EEDP-07-4
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# Environmental Effects of Dredging
## Technical Notes





### CONSTRUCTION OF A SHALLOW-WATER GRAVEL BAR HABITAT USING DREDGED MATERIAL

PURPOSE: This note provides information on techniques, materials, and equipment necessary to construct a shallow-water aquatic habitat in small to medium-sized rivers using coarse-grained sediments.

BACKGROUND: Two important attributes of flowing water systems (current velocity and substrate type) influence community characteristics, feeding strategies, and density of aquatic organisms (Hynes 1970). Typically, in the upper reaches of streams the substrate consists of cobbles and gravel; in the middle and lower reaches where current velocities are reduced, sands and silts predominate. Darters, many minnows, immature caddisflies, and true flies are fast-water inhabitants, whereas bluegill, other sunfishes, aquatic worms, and mosquito larvae are better adapted for slack-water habitats.

Riffles usually form on a bar where gravel, cobbles, or boulders congregate. Riffle-pool sequences are common features of unaltered gravel-bed alluvial stream channels. Riffles tend to be spaced successively at five to seven stream widths, although they are influenced by bed and bank heterogeneity (Leopold, Waldman, and Miller 1964; Keller 1978; Keller and Melhorn 1978). The greater the variety of particle sizes, the more diverse the invertebrate community. Organisms such as snails and freshwater sponges usually are found on firm substrates such as rocks, logs, or bedrock, whereas immature stoneflies, caddisflies, and mayflies can colonize gravel or cobbles. Thick-shelled freshwater mussels are common inhabitants of gravel bars; their presence usually indicates that substrate is stable, and not subject to erosion or accretion.

Environmental legislation, such as the Rivers and Harbors Act of 1899 and the Endangered Species Act of 1978, have encouraged beneficial uses of dredged silts and sands to create terrestrial or wetland habitat (Harrison and Luik 1980; Perrier, Llopis, and Spaine 1980; Newling and Landin 1985). However, gravel or other large-sized particles from maintenance dredging can be placed in flowing water to create shoals or bars. Habitat creation techniques in large waterways are fairly simple, and when incorporated into early planning, provide a mechanism to satisfy environmental concerns and still meet project purposes.

ADDITIONAL INFORMATION: Contact the author, Dr. Andrew C. Miller, commercial or FTS: (601) 634-2141, or the EEDP Program Manager, Dr. Robert M. Engler, (601) 634-3624.

## Development of the Project

### History

Construction of the Tennessee-Tombigbee Waterway converted a free-flowing river into a series of run-of-the-river reservoirs with deep, slow-moving water and fine substrate. This provided habitat for slack-water species at the expense of organisms that normally inhabit riffles and gravel substrate (McClure 1985). The Tombigbee River was well known for having a dense and diverse riverine fauna including darters and minnows, as well as invertebrates such as snails, oligochaetes, and insects. The mid-portions of the river provided habitat for freshwater mussels, many of which were collected for commercial purposes. Ecosystems altered by construction of dams and channel diversions are now the most prevalent lotic habitats on earth (Stanford and Ward 1979). Throughout the world, increased demands placed on lotic ecosystems by man have intensified the need for habitat improvement and creation.

### Site selection

The Tombigbee River originates in northeastern Mississippi, flows along the eastern section of the state, then enters Alabama south of Columbus, Miss. The Tennessee-Tombigbee Waterway was constructed to provide a more direct shipping route between the eastern Gulf Coast and the mid-continental United States. This was accomplished by connecting the upper portion of the Tombigbee River to the Tennessee River in extreme northeastern Mississippi.

Following completion of the lock and dam at Columbus, a 1-km reach of the Tombigbee River became an abandoned channel (Figure 1). A minimum-flow release structure, designed to pass 5 cu m/sec of surface water, was placed in the dam (Figure 2). However, because the river channel is 60 m wide, water from the release structure produced no measurable current in the channel. Therefore, it was necessary to narrow the channel with gravel to produce a measurable current.

