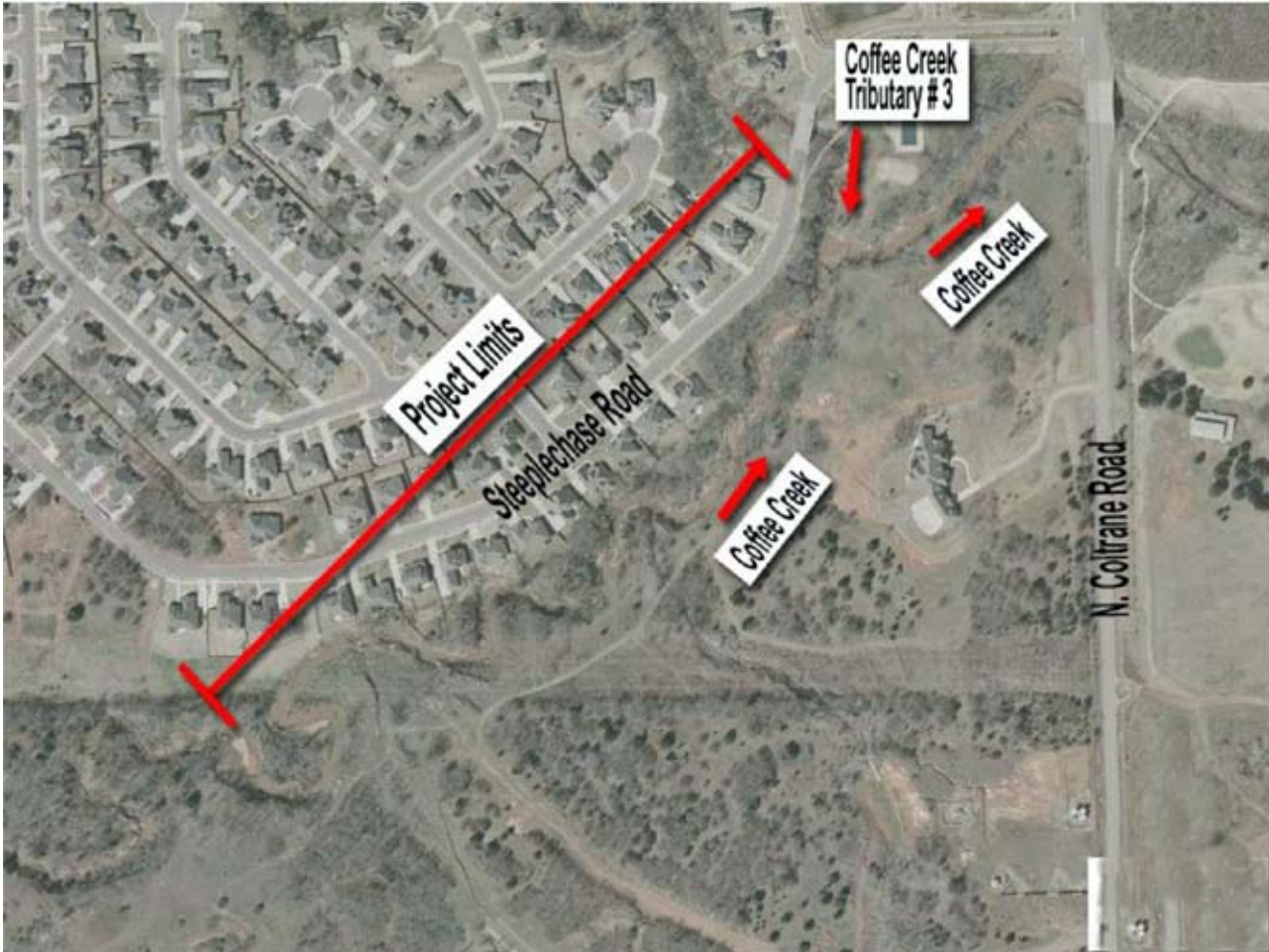
### Project background

In October 2000, an extreme flood event caused severe erosion and lateral instability of a portion of Coffee Creek located along the southeastern edge of the

**Figure CS16-1** Location of project



**Figure CS16-2** Aerial photo of project area



## Existing conditions

Coffee Creek is a deeply incised channel with a width/depth ratio of less than 5H:1V. The entrenchment ratio for this reach of Coffee Creek, the ratio of flood plain width to channel width, is approximately 2H:1V. Coffee Creek is a highly meandering stream and has undergone active lateral migration leading to a high degree of instability (figs. CS16-3, CS16-4, and CS16-5.) The channel cross section is highly irregular. Near vertical banks have developed in several locations. Previous attempts to prevent lateral migration through the use of riprap and retaining walls have been unsuccessful.

