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16. Proposed Riffle Construction in an Old River Channel

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Abstract. A lotic habitat consisting of four riffles separated by pools has been designed for possible placement in the old river channel of the Tombigbee River below Columbus Lake, near Columbus, Miss. The design of this artificially placed habitat is based in part on biological and physico-chemical characteristics of an existing riffle in the Buttahatchie River, and in part on the characteristics and constraints of the old channel where it is to be placed. The technical literature and reports of previous studies on the Buttahatchie and Tombigbee Rivers were also utilized.

Four riffle sections, each about 46 m long, will be separated by pools which will each be about 31 m long. The average velocity in the first three riffles will be approximately 46 cm/s and the last riffle will be about 31 cm/s. Each riffle is to be constructed from various sizes and mixtures of sand and/or gravel. The first riffle will be composed of coarse gravel and cobble; the fourth riffle will consist mainly of sand and small amounts of 2.5 - 7.6 cm gravel. Intermediate compositions of material will be in riffles 2 and 3. Because of favorable physical, chemical, and biological characteristics of the incoming water and the physically diverse nature of this proposed habitat, a dense and diverse invertebrate fauna, including over 20 species of common and uncommon mussels, could be expected to inhabit the area.

Introduction. The Tennessee-Tombigbee Waterway (TTW), authorized by Public Law 525 in accordance with recommendations contained in House Document 486 of the Congress, was designed to provide a more direct shipping route between the eastern Gulf Coast and the mid-continental United States (Figure 1). Development of the TTW requires considerable habitat modification such as channel development, dredging, and the construction of locks and dams. Upon completion, maintenance dredging, coupled with a reduction in water velocities and natural fluctuations in water levels is expected to favor slow water or pool species at the expense of riffle inhabiting species. The increased demands throughout the nation now being placed on natural lotic ecosystems by man have intensified the need for habitat rehabilitation and creation.

