DRAFT
TECHNICAL MEMORANDUM
AQUATIC BIOLOGY CRITERIA

SAN ANTONIO RIVER AUTHORITY
SAN ANTONIO, TEXAS

MUSEUM REACH

San Antonio River Improvements Project

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INTRODUCTION

An effort will be made to improve aquatic habitat for fish and other aquatic life, by providing structure and necessary elements that are required by the native species that have historically occupied the Upper San Antonio River (USAR). It is anticipated that the improvements made will also improve water quality so that conditions for the aquatic life will improve. In order to understand what conditions have existed there and what will be necessary to improve those conditions a careful review of the literature was completed. Hubbs, et. al., 1978 discussed the survival of introduced fishes in the San Antonio River. Gonzales, 1988 examined the Biotic Integrity of the Upper San Antonio River in a Masters Thesis at Southwest Texas State University. The San Antonio River Authority (SARA) has completed ten reports from 1988 – 2000 that have assessed the water quality and stream conditions of the Upper San Antonio River (SARA, 1988, 1989, 1994, 1995, 1996a, 1996b, 1997, 2000a, 2000b, and 2000c). Much of this work has been funded by the Texas Natural Resources Conservation Commission (TNRCC) as part of the Clean Rivers Program (CRP). In addition to this work two reports were completed by staff of the U S Geological Survey (USGS) (Taylor and Ferreira, 1995, Taylor, 1995). The most recent work has been completed by Roark, Andrews and Guttman, 2001 in a paper describing the genetic structure of the Western Mosquitofish, *Gambusia affinis* in a channelized portion of the San Antonio River. In the same year Edwards, 2001 looked at new additions of introduced fish and the persistence of previously introduced fish in the San Antonio River.

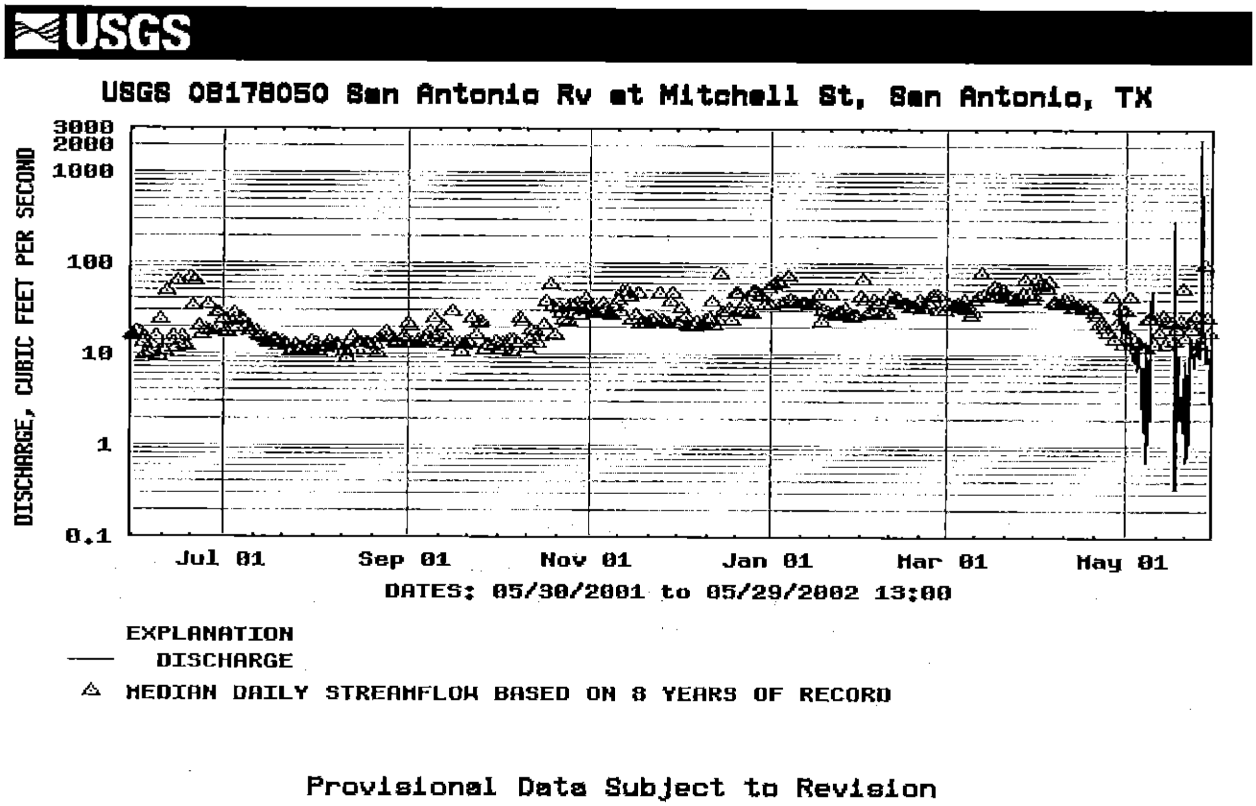
MUSEUM REACH

Numerous other references discuss methods for evaluating habitat and determining the quality of the aquatic ecosystem. These are listed in the references but not specifically noted here. The information available in reports for this system is sufficient to judge the quality of its habitat for the aquatic life existing in the Museum Reach of the Upper San Antonio River (USAR).

