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# An Evaluation of the Effects of Dredging Within the Arkansas River Navigation System - Volume I - Introduction, Summary and Conclusions, and Recommendations

Arkansas Water Resources Research Center
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# Arkansas Water Resources Center

**AN EVALUATION OF THE EFFECTS OF DREDGING WITHIN THE ARKANSAS RIVER NAVIGATION SYSTEM, VOLUME I,**

**Introduction, Summary and Conclusions, and Recommendations**
**An Interdisciplinary Study**

Conducted by the
Arkansas Water Resources Center
Under Contract No. DACW 03-77-C-0027, 1978
United States Corps of Engineers
Little Rock, Arkansas

**PUB-43**

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An Executive Summary

of

# ENVIRONMENTAL EFFECTS OF THE COMPLETED McCLELLAN - KERR ARKANSAS RIVER NAVIGATION SYSTEM

An
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# INTRODUCTION

The foundation for the development of the Arkansas River was laid with the authorization of many upstream reservoirs in the comprehensive River and Harbor Act of 1946 signed by President Truman. Subsequent authorizations were forthcoming and work began on many of the bank stabilization facilities in 1950 and on the major structures in 1957. The current McClellan-Kerr Arkansas River Navigation System was substantially completed in 1972. The authorized multiple-purpose plan for the Arkansas River and tributaries provided for the construction of coordinated developments in the interests of navigation, hydroelectric power, flood control, bank stabilization, and related benefits including recreation and wildlife enhancement.

Environmental effects were not considered formally in the evaluation and design of the McClellan-Kerr Arkansas River Navigation System, because construction was completed near the time or implementation of the National Environmental Policy Act, PL 91-190. However, environmental factors received significant consideration in design of the system to permit multiple uses of the river. Bank stabilization structures have been constructed, sediment traps have been designed into upstream lakes, treatment of municipal and industrial waste has been improved, some mitigation features have been undertaken, and other like actions have resulted in a noticeable improvement in the system to support more diverse human uses. Therefore, the objective of this study is to bring together into one report the impacts of the system on the environment and how the impacts relate to man. An interdisciplinary research team of ecologists, landscape architects, biologists, zoologists, chemists, environmental engineers, and archeologists studied five major areas of impact: visual characteristics, bank stabilization, water quality, ecological resources, and cultural resources. Changes in the natural environment were identified. The scope of these changes was then evaluated and associated with the development of the navigation system on a "best judgment" basis.

## Pre-project Description of the River

The Arkansas River Basin has a drainage area of approximately 160,533 square miles. Its source water originates near Leadville, Colorado on the eastern face of the Rocky Mountains. The river flows southeasterly through Colorado, Kansas, Oklahoma, and Arkansas to join the Mississippi River. The fall of the river ranges from 110 feet per mile near Leadville, Colorado to 2.2 feet per mile near Tulsa, Oklahoma to 0.4 feet per mile near its mouth. The upper portion flows through deep gorges and narrow valleys. Below Pueblo, Colorado the valleys widen and below Great Bend, Kansas the river becomes crooked and subject to shifting channels. The upper section of the navigation system flows through an alluviated flood plain from ½ to 6 miles in width bordered by and underlain by hard sandstone and shales of the Mississippian and Pennsylvanian age. The lower section of the navigation system flows through the Gulf Coastal Plain Physiographic Province. It joins the meander belt of the Mississippi River on the east and is bordered on the west by unconsolidated but resistant eocene clays. The alluvial deposits are underlain by unconsolidated or partly consolidated marine sands and clays of the Wilcox, Claiborne, and Jackson groups.

The stream flow of the Arkansas River prior to the navigation project was one of irratic flows with periodic floods and some intermittent flow in the upper reaches. Flooding occurred frequently prior to the construction of the upstream reservoirs. The flood of 1927 is the most notable in which it has been estimated that over five million acres in Arkansas were flooded due to the bursting of levees in a dozen places below Little Rock. During the winter months of 1971 alone, during two separate storms it has been estimated that the navigation project eliminated almost one and one-half million dollars in flood damage.

Eight chemical species were routinely monitored at fixed stations prior to the construction of the navigation project. These are calcium, chloride, fluoride, iron, magnesium, potassium, sodium, and sulfate. The average concentrations of these chemical species and other water quality parameters at Ft. Smith prior to the completion of the navigation project are presented below.