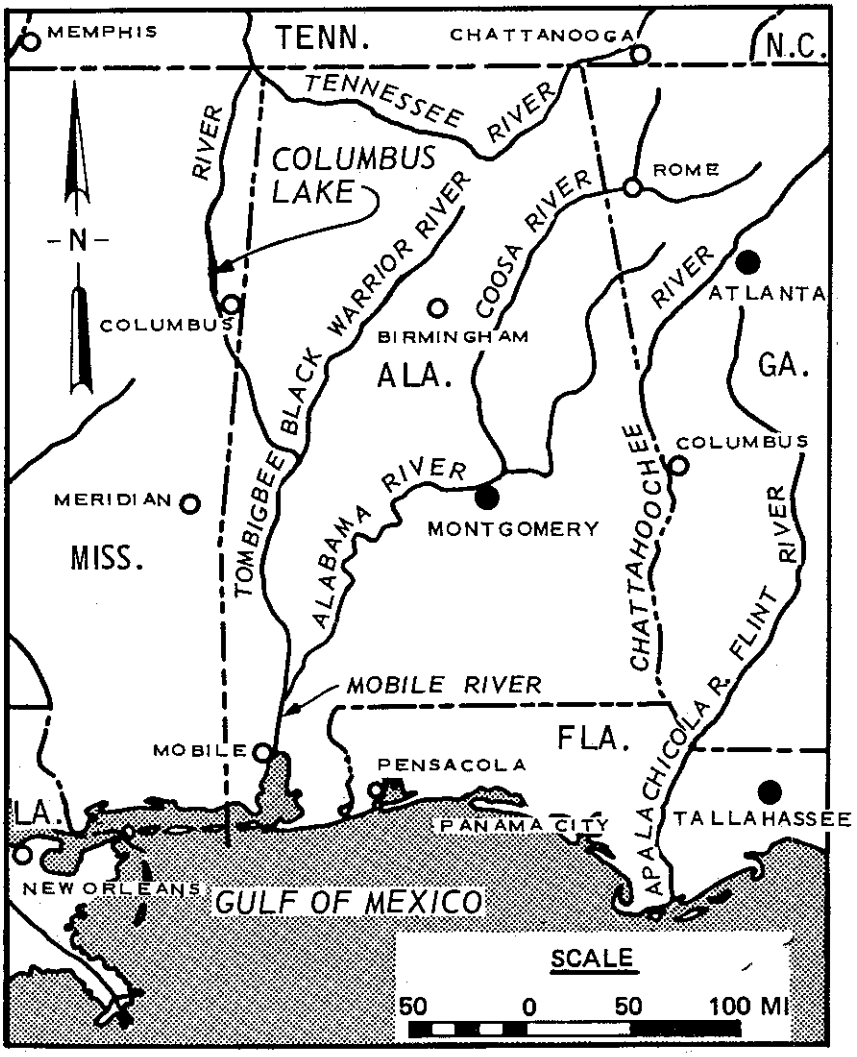

Figure 1. Proposed Tennessee-Tombigbee Waterway and Columbus Lake.

The purpose of this study was to design a lotic habitat for placement in the old river channel of the Tombigbee River directly below a minimum flow release structure at the Columbus Dam near Columbus, Miss. (Figure 2). The primary objective was to create a lotic habitat that would support a diverse indigenous invertebrate fauna, particularly unionid mussels, including some of the status review mussels (Federal Register 4/11/80) endemic to the Mobile River Basin.

Procedures - Preliminary Study. The first phase of this study was to examine a natural riffle area containing a high diversity of macroinvertebrates in the vicinity of the old river channel of the Tombigbee River. A riffle composed mainly of coarse gravel and cobble substrates in the fourth order Buttahatchie