Hydrology

The Museum Reach is the portion of the river that begins from the San Antonio Spring, sometimes referred to as the "Blue Hole" and associated springs on the Incarnate Word Campus in the Olmos basin. These springs issue from approximately 685 feet above mean sea level (msl). They flow only when Edwards Aquifer levels are above this elevation. Most of the time since the late 1940s they have not been flowing due to increased withdrawals from wells that lower the aquifer level below their discharge point. Most of the flow in the San Antonio River has been from wells located in Brackenridge Park Zoo area just downstream from Hildebrand Street. In addition, augmentation of river flow from reuse water added in the area of the Witte Museum, now accounts for much of the normal flow of the river through this upper region. The reuse water is treated wastewater having acceptable quality to maintain aquatic life. The SAWS recycle program of augmenting river flow is being used to assure a continuous flow in the river, when the river would normally dry were it not for pumping from wells. In time, all of the pumping from wells to augment the river flow will be stopped. The SAWS program provides approximately 30 cubic feet per second (cfs) at South Alamo Street compared to 8 – 10 cfs historically.

Figure 1 - Upper San Antonio River flow from May 30,2001 – May 29, 2002.



For the eight years of record the flow has averaged between 10 and 100 cfs, the variation comes when there there is rainfall sufficient to have runoff. The minimum flow has been 3.1 cfs, maximum has been 256 cfs and the mean has been 45.7 cfs. Table 1 illustrates the daily mean flow statistics based on 8 years of record.

Table 1 - Daily mean flow statistics for May 29 based on 8 years of record in cfs.

Current Flow	Minimum	Mean	Maximum	80 percent exceedence	50 percent exceedence	20 percent exceedence
	3.1	45.7	256	5.02	17.0	84.0

In the year 2000 springflow from San Antonio Springs only occurred during November and December

Stream characteristics

The USAR is a mixture of riffles and pools, at the lower end of Brackenridge Park the stream is impounded by a small dam/low water crossing. There is considerable overhanging vegetation is this upper reach characterized by tree limbs, aquatic macrophytes lining areas of the bank and grasses that provide cover for the fish and aquatic invertebrates. Turtles are numerous in this reach and can be seen sunning themselves on logs and sloping banks. At Hildebrand Street the bottom consists of gravel over a relatively stable limestone substrate. As you enter the Zoo area, the bottom of the stream appears to be mainly mud, below the zoo, in the golf course area before Mulberry Street, are a series of riffles and pools with gravel substrate. From this point downstream to the backwater from the Tunnel Inlet Structure just above Josephine Street the river meanders along with little attention to the care of the streamside area. It is anticipated that the river channel will remain much as it is currently in this area. There will be attention given to development of pathways along the river as this project continues. The channel area below Grayson Street will be modified to allow for river barges to travel up to the Turning Basin from downtown. From Grayson Street to I-35 the channel will be 35 feet wide with a minimum depth of four feet in the portion of the channel where the boats will travel. Along the side of this area will be a concrete cellular mat that will be used for maintenance when silt must be removed in the future. The river will vary from 35 feet wide in E. Grayson Street area to a minimum of 30 feet wide between McCullough Avenue and Lexington Street. Lexington Street is the lower end of the Museum Reach Project. In a recent study by the Environmental Services Division of the San Antonio River Authority (SARA, 2000a) one of the localities sampled was at Lexington Street on the river. They characterized the area as a pool habitat with depths from 2 feet along the bank areas to 4.5 feet midstream. Gravel was the dominant substrate with some sand and silt present. Signs of scouring were present. This area was found to support a fairly poor to poor macroinvertebrate community as determined using Hilsenhoff's Family level Biotic Index. Better macroinvertebrate communities actually existed in some of the constructed channels in other areas downstream. The reasoning given for this apparent anomaly, was that the Lexington Street area was exposed to more scour thereby preventing long term stable communities of invertebrates.