## Construction Details

### Placing material

The first step in constructing the gravel bar habitat was to transport random fill material, which consisted of sand, silt, or gravel, to the upper end of the channel by barge. A clamshell dredge was used to fill an 80-m

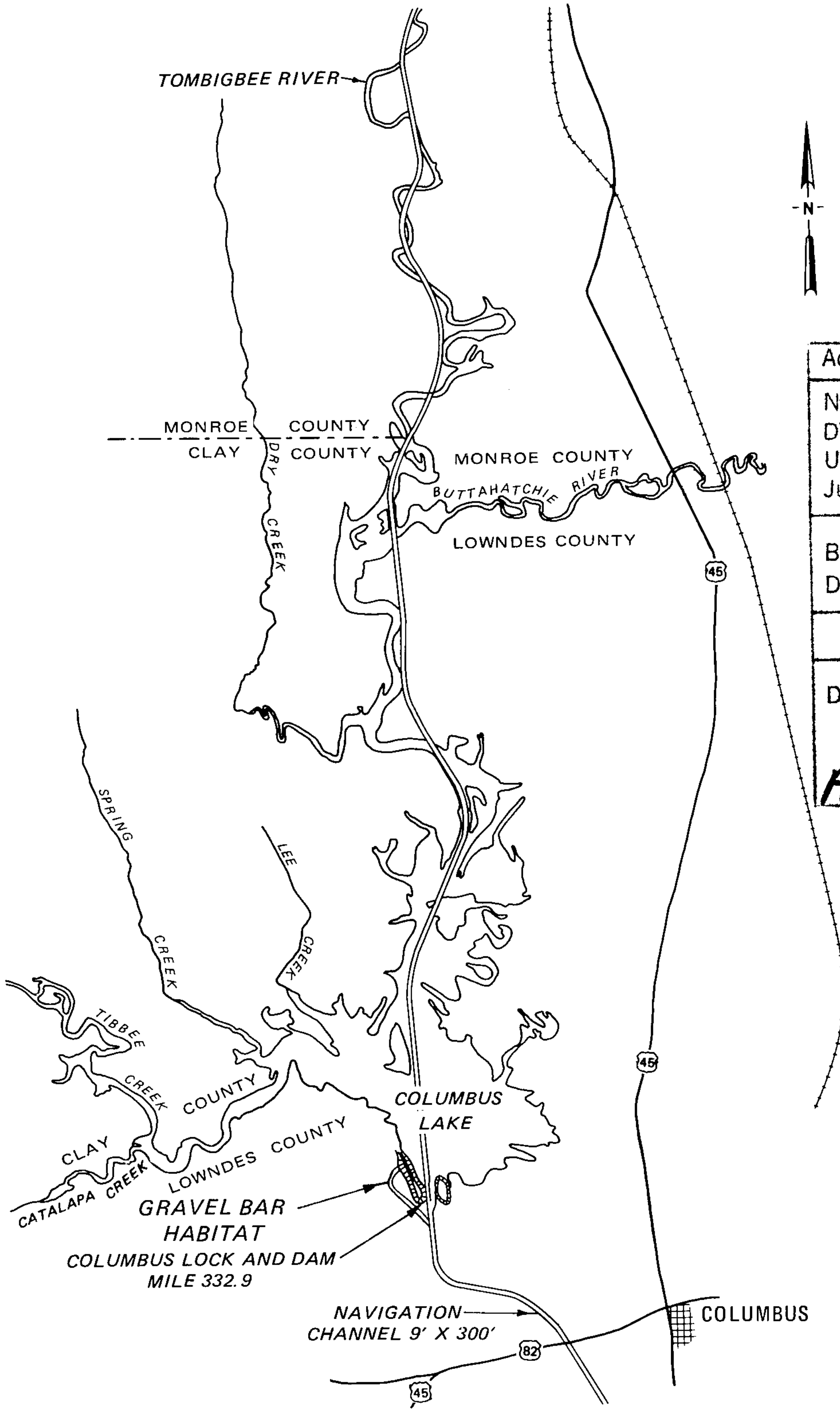
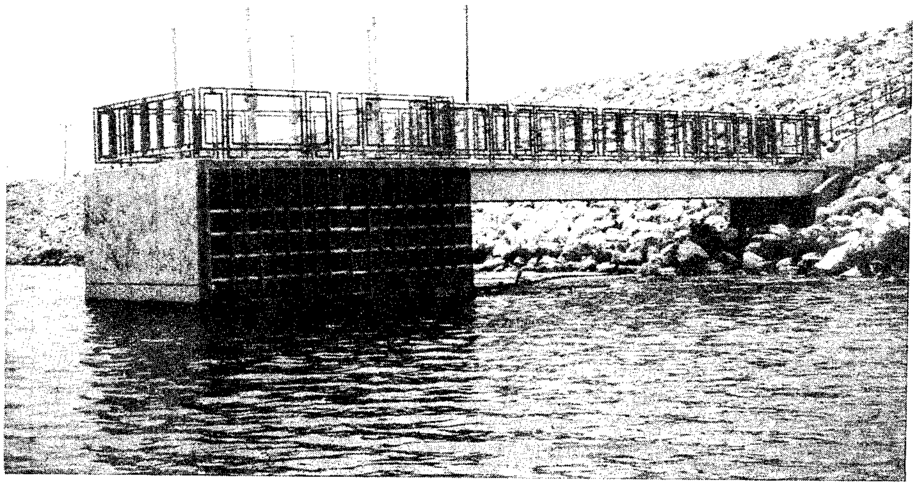
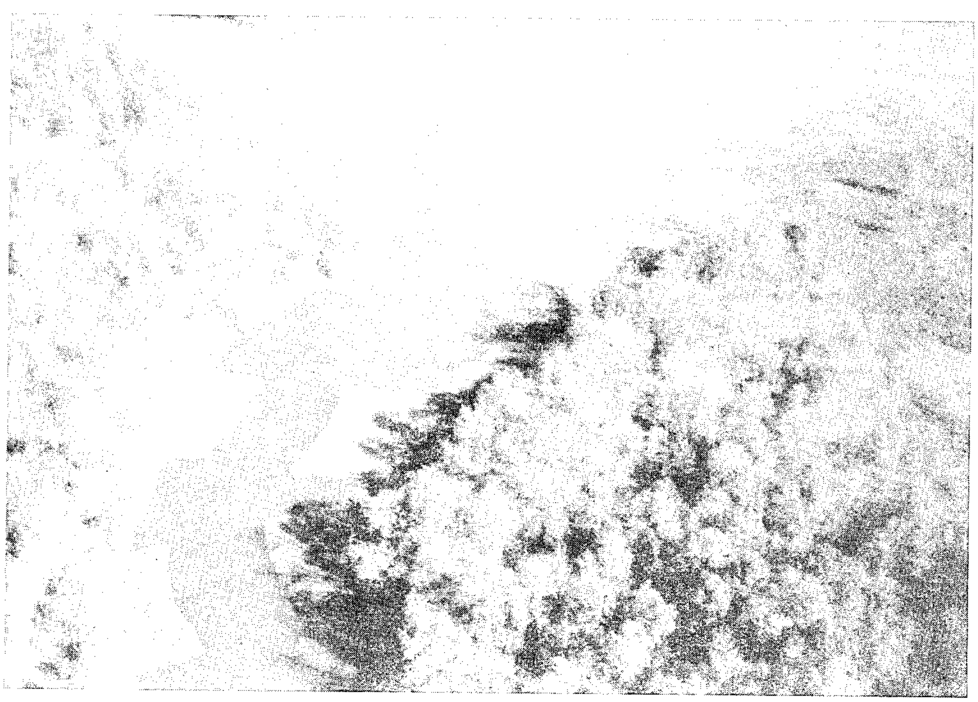