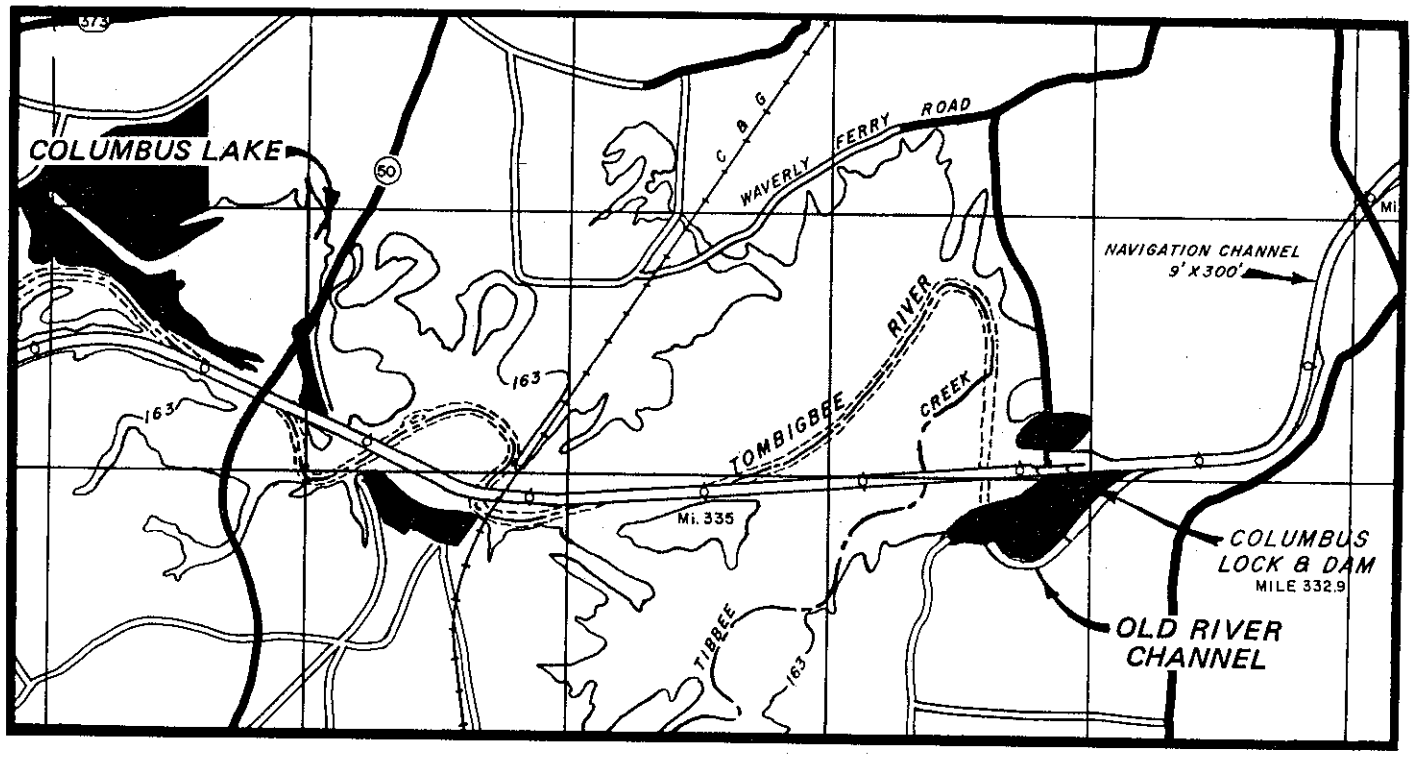

Figure 2. Columbus Lake and location of old Tombigbee River channel.

River (Figure 3) was used as a pattern for determining some of the characteristics for the proposed habitat.

Physical parameters measured during August 1981 at the Buttahatchie River study site included temperature, turbidity, conductivity, light availability, water velocity, and suspended particulate organic matter. In addition, 14 randomly selected sediment samples were taken from the riffle for particle size analyses. Chemical parameters monitored included total alkalinity, total hardness, calcium hardness, magnesium hardness, pH, and dissolved oxygen which were also measured during August 1981. Other chemical parameters included particulate organic carbon, dissolved organic carbon, total Kjeldahl nitrogen, nitrate nitrogen, total phosphorus, orthophosphorus, and calcium, magnesium, sodium, and potassium. These chemical parameters further characterized this natural system and served as a basis for comparison to the chemical characteristics of the incoming water at the proposed lotic habitat. Macroinvertebrates were identified and enumerated from triplicate quantitative grab samples taken at 12 randomly selected stations on the Buttahatchie riffle. Also, qualitative hand collections of macroinvertebrates (including mussels) were made very close to the riffle to further characterize the biota of this river system.

Most of the physical and chemical parameters measured in the Buttahatchie River were also measured during August and October 1981 in the old river channel of the Tombigbee River where the proposed artificial habitat would be placed. Artificial substrate samplers (rock-filled barbecue baskets) were placed in the old river channel during the fall of 1981 to determine if invertebrates were present that could colonize newly-placed substrates.

Results. While a detailed discussion of the methods and results of the first phase of this study is found in Miller et al. (1982), we include a brief overview here.

The Buttahatchie River at the study site was approximately 40 m wide with depths up to 127 cm during the study period. Velocities were diverse, ranging from 5.3 to 185.0 cm/s. Maximum water temperature observed was 28.0°C which was within the range (5.6 to 29.4°C) measured by Cotton et at. (1969) at a nearby site. Light values recorded at four stations on the riffle were considered low with midday values well below those necessary for development of photosynthetic epilithic communities. Particulate organic matter (POM) in suspension ranged from 7.8 to 8.5 mg AFDW/ℓ. The substratum was dominated by gravel and cobble with 88% of the sediments 2.0 mm in diameter or larger with a maximum observed diameter of 150 mm.

Dissolved oxygen values for the Buttahatchie River were fairly high and ranged from 83 to 87% saturation during the study. Chemical parameters monitored indicated a poorly buffered soft water system which was not limited by nutrients such as nitrogen and phosphorus.