Chemical Concentrations
Average Values for the Period 1945-1950
at Fort Smith, Arkansas

| Chemical | Mg/L |
|---|---|
| Calcium | 64.9 |
| Chloride | 308.2 |
| Fluoride | 0.15 |
| Iron | 0.004 |
| Magnesium | 15.4 |
| Potassium | 7.9 |
| Sodium | 179.3 |
| Sulfate | 66.5 |
| Total Alkalinity | 108.3 |
| Total Hardness | 225.1 |
| Turbidity* | 1089 (NTU) |
| Conductivity | 1286 (μMho) |

*Average values for 1959 and 1960

# VISUAL CHARACTERISTICS

It is the authors' judgment, based on available preconstruction information, that the overall visual quality of the river and its adjacent landscape has not dramatically been altered from its original state except at control areas (dams, locks, etc.). The river is still characterized and dominated by a natural setting. However, the sand bars and river debris which once dominated the waterscape has almost totally disappeared due to the construction of the navigational system and continuous maintenance. The periodic flooding which previously had disasterous effects upon the surrounding land has been eliminated by the stabilization of the level of water, effectuated by the construction of dams and levees. The lack of fluctuation of the river's level has not significantly altered the natural scenery or conditions associated with river flood plains (i.e., swamp lands, sand beaches, etc.). The river's previous fluctuations made access difficult during the spring months, but the navigational system has made the river more accessible to a larger number of people throughout the entire year. A larger population now can utilize the river and in addition the facilities that have been built as part of the navigational system such as, parks, overviews, locks and dams, and boat launching sites.

## General Visual Analysis

The General Visual Analysis describes the general visual character of the waterway and the discernible visual changes from the original river-state that have occurred along the waterway. This section of the report is divided into three (3) descriptions .

### Major Changes in the General Visual Character of the River

Construction of the navigational system created changes in the visual character of the waterway. Among the major changes that have occurred in all of the river segments are:

1. Stable water levels--Except for minor seasonal variations, the waterway level is consistent. This stabilization has decreased the physical effect of seasonal flooding. In some areas even minor variations would have significant impact.

2. New man-made structures--In each of the three (3) river segments locks and dams and other man-made elements (e.g., parks, commercial facilities docks, powerlines, etc.) have created visual contrasts with the natural character. These man-made elements have, in addition, frequently generated the development of greater access to the river.

3. Changes in the river's edge--Each river segment is characterized by general retention of original characteristics, but changes in the river's edge where they occur are usually from soft to hard visual character.

A Prototypical Representative Area is an area of major development along the river occurring as a direct result of the McClellan-Kerr Navigational System. The PRA's chosen for this study each basically represent one of the three general goals of the channelization program: river navigation transport, flood control, and recreation. They were (1) Keenan's Port of Dardanelle, (2) Murray Lock and Dam, and (3) Tar Camp Recreation Area.

The major changes within the area of Keenan's Port are a direct result of channelization. These changes include narrowing of the river channel, creation of new land masses and lowering of the river elevation. The change in visual character generally consists of new edge conditions, establishment of new terrain relationships and areas of new vegetation. New man-made facilities resulting from channelization have created economic and physical opportunities.

Before construction, the river channel was contained with steep wooded banks (15-20' high) which were fronted by low, sparsely vegetated sandbars. The commercial district of Dardanelle stood upon the southern bank of the river while the northern bank was densely wooded. The sandbars along either bank contributed to the distinct and varying character of the river channel.

In affecting the present visual character channelization construction utilized the "existing" sandbars in forming the sloping sand beaches which now constitute the south bank. The establishment of the new bank resulted in the narrowing of the river channel, producing a more uniform, controlled edge condition and redefining the visual relationship between the river and the City of Dardanelle. Vegetation along the sand beach consists of sparse scrub growth midway up the slope gradually becoming denser as young tree stands integrate with the established treeline at the slope top. New sand beaches occur along the north shore at the eastern extreme of the area. Here the "old" bank (before construction) of established woods has been visually set back from the river by the "new" sand beaches (after construction) and their "pioneer" vegetation.

Murray Lock and Dam was built as an integral part of the channelization project. The river elevation above the dam has been raised 15-20', widening the river, while channelization and stabilization below the dam has narrowed the river and established new land masses along both banks.