The channel bed slope is relatively flat at 0.0038 and appears to be relatively stable downstream of and within the project reach. There are no apparent signs of significant active channel bed degradation throughout most of the project reach. However, there are indications of previous bed degradation and headcutting. The headcutting was prevented from migrating farther upstream by an existing gabion grade control structure that had been installed as protection for a high-pressure gas line. The drop in channel flowline elevation across the gabion structure is approximately 4 feet, and the structure was slightly undermined and being flanked.

The soils throughout most of the project reach are highly erodible. Bank slopes are comprised typically of sandy clay and sandy loam. Bed material is mainly a sandy loam. A few areas of the bed are comprised of fat clay (highly plastic) with low erodibility. The ordinary high water depth is approximately 2 to 3 feet. Vegetation above the ordinary high water mark and within the channel is not well established due to the high degree of lateral instability. Limited riparian habitat exists outside of the main channel.

**Figure CS16-4** Streambank erosion prior to the project



**Figure CS16-3** Streambank erosion prior to the project



**Figure CS16-5** Proximity to infrastructure imposed restrictions on design approaches



## Hydrology and hydraulics

The contributing drainage area of Coffee Creek at the downstream end of the project reach is approximately 3.4 square miles comprised mostly of residential and rangeland areas. Just downstream of the project reach, Coffee Creek Tributary No. 3, a left bank tributary with a drainage area of approximately 2.8 square miles, discharges into Coffee Creek. FEMA discharges for Coffee Creek are published in the revised Flood Insurance Study (FIS) for the City of Edmond, Oklahoma, dated April 16, 1990. The 50-, 100-, and 500-year discharges are estimated by FEMA to be 2,465 cubic feet per second, 3,115 cubic feet per second, and 4,676 cubic feet per second, respectively. The existing channel banks are overtopped by discharges between the 50-year and 100-year event. The FEMA 100-year discharge was used for determining regulatory compliance for the project. The FEMA 500-year discharge, which is approximately 50 percent greater than the 100-year discharge, was used as the design discharge for the restoration project.

The current regulatory FEMA model for Coffee Creek was provided by the city. The U.S. Geological Society (USGS) Stepbackwater Program, E431, was used in the FEMA modeling. Data from the FEMA regulatory model was translated into a HEC-RAS model (U.S. Army Corps of Engineers (USACE) 1995a) for this study. Cross sections of existing conditions were then established throughout the project reach using current topography data and were added to the hydraulic model to supplement description of existing conditions.

Average channel velocities for the existing conditions channel generally ranged between 4 and 9 feet per second for the 500-year discharge. The maximum average shear stress for the existing channel was estimated to be approximately 7 pounds per square foot for the 500-year discharge.

## Project objectives and design constraints

The primary objective of the project was to eliminate the excessive erosion and protect public and private infrastructure along the project reach. Threatened infrastructure included:

- two sanitary sewer lines
- several homes
- a high-pressure gas line
- a high-power electric transmission line
- a domestic water line
- an oil field operation in the area

A secondary objective was to restore the channel using soil bioengineering methods to the greatest extent practicable to minimize potential adverse environmental impacts of the project and maximize aesthetic value.

Several significant project constraints were addressed. Project management constraints included:

- coordinating and securing the 25 percent matching funds from multiple sources including the municipal stormwater utility, adjacent homeowners, and a private utility company
- a single property owner of most of the land along this reach of Coffee Creek requiring significant project coordination regarding the project approach, alignment, and easement issues
- scheduling issues related to project funding and the securing of easements placed a significant constraint on design activities, forcing the majority of the project design to occur over a 2-week period

Project design constraints included:

- using soil bioengineering techniques, while being confined to a less than desirable cross-sectional width
- protecting existing infrastructure and avoiding adverse impacts to other adjacent infrastructure

The project is located within a FEMA Zone AE flood plain and required fill within the regulatory floodway. Due to project scheduling constraints, there was not enough time to secure a Conditional Letter of Map Revision from FEMA. Therefore, a zero-rise condition for the 100-year flood event was necessary to meet local and Federal flood plain requirements.