Seventy-one taxa of macroinvertebrates were collected; the Insecta dominated with 43 species, followed by the unionid mollusca with 19 species. The most abundant insect species were collectors such as the chironomids *Glyptotendipes* nr *senilis*, *Tanytarsus querla* group, and *T. glabrescens* group, the net-spinning caddisflies *Chimarra* and *Cheumatopsyche*, and the mayfly *Stenonema spp.* In addition to the common unionid mollusks, the status review

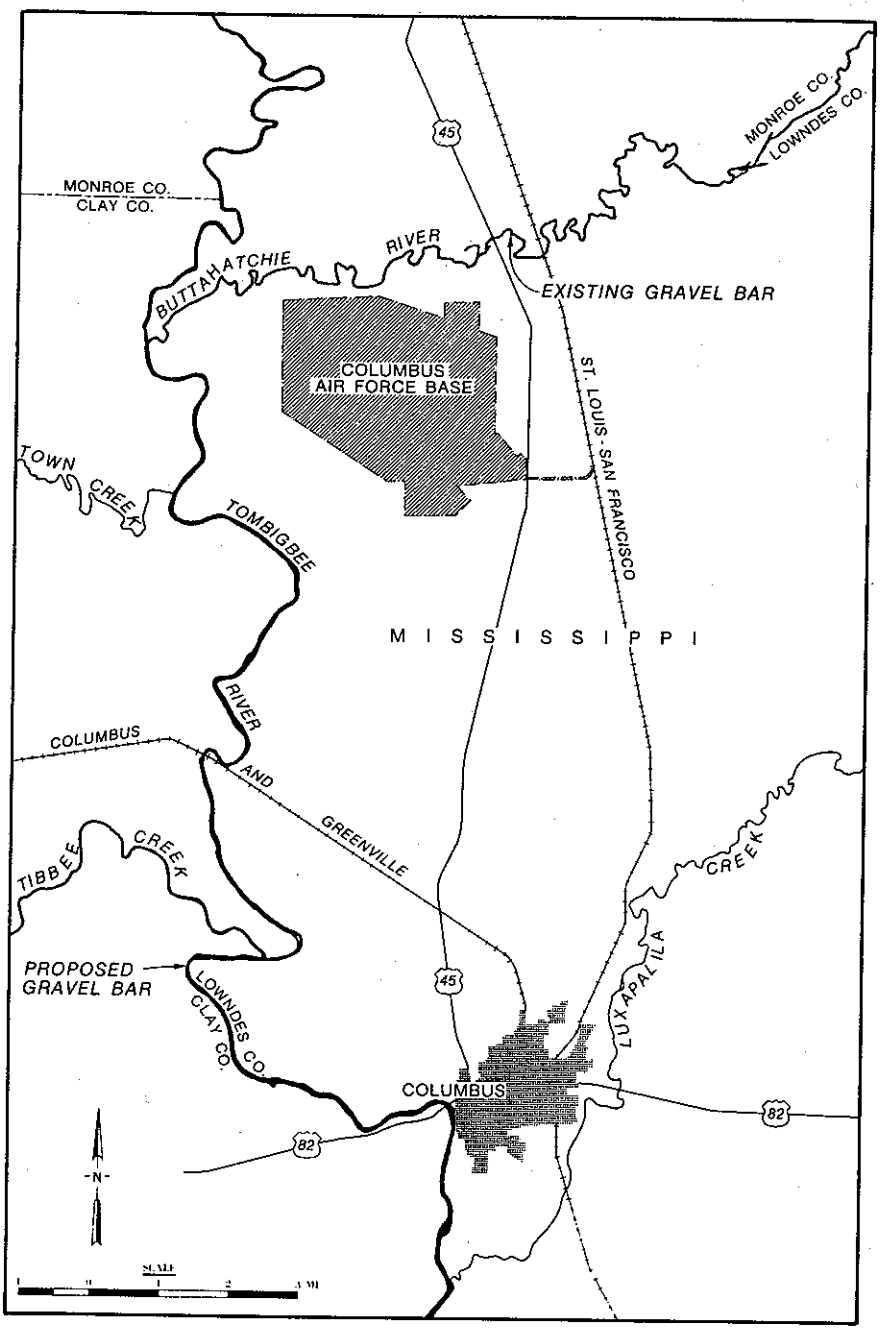

Figure 3. Buttahatchie River site and location of proposed lotic habitat.

mussel *Dysnomia penita* as well as *Pleurobema decisum* were fairly common in the Buttahatchie River. Both species are endemic to the Mobile River Basin.