Visual change on the south bank above the dam is limited to a revetment constructed along this edge and a rise in the original river's edge. Further above the dam, stands of dead trees (snags) are visible near the mouth of the Little Maumelle River at the south end of the I430 bridge. Below the dam, new land masses have been established from old sandbars and channelization construction. This new edge consists of low sand banks with grass and tree cover created as a result of the construction of the Murray dam site and overlook park recreational area. Immediately below the dam, the edge has been rip-rapped and is usually an extension of the dam's mass. As a part of the lock and dam facility, an observation structure/ visitors' center was constructed mid-way (vertically) up the south slope. The "unique" geometric design of the structure makes it an "outstanding" feature against the wooded slope.

Above the dam, the inundation of lowlands and sand banks along the north shore have formed a lake-like water body with a number of small islands fronting the "new" bank. These islands vary from small marsh grass islands to larger islands of sand bank willow and young cottonwoods. Beyond these islands, the "new" edge is formed by the heavily wooded levees of the "old" river which become "new" levees and rip-rap revetments near the dam.

Below the dam, new edges of long, sloping sand banks and rip-rap dikes with young scrub growth are backed by a permeable line of lowland woods. These sand banks are dotted with rock, logs and scrub growth and have a "waste land" appearance.

The lock and dam is visually tied into the banks in all directions by the rip-rap revetments and dikes which reflect the character of the lock and dam in their color, man-made character and relative mass.

Tar Camp Park was built as part of the channelization project, as was the Brodie Bend Cutoff on which the park is located. While both represent substantial change and modification of the riverscape and the surrounding terrain relationships, preception of change is difficult to visualize. This is due to the manner of developmental implementation, utilizing existing vegetation, terrain patterns and natural river action and flow to create the new channel and park.

The Brodie Bend Cutoff was created by cutting a narrow pilot channel and constructing rock revetments along the "future" north bank. The natural erosive action of the river was then allowed to carve out the new channel. This method closely parallels the river's natural process in straightening its course by cutting a short channel across an oxbow neck. Construction techniques have merely hastened this process within desired limits.

The use of this "natural" method resulted in retention of the basic visual character of this area while markedly altering the river's course. This is due to the natural formation of new banks and the existence of established woods upon these banks. Thus the "new" edge condition and stage of maturity of the tree line closely match that of the existing riverscape in the area surrounding the cutoff.

Tar Camp Park was thoughtfully situated within the existing terrain and vegetation along the cutoff. Though it is highly visible from the river, due to the "soft," permeable edge condition, all new structures have been located and designed to exert minimal visual impact upon the site. As seen from the river, the most noticeable elements of the park are the sand beach cove and launch area, the playground equipment and the autos and camper trailers of the park users.

The Most Significant Visual Changes

A number of significant visual changes occurred on the waterway and the adjacent landscape in the period between the initiation and completion of the navigational system. These changes modified the visual character of the waterway with respect to edge conditions, vistas and grain character.

Edge conditions and the width of the waterway have generally been stabilized as a result of the control of the flow of the water (in terms of elevation and surface dimension) and stabilization of the river banks. Although some edge conditions have shifted and/or changed substantially due to river construction, including changes in water elevation, they are now predominantly stable with minor seasonal changes (due to water flow from rivers flowing into the waterway). This is a marked difference from the generally free flow of the river before construction of the navigation system (no more occasional massive flooding of lowlands). Among the more significant changes in edge conditions is the widening of the river in the Lake Segment, creating new river edges, and significant straightening of the navigational channel occurring throughout the waterway's course.

Changes in vista are significant in terms of how they affect and modify the visual character of the riverscape. Some vistas have been modified due to changes in the river's course (cuts in the terrain to shorten the route), some due to flooding, resulting in the widening of the visual channel (this is especially true in the Lake Segment where large areas of lowland were flooded to create a lake-like environment).

Physical manifestations (vegetation) on the river, such as the locks and dams, have had a significant visual impact on modifying vistas especially those within the visual channel of the waterway. Another modification of vistas was that increased access to the river's edge (creating changes in itself) has resulted in auxillary development such as ports and parks. Modification of the visual character due to auxillary development varied according to the degree of integration this type of development had with the existing riverscape (visual impact of parks such as Tar Camp are minimal in comparison to that of Dardanelle Port, although the parks have given many more people access to the views and vistas of the river). As more man-made landscape features are built on the riverscape, vistas and the general "naturalistic landscape quality" (now existing) are expected to deteriorate.

Changes in grain character were a reflection of increased changes in edge conditions and the addition of new man-made landscape features on the riverscape. At present the impact of new man-made features is an interesting (positive) relief, varying the pulse and rhythm of the grain character to some small degree (especially on the consistently flat terrain of the Delta Segment). These features generally reflect the conditions occurring beyond the visual channel. Should man-made landscape features proliferate on the riverscape, their effect would be negative, decreasing and conflicting with the "natural look" of the present riverscape in the study area.