Aquatic community

Macroinvertebrates

The macroinvertebrate community in the Museum reach of the river was characterized by 9 families at the McAllister Freeway (SARA, 1997). These families included two families of mayflies and one of caddisflies, considered less tolerant to pollution. It is important that macroinvertebrates be abundant in the river since they provide food for fish and help complete the aquatic community. Through the years studies have shown that despite the abuses of being in an urban setting the San Antonio River has been able to maintain an aquatic community. The most important threats to the community have been scouring by stormwater runoff, unstable substrate and occasional nutrient enrichment. SARA, 1996a provided information on the macroinvertebrates at Hildebrand Street. The community was dominated by molluscs in the family Lymnaeidae, a group of algae eaters that usually characterize areas with nutrient enrichment. The water quality at this area should be the best in the Museum reach since the flow is typically from an artesian well providing water from the Edwards Aquifer.

Fish

The San Antonio River Authority provides a listing of the fishes found in the Upper San Antonio River, Segment 1911 as designated by the Texas Natural Resources Conservation Commission (TNRCC) in their 1996 report (SARA, 1996a). They indicate that 34 species occur in this portion of the San Antonio River watershed. Not all of these would be expected to be common in the Museum reach of the river. They are listed in Table 2. Hubbs et al., 1978 sampled the San Antonio River looking at the survival and abundance of introduced fishes. They found that introduced fishes comprised 35% of the total in the Upper San Antonio River (USAR). It is important that as modifications to the river habitat occur during this project, nothing be done that will further increase the ability of the introduced fish to compete in the system. If opportunities occur for elimination of

Table 2 - List of fishes occurring in the San Antonio River (SARA, 1996a)

Species	Common Name
Lepisosteus spatula	Alligator Gar
Lepisosteus osseus	Longnose Gar
Lepisosteus oculatus	Spotted Gar
Dorosoma cepedianum	Gizzard Shad
Astyanax mexicanus	Mexican tetra*
Notropis lutrensis	Red Shiner
Notropis volucellus	Mimic Shiner
Notropis venustus	Blacktail Shiner
Dionda episcopa	Roundnose Minnow
Pimephales vigilax	Bullhead Minnow
Pimephales promelas	Fathead Minnow
Ictalurus punctatus	Channel Catfish
Ictalurus furcatus	Blue Catfish
Ictalurus natalis	Yellow Bullhead
Pylodictis olivaris	Flathead Catfish
Noturus gyrinus	Tadpole Madtom
Gambusia affinis	Mosquitofish
Poecilia latipinna	Sailfin Molly*
Micropterus salmoides	Largemouth Bass
Moxostoma congestum	Gray Redhorse
Lepomis gulosus	Warmouth
Lepomis cyanellus	Green Sunfish
Lepomis microlophus	Redear Sunfish
Lepomis macrochirus	Bluegill
Lepomis auritus	Redbreast Sunfish
Lepomis megalotus	Longear Sunfish
Lepomis punctatus	Spotted Sunfish
Cichlasoma cyanoguttatum	Rio Grande Cichlid*
Tilapia aureua	Blue Tilapia*
Tilapia mossambica	Mozambique Tilapia*
Cyprinus carpio	Common Carp*
Campostoma anomalum	Central Stoneroller
Hypostomus plecostomus	Suckermouth Catfish*
Xiphophorus helleri	Green Swordtail*

introduced species they should be used. The exotics (introduced species) typically have a substantial impact on the native fish of an area. The area where Hubbs et al. collected fish in the USAR will be left in a more natural condition, with some enhancement in the area known as Catalpa-Pershing Channel. This area offers an opportunity to stock only native species in a restored area. Possibly a barrier to fish migration can be constructed at the lower end of the restored creek in order to prevent the invasion of introduced species that occur in the San Antonio River. Of the 34 species listed at least 8 are known to be introduced. Among the fish are common species caught for recreation and food, especially the bass, catfish and sunfish. Many of the other species listed serve as food for the major predator fish. The diversity exhibited does indicate an aquatic habitat capable of sustaining a recreational fishery.