Macroinvertebrate Shannon-Weaver diversity (EPA 1973) values for 12 quantitative sampling stations on the riffle ranged from 1.15 to 3.49 with a mean diversity of 2.4 for the riffle. Equitability (EQ) values ranged from 0.51 to 0.88. These diversity and equitability values are indicative of an unperturbed ecosystem (EPA 1973).

Many of the physico-chemical characteristics of the water entering the old channel of the Tombigbee through the minimum release flow structure from Columbus Lake were very similar to those obtained for the Buttahatchie River. The maximum water temperature recorded in this study for the Tombigbee study site was 30.0°C. Howell et al. (1978) reported maximum temperatures of 29.0°C and 30.0°C during 1976 and 1977, respectively, and the USGS (1978) reported a maximum temperature of 31.0°C during 1978 for sites on the Tombigbee near the Columbus Lock and Dam. Suspended POM values were very similar between the two study areas, but the organic fraction was significantly higher in the Tombigbee River water samples. In general, the values for hardness, alkalinity, and pH were higher in the Tombigbee system than they were in the Buttahatchie River.

Seventeen taxa of macroinvertebrates were recovered from the artificial substrates placed in the old channel of the Tombigbee River, with the filter-feeding caddisfly *Cynellus fraternus* most abundant. Of particular interest was the presence of the young unionid mussels: *Leptodea fragilis, Lampsilis ornata,* and *Plectomerus dombeyanus.*

Design Rationale. As depicted in Figure 2, the old river channel of the Tombigbee River was isolated by placement of the Columbus Lock and Dam. At Columbus Lake, a minimum flow release structure (Figure 4) removes 5.7 m^3/s of surface water and diverts it under the dam and into the upper end of the old river channel. The velocity of this water moving into the old channel is quite high (Figure 5). Within several meters, however, flow becomes barely detectable because of the fairly large size (about 60 m wide) of the receiving river channel. To establish lotic habitat in this area would require some mechanism to increase water velocities and thereby periodically flush the substrate of settled particulates. In our proposed plan, increased flow is to be achieved by channel constriction from placement of fill material directly into the old river channel. Four separate riffle sections, to be exposed during low flow, will be constructed on top of this fill material. Columbus Lake water is to be directed through fairly narrow channels across the top of each riffle. Velocity of the water should be sufficient to erode clay and silt particles from the riffle, leaving the sand and gravel substrate. At high riverflow, these riffles will be inundated by backwater from the Tombigbee River and velocities in the old channel may be virtually nonexistent. When water levels decline, the flow will be contained in the channels on the top of each riffle and all settled particulates should be swept down river.

It is intended that a series of alternating riffles and pools with desirable velocities and substrate types will be created to facilitate the survival and propagation of common lotic organisms.

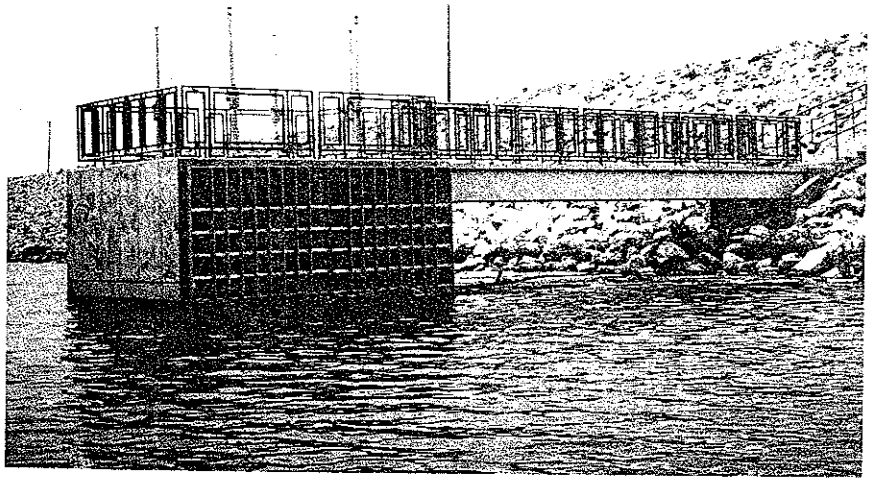

Figure 4. Minimum release flow structure at Columbus Lake.