Comparison of the river segments revealed that the most significant discernible changes occurred in the Lake Segment. The Delta Segment underwent major physical changes with regard to the waterway course and edge stabilization, but these changes are not usually visually discernible due to their segment's general similarity of terrain and the Corps of Engineers' successful integration of these physical changes into the existing landscape.

## BANK STABILIZATION

The bank stabilization and channel rectification program has been an extensive project providing a stable navigation channel from the Short Mountain Dam Site in Oklahoma (N.M. 340) to the mouth. The design criteria were patterned after those suggested by the background studies of the lower Missouri River and certain European river training practices. The alignment consists of a series of easy bends of alternating curvature, usually connected by straight crossing reaches about two to four times as long as the stream width. Excellent results and economical savings have been accomplished by controlling or "training" the river to its own configuration rather than forcing it into an artificial alighment. The channel width has been established at 250 feet and the design depth at 19 feet. This has been accomplished by the use of (1) revetments to stabilize the concave banks of bends; (2) dikes to close off secondary channels, to control the direction of flow from one bend to the next, and to fair-out the natural concave banks to a more desirable alignment; and (3) cutoff channels to eliminate bends of small radius of curvature.

The bank stabilization and channel rectification program has had a positive environmental effect on the Arkansas River in several ways. Turbidity measurements recorded indicate an apparent relationship between the navigation project and the reduction in turbidity of the river water. Other factors also indicate that turbidity has been reduced and that this is in part directly associated with the bank stabilization program, other causes being sediment storage on principal tributaries and on the main stem of the river. Prior to 1965, the average suspended sediment load ranged from 62 to 97 million tons/year whereas the estimate for the period 1965-1971 is only 10 million tons/year. Isolated turbidity measurements reflect a similar type of reduction trend.

This reduction of suspended sediment also is substantiated by the fact that the Plains Shiner and the Arkansas River Shiner probably no longer exists in the system because they prefer silty rivers. Indirect effects of this reduced turbidity are enhancement of the visual and aesthetic value of the river and of sports fishing.

The backwater areas created by the dikes and revetments provide excellent habitats for fish and wildlife but care must be taken to prevent destruction of their habitats during routine and ongoing maintenance operations.

The construction of bank stabilization and channel rectification and alignment structures has probably had the greatest impact on water quality parameters such as decreasing turbidity and suspended sediment. Rock dikes and revetments have been used to create backwater areas along narrow stretches of the river. The value of these areas as fish habitat, particularly as nurseries, was discussed by Buchanan (1976). The rock materials comprising these structures frequently provide valuable cover and spawning sites. Drift and debris which tend to accumulate on or behind the pile dikes also serve these purposes.

## WATER QUALITY

### Chemical Species

To determine an overall impact of the project on the concentration of chemical species, it is necessary to compare chemical analysis data prior to initiation with those obtained after completion. The chemical species that meet this data requirement are calcium, chloride, fluoride, iron, magnesium, potassium, sodium, and sulfate.

Chemical Analysis data were collected on a regular basis at fixed stations along the Arkansas River in the State of Arkansas by the United States Geological Survey (USGS), the Environmental Protection Agency (EPA), and the Arkansas State Pollution Control and Ecology Department (APCE).

Combining agency stations showed that extensive sampling was carried out at six major locations along the Arkansas River in Arkansas: Pendleton, Pine Bluff, Little Rock, Dardanelle, Ozark, and Fort Smith.

There has been a general overall decrease in the yearly average chloride concentration during the time period 1945 through 1976 at the major stations. This decrease in chloride concentration is reflected by the fact that the total chloride load also has decreased over the same period of time. The yearly average chloride concentration decreases at progressively downstream stations of the dilution effects by the many streams that empty into the Arkansas River. The average streamflow increases at each progressively downstream station, resulting in a larger volume of water and therefore a decrease in concentration. The observed decrease in chloride concentration at progressively downstream locations is not due to a decrease in the total chloride load because the total amount of chloride remains constant from station to station within a given year.

It is difficult to attribute the decrease in chloride concentration and chloride load to any specific project on the Arkansas River. Both the yearly average chloride concentration and yearly total chloride load show a continual overall decrease in the 32-year period 1945-76.