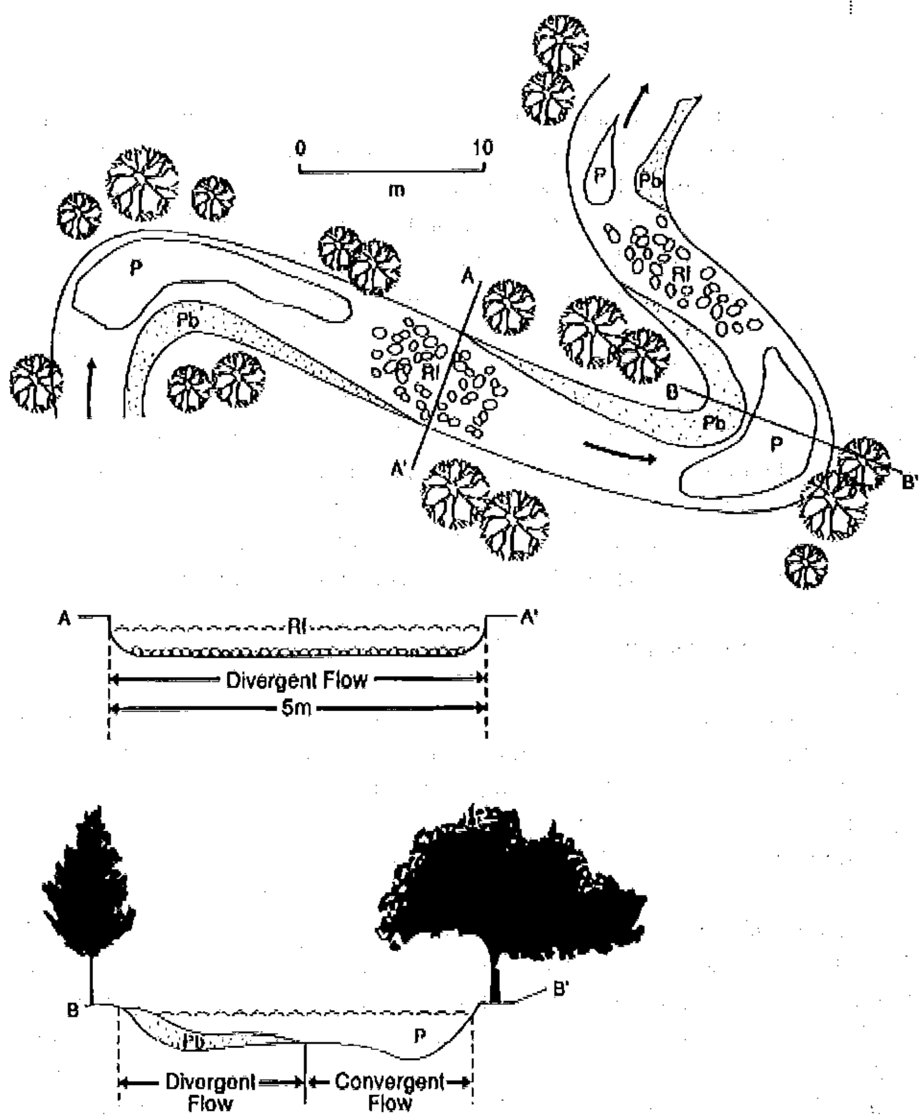
RECOMMENDATIONS FOR HABITAT DESIGN IN THE ALTERED SECTIONS OF THE UPPER SAN ANTONIO RIVER

Rivers have many functions including the natural functions of transport of water, sediments and nutrients to the sea and maintainance of natural biodiversity. They also provide many important recreational uses such as fishing, corridors for migratory birds and habitats for many plant species. The wetland habitats associated with waterways often provide homes for many other important species including amphibians and reptiles that are adapted to these regions. The USAR has a very large population of turtles, a reptile that uses the adjacent banks for nursery sites for its eggs. Care must be taken in the structural modifications to allow for sandy and sandy loam soils to be available for turtles near the river. Since the portion of the river from Hildebrand Street to Josephine Street is not going to undergo further channel modification there should be a good reservoir of fish and invertebrates to continually repopulate the lower modified sections from Grayson Street to Lexington Street. Many of the invertebrates drift daily and this is a natural mechanism which will allow them to continually provide food and repopulation of areas in the modified section of stream channel. The fish species found in this river will easily travel between the unmodified and modified sections of the river. It is possible, by careful construction of banks and bottom of the altered section, to actually provide better habitat for the fish and other aquatic life. It will be important for there to be areas of sand and gravel maintained in the altered section. Fish need the gravel and sandy areas for nest sites and these areas can also provide habitat for burrowing macroinvertebrates.