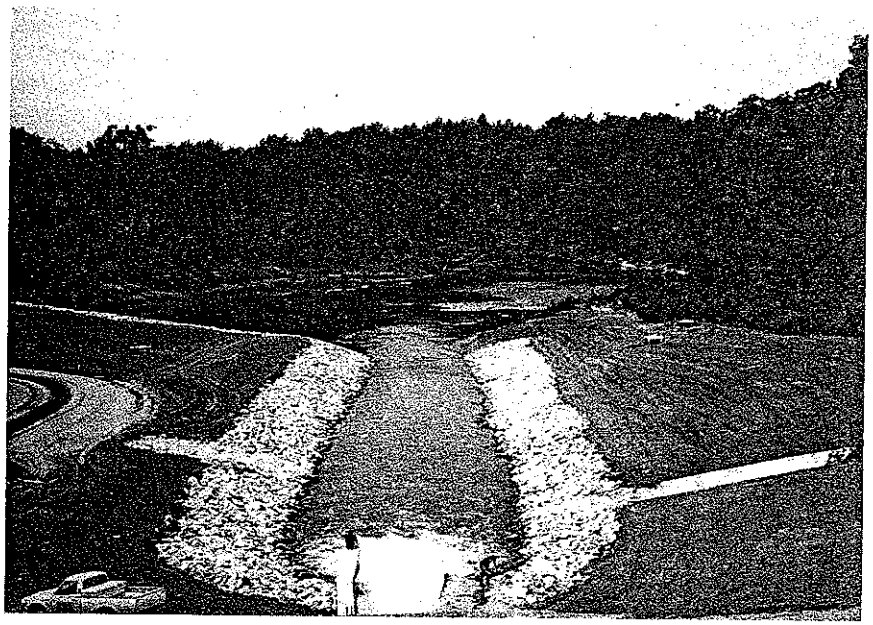

Figure 5. Riprapped flume connecting Columbus Lake and old Tombigbee River Channel.

Habitat Design. The final design (Figure 6) consists of four riffle sections, each about 46 m (150 ft) long, which are separated by pools that are about 31 m (100 ft) long. The cross sectional area of the riffles was designed to constrict the channel so that the average velocity in riffles 1, 2, and 3 would reach about 46 cm/s (1.5 ft/s) and the average velocity in riffle 4 would reach about 31 cm/s (1.0 ft/s) (Table I) when the Tombigbee River stage falls to El 41.6 m (136.5 ft) NGVD (National Geodetic Vertical Datum). Transverse slope was included in each riffle section to further diversify the habitat. Each riffle will slope from a