Many projects, which include the McClellan-Kerr Arkansas River Navigation Project, have been completed by the Corps of Engineers in the Arkansas River basin in Arkansas and Oklahoma since 1938. These projects may have resulted in some decrease in the total amount of chloride. However, because the total chloride load is the same at both the Fort Smith and Little Rock stations, the conclusion from the data available is that these projects have not significantly decreased the amount of chloride in the Arkansas River <u>in Arkansas</u>. Preliminary studies of the available data indicate that the majority of the chloride (also dissolved sodium, magnesium, calcium, sulfate, and potassium) originates in the states of Kansas and Oklahoma where the Arkansas River flows through the Salina and Mid-Continent Salt Basins. Results from preliminary studies also suggest that feeder streams such as the Salt Fork of the Arkansas River, Big and Little Salt Plains of the Cimarron River and Salt Creek of the Cimarron River contribute significant amounts of the dissolved salts to the total load.

It is possible that projects completed by the Corps of Engineers in Oklahoma and Kansas have resulted in some or most of the decrease in chloride. These projects, including the Great Salt Plains dam, date from 1940. The decrease in chloride also may be due to a natural decrease in the amount of source salts available.

All of the trends observed for dissolved sodium, potassium, calcium, magnesium, total sulfate, total hardness, and total alkalinity are qualitatively identical to the trends observed in the chloride system. This finding is expected because these chemical species appear to have the same source in Oklahoma and Kansas as does chloride. For example, the most important compounds found in the Great Salt Plains of Oklahoma are sodium chloride (NaCl), potassium chloride (KCl), calcium sulfate ($CaSO_4$) or gypsum, magnesium calcium sulfate ($CaMg(SO_4)_2$), calcium carbonate ($CaCO_3$), and calcium chloride. The trends in the chloride system and the explanation for those trends are also applicable to these other chemical species and parameters.

Physical and Biological Aspects

Years in which physical and biological data were collected on the Arkansas River varied considerably among the agencies and stations, covering an overall period from 1945 to date. Because data collection was sparse or incomplete at several stations, sampling locations for this section were selected on the basis of availability of a sufficient period of water quality data collection at various points along the Arkansas River before and after the completion of the McClellan-Kerr Arkansas River Navigation Project. Data collected by two separate agencies at the same location were combined for one sample location. Data for temperature, color, turbidity solids, pH, dissolved oxygen, and bacteria are available and were reviewed for consideration in this report. The important findings are stated below.

Data at Van Buren, Dardanelle, and Little Rock indicate that there was a fairly even level of color during the period of record before 1970 and then an increase in color level in the years after 1970. These increases roughly correspond to the completion of the navigation project. No explantion for this color change can be found. It is unlikely that this apparent change would be found to be detrimental to the river. In general, only a few values below water quality standards are recorded. Also, the average percent saturation of oxygen concentrations in the river indicates that the ability of the river to maintain adequate dissolved oxygen has not changed as a result of the navigation project.

Total coliform concentrations in the river are generally high through the period of record. Samples taken at North Little Rock show an apparent increase in the number of coliforms during the period corresponding to construction of the project samples taken above and below Fort Smith, if taken together, also appear to show an increase. However, because the period of sampling does not overlap for the two stations it is possible that the apparent trend is not due to construction projects but only to the difference in location.

The apparent increases in total coliform concentrations could have been caused by construction activities. Total coliform bacteria can concentrate in soil and silt deposits on the bottom of the river, and during construction the disturbance of these deposits would result in an increase of organisms in the water. This increase would then tend to disappear during periods of no disturbance. Data are not sufficient to establish this point clearly, although the foregoing explanation appears valid.

Turbidity data reflects an apparent decrease starting about 1964. This observed turbidity decrease is probably the result of both the construction of locks and dams and the efforts to stabilize the banks of the river.

### Fish Aspects

There are three generally accepted criteria for evaluating the potential for reservoirs to produce sports fishes. These are that the total dissolved solids be in the range of 100 - 350 ppm (moderately hard), that the ionic concentrations of carbonate - bicarbonate exceed that of sulfate - chloride, and the mean annual suspended sediment load of inflowing streams be less than 2000 psia. Using these criteria one would predict a below average potential for production of sports fishes in the lake sections of the navigation system. This production does not account for management successes which have occurred such as the establishment of the striped bass. The total standing crops and sport fish standing crops were generally much higher for the Arkansas portion of the navigation system than for all Oklahoma reservoirs. However, the Arkansas River Navigation System is probably experiencing the "new reservoir" effect, and if the above predictions are valid a decline in sport fish populations of undetermined extent can be expected as the navigation system ages.