## Design elements

Consideration of the project objectives and constraints resulted in the use of several specific design elements including:

- A horizontal alignment was developed to move the creek away from the threatened infrastructure to the greatest extent practicable, while also minimizing encroachment of the creek farther onto the adjacent primary property owner, and minimizing changes to the existing meander pattern. A comparison of existing conditions and proposed channel alignments is provided in figure CS16-6.
  - Grade control structures were needed to maintain a stable channel bed and to compensate, through the use of small drop structures, for the reduced channel length of the proposed alignment.
  - A uniform typical section was developed to provide a low-flow channel capable of conveying the 2-year discharge. The channel was also designed to maximize conveyance, while minimizing encroachment onto the adjacent property.
- Stone riprap was used to secure a fixed channel alignment at the upstream and downstream ends of the project.
  - A three-tiered approach was developed for controlling the horizontal alignment of the creek. The approach provided hard armoring to protect the nearby infrastructure and also maintained a natural section to the greatest extent practicable. The main elements of the three-tiered approach:
    - Grade control structures were designed to double as horizontal alignment control structures. The structures were designed as sheet pile weirs with concrete caps. These structures provide hard armoring stability at select locations within the project reach. Structure locations were selected to provide protection for threatened infrastructure, as well as provide overall stability to the channel alignment by creating fixed points along

**Figure CS16-6** Aerial view of project channel alignments

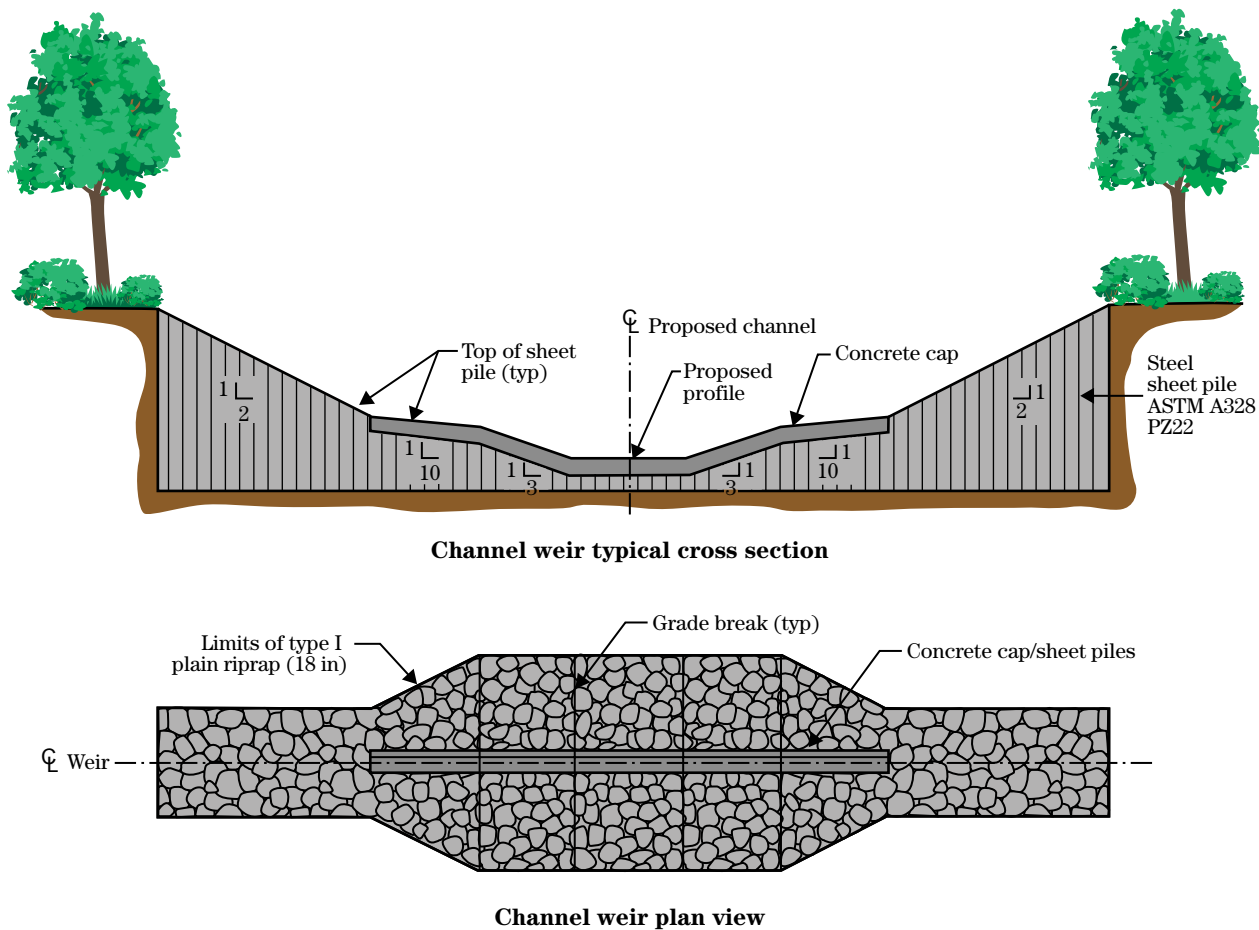


the alignment. A typical section and plan view of the weir structures is provided in figure CS16-7.