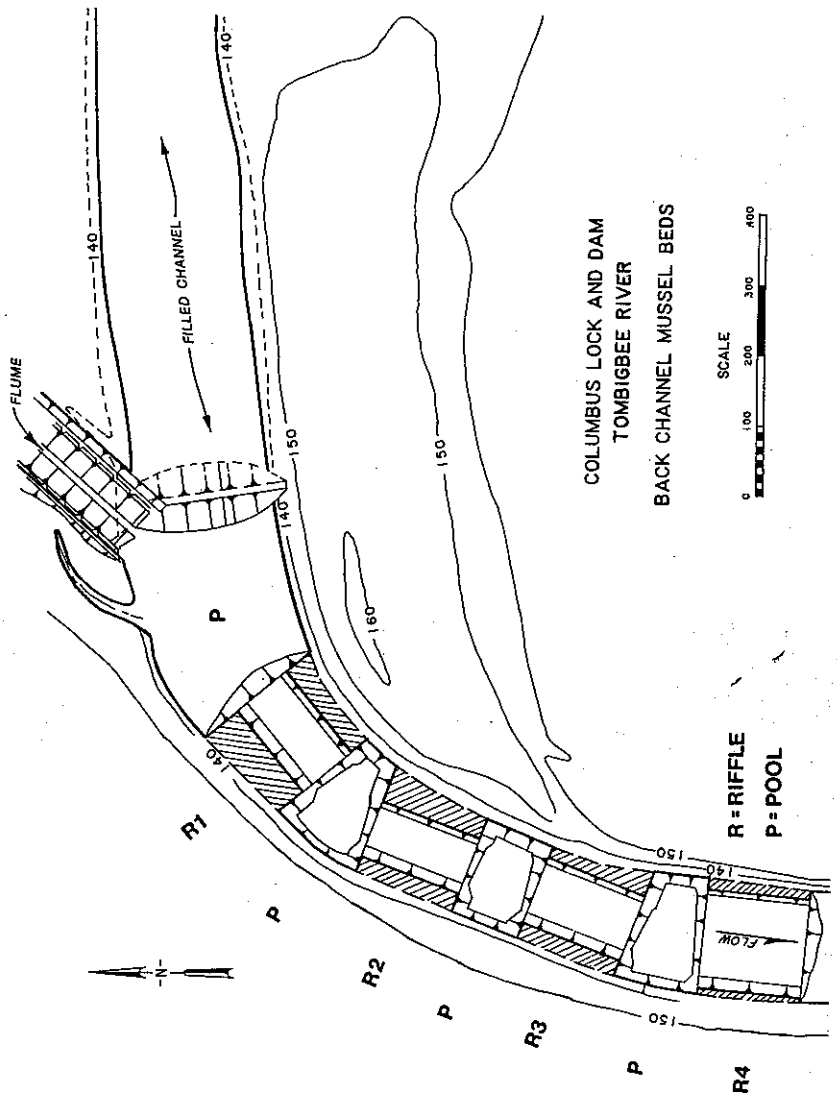

Figure 6. Proposed lotic habitat for old Tombigbee River channel.

depth of approximately 0.46 m on the east side to a depth of either 1.2 m (riffles 1 and 2) or 0.9 m (riffles 3 and 4) on the west side (Table I). The substrate material and design velocity for each riffle section are listed in Table I. Based on data presented by Vanoni (1975) these inorganic materials will not erode significantly at the velocities indicated.

Table I. Physical characteristics of riffle sections of proposed habitat.

	RIFFLE			
	1	2	3	4
LENGTH (m)	46	46	46	46
WIDTH (m)	18	18	23	35
WATER DEPTH (m)	0.46 to 1.2	0.46 to 1.2	0.46 to 0.9	0.46 to 0.9
VELOCITY (cm/s)	46	46	46	31
SUBSTRATE (dia.-cm)	100% Gravel & Cobble (2.5-13.0)	100% Gravel (2.5-7.6)	90% Gravel (2.5-7.6) 10% Sand (medium to coarse)	25% Gravel (2.5-7.6) 75% Sand (medium to coarse)

Suitability of the Habitat. The projected suitability of the artificial habitat for certain organisms was based on characteristics of the Buttahatchie riffle section and the old channel of the Tombigbee River. Technical literature and reports of previous studies on the Buttahatchie and Tombigbee Rivers (e.g., Cotton et al. 1969, Howell et al. 1978, Pennington et al. 1981, and Yokley 1978) were also utilized.

The first riffle (Figure 6), to be constructed of the largest sized materials (Table I), should be suitable for the large, thick-shelled molluscan species that are typically found in riffle areas composed of gravel and/or cobble substrates. Unionids which could colonize and survive in this area include *Arcidens confragosus*, *Tritogonia verrucosa*, *Quadrula quadrula*, *Plectomerus dombeyanus*, and *Amblema costata*.