The most important consideration for this upper reach of the San Antonio River is the maintenance of flow. The recycling of water, as provided by SAWS, is an important consideration, and this supply should be continuous. It is likely that some amount of pumped water will continue to flow into the river in the Zoo area since it is important to the maintenance of species in the Zoo. Where possible this pumped flow should be replaced with high quality recycled water. The river in this upper section is still a product of the drainage system and is dynamic with highly variable flows controlled primarily by releases from the Olmos dam, a flood control structure above Hildebrand Street. As flooding occurs there will be changes in the river that both eliminate existing habitats and create new habitats. This change leads to patchiness in rivers. They are not uniform environments. They typically consist of riffles and pools following each other sequentially in the stream. Since the area to be utilized for barge traffic will not allow this exact sequence, the area for the boats will have to simulate the pool habitat and the adjacent shallow areas over the maintenance pads will have to occasionally be shallow enough to simulate riffles. This may be assisted by some circulation of water and the addition of aeration features. The construction of a more natural channel will be possible in the Catalpa-Pershing Channel Figure 2. An important consideration often overlooked is the need for an area below the bed of the stream that can serve as the hyporheic zone. This zone serves temporary residents (fish eggs and larvae), as well as permanent residents adapted to life in the interstices between the substrate particles

(National Research Council, 1992). Efforts should be made to where possible to link the river with the riparian areas. These ecosystems are typically intimately linked. The riparian area is often flooded and contributes nutrients to the river, it is also the source of overhanging vegetation, instream cover (snags) and logs. Where possible these attributes, which are important as fish cover and invertebrate habitat should be simulated. There are 8 bridges that will cross the altered section of the river. These structures offer extra challenges since the design parameters and concepts are significantly different for stream restoration and bridge foundation protection.

Figure 2 - Idealized natural channel prototype:P, pool; Rf, riffle; Pb, point bar.(National Academy Press,1992)



These conflicting design objectives for a naturalized channel and a bridge opening are discussed in Johnson et al. 2002. Recommendations are given for the use of vanes, cross vanes and w-weirs. Through laboratory experiments they demonstrate that the rock structures can be used to create flow transitions from restored streams through bridge openings. These can help to prevent undesirable scour along the abutments and piers. Illustrations of these design features are shown in Figure 3.

Figure 3 - Rock vanes, cross vanes and W-rock weirs (Johnson et al., 2002)