Figure 1. Tombigbee River and location of gravel bar habitat



a. Minimum-flow release structure



b. Aerial view of habitat

Figure 2. Columbus Dam

reach of the channel to an elevation of 39.6 National Geodetic Vertical Datum which was about 2 m below normal water level. The fill was then capped with 24,000 cu m of 2- to 80-mm coarse sand and gravel (Figure 3) obtained from a borrow pit and brought in by barge.

Configuration of the gravel bars

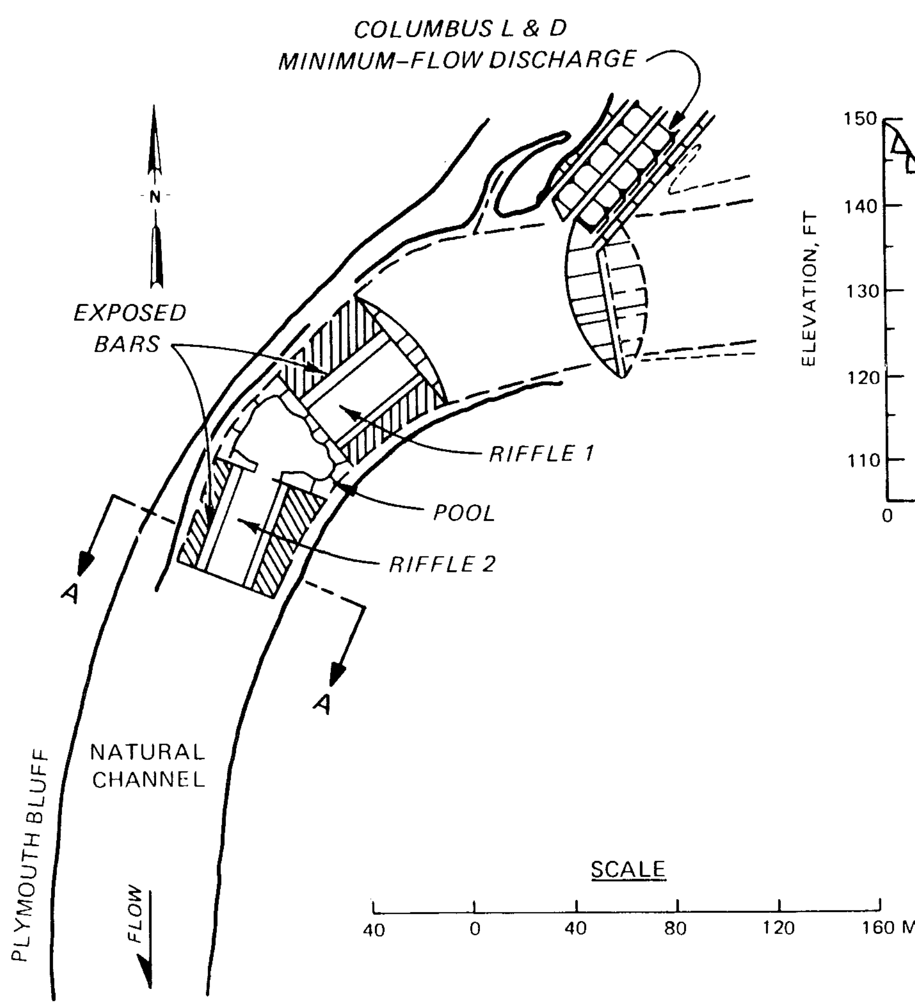
The gravel was placed to create two exposed bars, with a riffle or channel down the center of each. Each riffle is 46 m long, 24 m wide, and has a maximum depth of 1.2 m (Figure 3). The gravel constricts the channel and causes a velocity of approximately 50 cm/sec, which is sufficient to prevent excess sedimentation but not erode the base material (Vanoni 1975). At high discharge the entire habitat, including the normally exposed gravel, is covered with backwater from the Tombigbee River. Water velocity is then essentially zero since the constriction no longer exists. When levels decline, the water is restricted to the channel and the water flows at 50 cm/sec.