- Native grasses and legumes were designed for the flood plain benches and channel side slopes between the weir control structures. The vegetation is supported by a combination of turf reinforcement mat and degradable erosion control blankets. A variety of trees were placed along the top of the channel bank to replace the riparian and upland habitat removed in the channel realignment. This design element enhances channel stability between the hard-armored weir struc-

tures, while maintaining a natural section to maximize the environmental benefits and aesthetic values of the project. The low-flow channel was left unreinforced to allow the creek freedom to meander and form a natural aquatic habitat. The small flood plain bench was reinforced with vegetation and a degradable erosion control mat. The lower portion of the 2H:1V main channel bank slope was reinforced with turf reinforcement mat to help maintain a stable toe of slope. A degradable erosion control mat was also used for the upper portion of the main channel bank slope where shear stresses are lower, and the additional protection afforded

**Figure CS16-7** Weir structure, plan view, and cross section





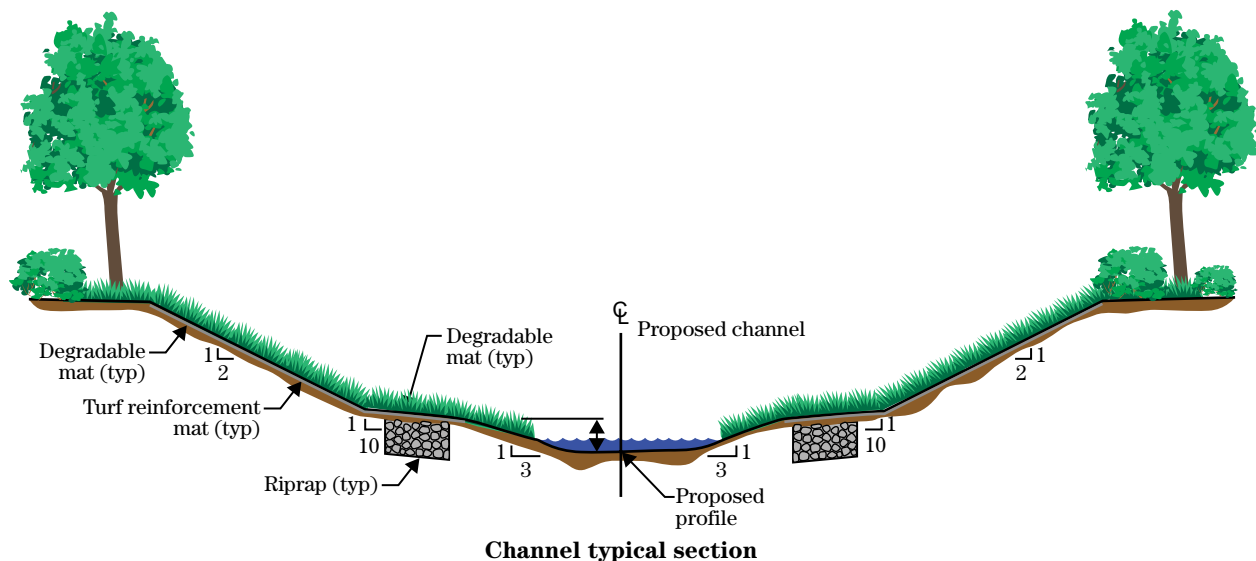
by the turf reinforcement mat was not necessary. A typical section of the channel is provided in figure CS16–8.

- It is recognized that due to the proximity of adjacent infrastructure, adequate space was not available to re-create what may be considered a stable channel through application of traditional geomorphologic principles. Therefore, since the low-flow channel may, over time, begin to change size and alignment and place the stable 2H:1V main channel banks at risk, buried riprap was placed under the main channel toe of slope along the entire length of the project between the weir structures. While the low-flow channel and flood plain benches were allowed to remain natural, and hence deformable, the riprap was added to provide some assurance of a stable toe for the main channel bank.

## Results

Project construction began in October 2002 and was substantially complete in August 2003. The project has been subjected to several significant postconstruction runoff events including an event that inundated the flood plain bench. Vegetation has begun to establish, and the channel is stable. As expected, the low-flow channel has begun to change shape and alignment. In a few locations, the low-flow channel has migrated to, and exposed, the buried riprap toe. The excessive erosion and scour, lateral migration, and general widening of the channel have ceased. The channel banks are stable, and the infrastructure has been protected. The project will continue to be monitored to help assess and document long-term performance of the design elements. Figures CS16–9 through CS16–11 show a comparison of preconstruction photos and photos taken after construction was substantially complete.

**Figure CS16–8** Typical channel cross section with toe slope protection



**Figure CS16-9** Eroding channel prior to construction, and after project implementation; house and property lines imposed restrictions on the design



**Figure CS16-10** Eroding channel prior to construction, and after project implementation; house and property lines imposed restrictions on the design



**Figure CS16-11** Eroding channel prior to construction and after project implementation