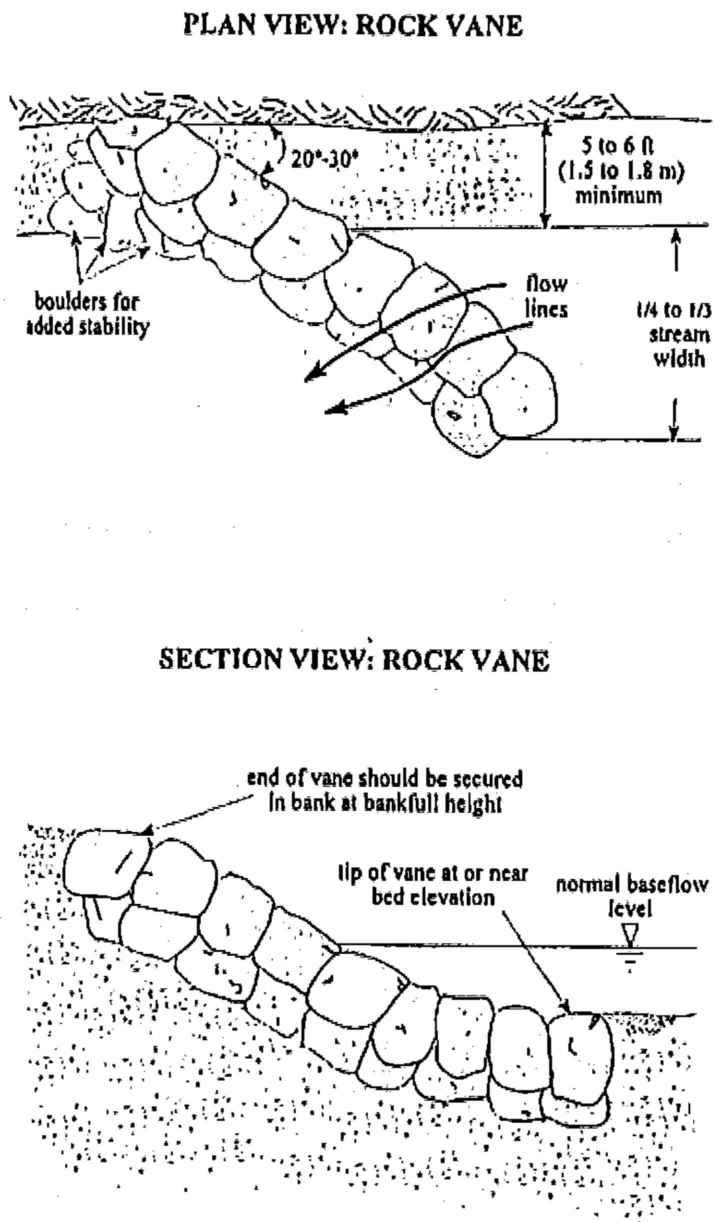


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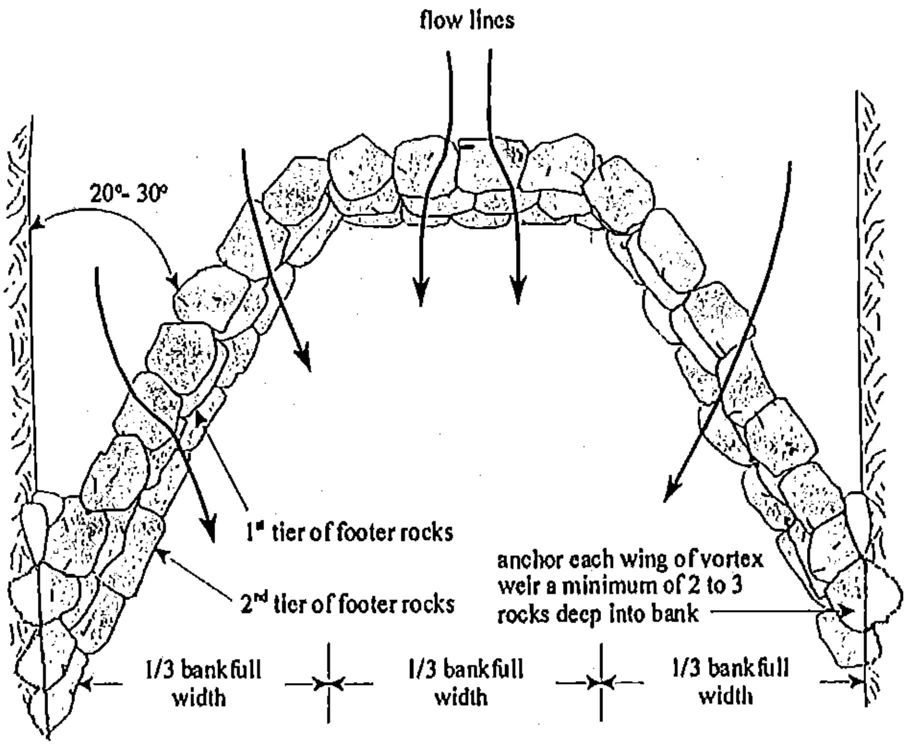
Figure 3 - Continued