## Evaluation of the Habitat

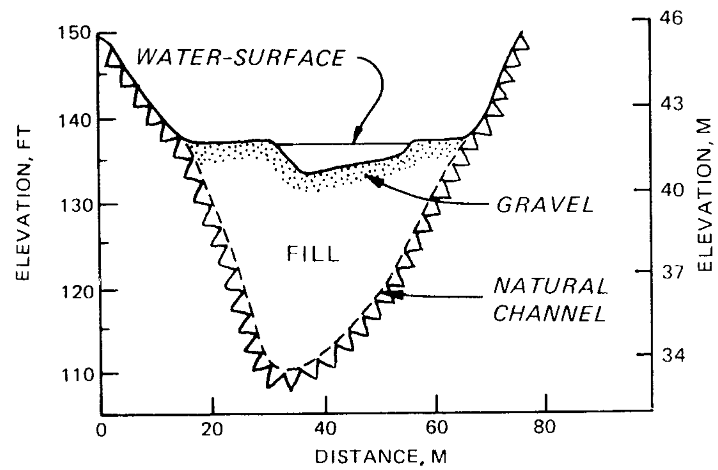
Macroinvertebrates

Colonization by invertebrates was rapid. After 3 months, 19 and 21 taxa were identified at the riffles, with estimated densities of 3,499 individuals/sq m (standard deviation, SD = 1,357; number, N = 15) at Riffle 1 and 2,864 individuals/sq m (SD = 3,072, N = 15) at Riffles 2. By October 1985, approximately 8 months after construction, 34 taxa were found in each riffle. Total density of macroinvertebrates was estimated at 11,450 (SD = 2,270, N = 15) and 10,718 individuals/sq m (SD = 4,081, N = 15) at Riffles 1 and 2, respectively. Total macroinvertebrate biomass was 680.5 and 591.3 mg ash-free dry weight (AFDW)/sq m (N = 15) at both riffles. In October 1986, the last collection date for invertebrates, more than 60 taxa of invertebrates were identified. Density at Riffle 1 and 2 was estimated at 17,949.1 (SD = 77,266, N = 5) and 10,9827 (SD = 4,726.7, N = 5) individuals/sq m, respectively. Total invertebrate biomass was estimated at 15.51 (N = 5) and 4.33 mg (N = 5) AFDW/sq m at the two riffles. The majority of the invertebrate biomass in the latter collections was due to the Asiatic clam, *Corbicula*, an exotic bivalve that lives for several years and can reach a maximum shell length of 3 to 4 cm.

Most aquatic insects colonize new substrate by downstream drift and




a. Aerial view




b. Transverse diagram

Figure 3. Shallow-water gravel bar habitat

dispersal by adults that fly (Fisher 1983, Light and Adler 1983, Minshall and Petersen 1985). At the Columbus site, these two mechanisms probably account for the majority of the aquatic insects in the riffles and pool. However, upstream movement in the water and along the bottom does occur (Bishop and Hynes 1969), and the Asiatic clam, *Corbicula*, can disperse by entering the drift and being carried on currents by a mucus thread (Prezand and Chalermwat 1984).

Fish

Forty-four species of fishes were collected in a four-season investigation; 34 were found at the gravel bar and 24 were found in the river channel immediately below the habitat. The crystal darter, listed as endangered in Mississippi, and the blue sucker, considered to be uncommon in the Tombigbee River, were collected. Shad dominated the catch at the gravel bar (43.2 percent), and minnows and darters were the second most abundant group (23.8 percent), followed by sunfishes (19.8 percent) and crappie (5.5 percent). An abundance of minnows and shiners, indicative of a riverine habitat, was reported by Pennington et al. (1981) in the bendways of the Tombigbee River before construction of the waterway.

Total fish density at the gravel bar (500 to 1,300 fish/ha) was lower than estimates (>2,000 fish/ha) from natural streams with riffles (Kelly, Catchings, and Payne 1981; Schlosser 1985). However, the habitat at Columbus exhibits species composition similar to smaller streams with pool-riffle sequences. The gravel riffles, pool, and outfall from the minimum-flow release structure provide conditions that maintain a unique assemblage of aquatic organisms in a river altered by water resource development.

## Conclusions and Implications

The use of artificial gravel bars to provide spawning and rearing habitat for coldwater species, such as trout and salmon, is a successful management technique in the western United States (Bell 1986). Gravel has been used to restore biota in warmwater streams (Edwards et al. 1984) and to facilitate biological recovery in streams modified by channel development (Shields 1983).

Coarse gravel can be placed on sand substrate at suitable sites in rivers to create habitat for aquatic organisms. Gravel can be used not only to provide substrate, but also to constrict the flow, thereby increasing current velocity. Stable substrate with a variety of particle sizes is necessary for development of a diverse community of aquatic organisms. Construction techniques are fairly simple and should be considered when a suitable site and materials are available.

## References


Bell, M. C. 1986. "Fisheries Handbook of Engineering Requirements and Biological Criteria," US Army Corps of Engineers, Office of the Chief of Engineers, Washington, DC.