The second riffle is designed to be very similar to the first riffle except that the grain size will be smaller and more uniform. Some of the smaller unionids such as *Pleurobema decisum*, *Obovaria sp.*, *Elliptio arcus*, and possibly the status review species *Dysnomia penita*, could inhabit this riffle.

The third riffle would be similar to the second riffle, however, to add physical diversity would contain approximately 10 percent sand by weight. This riffle, like the second, would be very similar to the riffle on the Buttahatchie River and could support the common thick-shelled bivalves such as *Fusconaia ebena*, *Quadrula asperata*, and *Q. rumphiana*.

The fourth riffle, to be composed mainly of sand, will exhibit reduced current velocities (Table I) and resemble the preferred mussel habitat defined by Kaskie (1971). This area was designed for *Ligumia recta*, *Lampsilis anodontoides*, *Leptodea fragilis*, and *Lasmigona complanata*, which typically inhabit systems with sandy substrates.

The pools occurring between each riffle will initially have a sand bottom, however, fine particulates from Columbus Lake are expected to accumulate because of reduced to nonexistent water current. The thin-shelled mollusks such as *Leptodea fragilis* and *Anodonta grandis*, as well as other slack water inhabitants such as, *Lampsilis straminea*, *Lasmigona complanata*, and *Proptera purpurata*, should exist in these areas. The bank climber *Plectomerus dombeyanus* and the mapleleaf *Quadrula quadrula*, both common to riffle and pool areas, could also be successful in these pools.

Colonization of any area by mussels requires the presence of a specific host fish or fishes suitably infected with the immature clams known as glochidea. The majority of the above described mussels have the proper host fish present in this section of river based on host requirements discussed by Fuller (1974) and on the results of a 1979-1980 fish survey conducted by Pennington et al. (1981). In addition, three species of unionids (*Leptodea fragilis*, *Lampsilis ornata*, *Plectomerus dombeyana*) were taken from the artificial substrate samplers. We are confident that mussels could colonize artificially placed gravel bars in this area. This does not, however, preclude the possibility of artificially introducing either common or uncommon mussels to this site.

Many non-molluscan macroinvertebrates found in the Buttahatchie riffle and on the artificial substances placed in the old channel of the Tombigbee River (Miller et al. 1982) should also colonize this area after placement of the recommended substrates. These organisms will reach this area primarily through natural drift from upstream areas, migration from downstream areas, and/or oviposition by gravid adults. The riffles should be colonized by mayflies of the families Heptageniidae, Baetidae, Siphlonuridae, Caenidae, and Leptophlebiidae. Net-spinning Trichoptera should also be abundant with representatives from the Hydropsychidae, Philopotamidae, Psychomyiidae, and Polycentropidae. Beetles of the family Elmidae should be present and dipterans such as the Chironomidae (midges) and Simuliidae (blackflies) should be common. Predators such as the dragonfly *Gomphus* and the megalopteran *Corydalus* should also colonize these riffle areas.

It is anticipated that the pools would be suitable for insects such as the burrowing mayfly *Hexagenia* as well as the mayflies of the Caenidae and Leptophlebiidae. Dipterans such as Chironomidae and Chaoboridae should also be abundant. Non-insectan groups such as oligochaetes, amphipods, isopods, and possibly copepods and cladocerans should also inhabit these depositional areas.

Summary. A lotic habitat consisting of four riffles separated by pools has been proposed for development in the old channel of the Tombigbee River and was designed to provide a suitable habitat for a diverse benthic macroinvertebrate fauna.

The physical and chemical properties of the incoming water measured in this study appear to be suitable for many organisms, including unionid mussels. Many members of the collector functional group, particularly those with a filtering mode of obtaining food such as net-spinning caddisflies, blackflies, certain chironomids, and unionid mussels, would be expected to be abundant because of suitable water quality and large amounts of suspended FPOM (fine particulate organic matter) from Columbus Lake.

This proposed habitat, if constructed, is expected to provide a suitable habitat for many lotic organisms and will provide a basis for future projects of this nature.

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