PLAN VIEW: CROSS VANE



SECTION VIEW: CROSS VANE

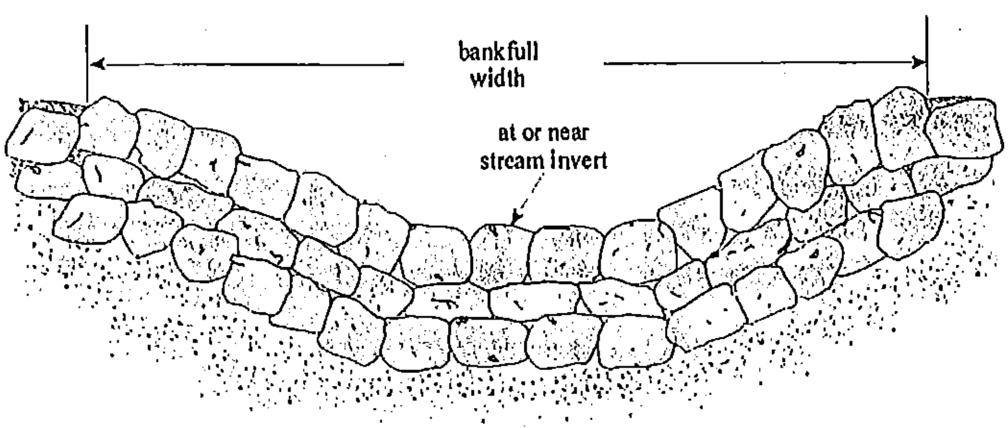


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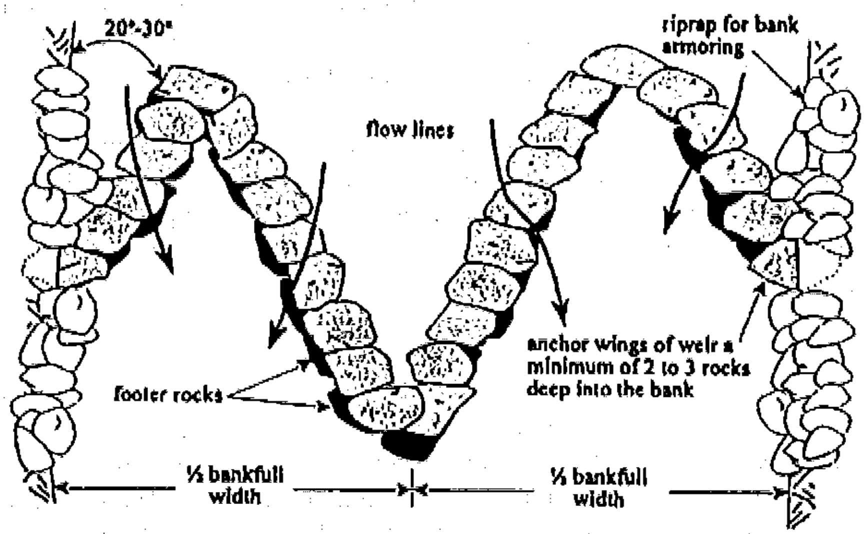
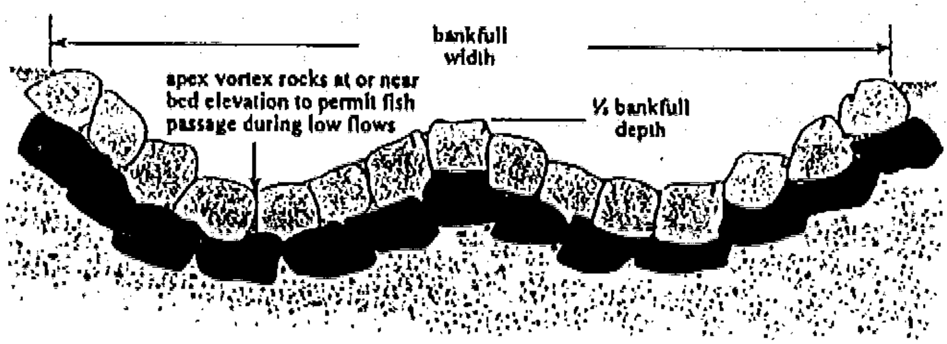
Figure 3 – Continued





C

Recommended Habitat for Fish

A most important consideration for fish is food availability. They must have adequate nutrition to survive. Most river fish are somewhat opportunistic, feeding on organisms that they can get in their mouth. Food habits differ during different life stages. Small fish typically feed on the smaller invertebrates including annelid worms, small molluscs, and small crustaceans and insect larvae. In general the larger the fish the larger its prey, unless it is an herbivore. The food items of larger fish can include small snakes, rodents, or any other organism that will fit inside their mouth. Some fish are specialized for feeding on the bottom (benthic forms) and they derive nutrition from organisms in sediments sucked off the bottom or the sediments themselves in some cases. Generally fish can be grouped into major feeding types: predators, including large catfish, gars and bass; grazers, including many young fish and the sunfish as a group; strainers (not common in rivers) that feed typically on plankton; and suckers, including carp and some young catfish, these fish can be identified easily since they usually have their mouth on the bottom of their head. In addition to food, temperature, light and current are important factors influencing fish distribution. Temperature is often important in stimulating reproductive changes and some fish have a narrow tolerance to termperature changes. Since the San Antonio River is fairly warm, the fish species that occur there are adapted to the temperatures, but this has also allowed exotic tropical fish to gain a foothold in the river. They have been able to reproduce and proliferate. Less turbid water allows better light penetration thereby stimulating the growth of periphyton and macrophytes. These plants provide both food and habitat for young fish and invertebrates.

Catfish

Most of the species of catfish are predators as adults, they typically feed at or near the bottom and are often more active at night. An adequate supply of smaller fish is the primary requisite for this group. They tend to stay in the deeper water and under overhanging ledges. They are opportunistic feeders, eating any organism they can get in their mouth. As a group the catfish can withstand lower dissolved oxygen levels than most other fish except perhaps carp. They require structure with openings for their nests typically.

Bass

This group of fish are also predators as adults and as juveniles they also are opportunistic feeders, utilizing any prey that they can eat. They seem to prefer macrophytes to hide in and they also utilize undercut banks for cover. They are attracted to any kind of cover in their stream. Aquatic macroinvertebrates are an important part of their diet when young and small fish are a main food item as adults. Terrestrial insects that end up in the stream are also a major food item during some periods. It is most important to supply adequate cover and dissolved oxygen for this group.

Sunfish

The sunfish, which are important prey items for the catfish and bass are considered to be grazers, feeding on the attached periphyton, also taking small invertebrates. They must have plants and invertebrates both as young and adults. They tend to occupy the shallower areas, and they need shallow sandy bottoms for their nests.

Minnows

Some of the minnows are strainers, but since plankton is not common in the river this is not their primary food. They are opportunistic, feeding omnivorously on both attached periphyton and small invertebrates. They typically like to have macrophytes to hide in from predators.