Bishop, J. E., and Hynes, H. B. N. 1969. "Upstream Movements of the Benthic Invertebrates in the Speed River, Ontario," Journal of the Fisheries Research Board of Canada, Vol 26, pp 279-298.

Edwards, C. J., Griswold, B. L., Tubb, R. A., Weber, E. C., and Woods, L. C. 1984. "Mitigating Effects of Artificial Riffles and Pools on the Fauna of a Channelized Warmwater Stream," North American Journal of Fisheries Management, Vol 4, pp 194-203.

Fisher, S. G. 1983. "Succession in Streams," Stream Ecology: Application and Testing of General Ecological Theory, J. Barnes and G. W. Minshall, eds., Plenum Press, New York, pp 7-27.

Harrison, W., and Luik, A. 1980. "Suitability of Dredged Material for Reclamation of Surface-Mined Land, Ottawa, Illinois, Demonstration Project," Technical Report EL-80-7, Argonne National Laboratory, Argonne, Ill., prepared for the Environmental Laboratory, US Army Engineer Waterways Experiment Station, Vicksburg, Miss., NTIS No. AD A088 586.

Hynes, H. B. N. 1970. The Ecology of Running Water, University of Toronto Press, Toronto.

Keller, E. A. 1978. "Pools, Riffles, and Channelization," Environmental Geology, Vol 2, pp 119-127.

Keller, E. A., and Melhorn, W. N. 1978. "Rhythmic Spacing and Origin of Pools and Riffles," Geological Society of America Bulletin, Vol 89, pp 723-730.

Kelly, H. D., Catchings, E. D., and Payne, V. W. E. 1981. "Fish Population and Water Quality of an Upland Stream Having Two Impoundments with Coolwater Releases," Warmwater Streams Symposium, L. A. Krumholz, ed., American Fisheries Society, Lawrence, Kans., pp 168-181.

Leopold, L. B., Waldman, M. C., and Miller, J. P. 1964. Fluvial Processes in Geomorphology, W. H. Freeman, San Francisco, Calif.

Light, R. W., and Adler, P. H. 1983. "Predicting the Colonization Cycle of Aquatic Invertebrates," Freshwater Invertebrate Biology, Vol 2, pp 74-87.

McClure, N. D. 1985. "A Summary of Environmental Issues and Findings: Tennessee-Tombigbee Waterway," Environmental Geology and Water Sciences, Vol 7, pp 109-124.

Minshall, G. W., and Petersen, R. C., Jr. 1985. "Towards a Theory of Macroinvertebrate Community Structure in Stream Ecosystems," Archiv fuer Hydrobiologie, Vol 104, pp 49-76.

Newling, C., and Landin, M. 1985. "Long-Term Monitoring of Habitat Development at Upland and Wetland Dredged Material Disposal Sites, 1974-1982," Technical Report D-85-5, US Army Engineer Waterways Experiment Station, Vicksburg, Miss.

Pennington, C. H., Baker, J. A., Howell, F. G., and Bond, C. L. 1981. "A Study of Cutoff Bendways on the Tombigbee River," Technical Report E-81-14, US Army Engineer Waterways Experiment Station, Vicksburg, Miss.

Perrier, E., Llopis, J., and Spaine, P. 1980. "Area Strip Mine Reclamation Using Dredged Material: A Field Demonstration," Technical Report EL-80-4, US Army Engineer Waterways Experiment Station, Vicksburg, Miss.

Prezant, R. S., and Chalermwat, K. 1984. "Flotation of the Bivalve *Corbicula fluminea* as a Means of Dispersal," Science, Vol 225, pp 1491-1493.

Schlosser, I. J. 1985. "Flow Regime, Juvenile Abundance, and the Assemblage Structure of Stream Fishes," Ecology, Vol 66, pp 1484-1490.

Shields, F. 1983. "Design of Habitat Structures for Open Channels," Journal of Water Resources Planning Management, Vol 109, pp 331-344.

Stanford, J. A., and Ward, J. V. 1979. "Stream Regulation in North America," The Ecology of Regulated Streams, J. V. Ward and J. A. Stanford, eds., Plenum Press, New York, pp 215-236.

Vanoni, V. 1975. "Sediment Transport Mechanics," Sedimentation Engineering, ASCE Manuals on Engineering Practice, No. 54, pp 91-107.