All of the smaller fish are also the prey of wading birds such as herons that frequent the river.

METHODS FOR ESTABLISHING FOOD TYPES

It should not be necessary to add fish or invertebrates in the altered channels, with adequate structure and some sand and gravel substrate, the invertebrates should drift down into the altered sections from the unaltered channel upstream. Within a few weeks there should be an established macroinvertebrate community in and on the substrate of the altered section. What does need to be added as food and shelter are some typical native stream plants. These could include *Sagittaria latifolia* (Duck potato), *Ludwigia* sp. (False Loosestrife), *Ceratophyllum demersum* (Coontail) and *Potamogetan* sp. (pondweeds), which are aquatic species. In addition some *Nasturtium officinale* (Water Cress) and *Eleocharis* sp. (Spikerushes) could be added near the banks of the stream. Care should be taken not to introduce exotic plants in the river or riparian zone. Examples of plants to avoid are *Eichornia crassipes* (Water Hyacinth) and Elephant Ears. These plants are a major problem on other spring fed streams in Texas. Care should also be taken to avoid introduction of *Hydrilla* sp., a pest species that can choke the river. A more complete listing of plants native to this river basin can be found in Young et al., 1973. In the same report a list of invertebrate and fish species found in the San Antonio River is given. The main concern for establishing food types is to utilize only native species.

RECOMMENDATIONS FOR STRUCTURE FOR AQUATIC BIRD SPECIES

The kinds of fish and invertebrates known to occur in the USAR are typically used as food by a variety of birds. Herons are not uncommon in this area. They can add to the recreational value of the river. Ducks and other water birds have been observed nesting near the banks of the river and adequate stands of native riparian vegetation will aid them. Birds are naturally attracted to the river for water and bathing. The provision of some shallow areas should encourage their presence.

RECOMMENDATIONS FOR TURTLE NEST AREAS

Turtles will require riparian areas, having sandy loam soils or similar soil that nests can be contructed in. These areas should be less likely to be utilized by pedestrian or bicycle traffic. They should be relatively undisturbed most of the time.

SUMMARY

The recommendations included in this report are based on experience and references in the area of Aquatic Biology. A thorough and careful review of the conceptual design (SWA Group, 2001) has stimulated the recommendations given in this report. One specific comment is that where possible solid concrete walls or paths should be avoided, providing instead structure that will accomplish the same purpose but will also allow the infiltration of water. I concur with the proposed widening of the channels in the altered region utilizing the concepts for bioenginnering of the new stream bottom and sides adding structure to simulate undercut banks (as in the "lunker structure"). Where possible in the area between the maintenance pad and the deeper portion of the channel (used for boats) an alternating of cobble, sand and gravel should occur. Sediments will soon occur in the deeper areas due to runoff during floods and therefore it should not be necessary to add the finer sediments. Where possible some side pools should be added to allow very shallow wetland type development. The expanded width of the river in the altered section should allow adequate area to simulate natural bottom between the maintenance pad and the deeper section used by the boats. The depth of the water over the maintenance pad should be varied from six inches to two to three feet. This will allow a variety of aquatic plants to establish themselves in the area. These plants will then offer a variety of cover for the small fish and invertebrates. Where possible the edges of the river channel should provide many small openings for use by small aquatic forms for cover and protection. This can be accomplished in many cases by using rocks with many openings between them. In areas distributed where possible through the altered area provision should be made for anchoring submerged logs on the shallow side of the stream. These should be fixed in such a way that they can easily be replaced in time when they break down or during maintenance they should swing free of the maintenance pad. This is an important consideration since many aquatic invertebrates prefer to colonize woody material in the water. This will also enhance the structure for fish cover. The greatest opportunities for developing new aquatic habitats will occur in the Catalpa-Pershing Channel. This creek will be restored using fluvial geomorphological principles. That is meanders will be placed in the channel to simulate a more natural waterway. This area will allow a variety of aquatic habitats to be constructed. It is suggested that the channel be a series of pools and riffles, in sequence. This is the situation that occurs under most natural situations where streams develop through time. The riffles will allow a type of habitat that is preferred by fish such as darters and logperch that were probably native to this region of the watershed. The bottom substrate should be cobble alternated with sand and some larger rocks. Other types of sediment will come to the stream as runoff occurs after construction. It will not be necessary to add fine sediment to the restored waterway. If possible some wide areas should be constructed that are relatively shallow (< one foot). This will allow the development of a wetland that will be very attractive to small fish and will also serve as excellent habitat for emergent aquatic plants. This type of area should also attract many birds.

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