## ECOLOGY

An analysis was made of the effects of the navigation project on the ecology of the Arkansas River. Included were aquatic resources, terrestrial resources, wetlands, and mitigation/enhancement features. The analysis was limited to data already available. In some cases assumptions and best judgments were used to estimate preproject conditions.

### Changes in Fish Species Composition

Prior to the construction of the navigation system, 43 species of fishes were reported from the main Arkansas River before 1940, and three additional species were listed in Game and Fish Commission rotenone sample reports for 1957-1963, for a total of 46 species. During 1974, and in subsequent collections in 1975 and 1976, 109 species were collected from the navigation system, including the lower White River portion and the Arkansas Post Canal and Lake Merrisach. Of the 109 currently known species, 97 were found in the main Arkansas River. Three additional species not reported in 1976 have been collected. The channel darter, *Percina copelandi*, was collected on 12 August 1975 at N.M. 246 in Franklin County. This upland species is probably only accidental to the navigation system. Also confirmed from the system since 1974 are the walleye, *Stizostedion vitreum* ,which was collected from Dardanelle Reservoir in 1976, and the alligator gar, *Lepisosteus spatula* Lacepéda. Alligator gar recently were collected from the mouth of Lee Creek near Fort Smith in 1975 by a commercial fisherman, near the mouth of the Petit Jean River in Logan County in 1976 and near Little Rock in May 1977 by commercial fishermen (an eight-foot, 206 pound specimen; photograph appeared in *Arkansas Gazette*, May 25, 1977).

The discrepancy in the numbers of species of fishes known before and after the construction of the navigation system mainly reflects the lack of collections from all parts of the river before the navigation system was built, rather than the major habitat alterations that have occurred. Therefore, it is difficult if not impossible, to determine whether a species which has only recently been reported from the system also was present there prior to its construction. Of the species reported only after the construction, only two, the striped bass, *Morone saxatilis* (Walbaum), and the grass carp, *Ctenopharyngodon idella*, definitely were not present in the river prior to the construction of the navigation system. Certainly most, if not all, of the remaining species were present in the Arkansas River to some extent before the navigation system was built, if only as accidentals to the river.

Four species reported prior to the construction of the navigation system have not been collected since its construction:

(1) the plains minnow, *Hybognathus placitus* -- This is primarily a species of the large, turbid rivers of the great plains, where it is found in the main channels over a sandy bottom. The plains minnow apparently formerly reached the mideastern periphery of its range in the upper Arkansas River in Arkansas River, but it has not recently been collected despite considerable effort to do so.

(2) the speckled chub, *Hybopsis aestivalis* -- This is another species that is rare all over the state. The speckled chub inhabits the main channels of large, turbid rivers, where it occurs in shallow, flowing water over a clean sandy bottom. The absence of the speckled chub from the main navigation system, especially the upper part, is difficult to explain.

(3) the Arkansas River shiner, *Notropis girardi* Hubbs and Ortenburger -- The only known record of this species from Arkansas is that it was collected from the Arkansas River at the mouth of the Piney Creek in Logan

County, on 23 July 1939. This shiner is found most commonly in the main channel of the Arkansas River and its large, sandy tributaries in Kansas, Oklahoma, and Texas. It formerly reached the eastern periphery of its range in western Arkansas, where it has not recently been collected.

(4) the sucker mouth minnow, Phenacobius mirabilis-- This species was originally described from the Arkansas River at Fort Smith. In 1940 it was a very rare species in Arkansas, and it is doubtful whether the sucker-mouth minnow now is present anywhere in the state.

## Changes in Fish Species Abundance

Species of fish currently known in the Arkansas River can be assumed to have decreased in absolute numbers as a result of the navigation system construction (although some species may have been entirely eliminated). Species which were already decreasing over their ranges, such as the alligator gar, paddlefish, and American eel, may have been affected either positively or negatively by the altered conditions of the system, but many more years of monitoring fish populations will be needed to determine their status. It is likely that the majority of species have increased in actual abundance, and that some drastic shifts in relative abundance have occurred. Those species believed to have shown marked population increases due to the construction of the navigation system are listed below. Most of the 18 species listed have increased in abundance throughout the navigation system, but some, such as the green sunfish, have become more abundant only in the two large reservoirs. Of the fishes on this speculative list, 10 are game species, 4 a primarily "rough" species, and 4 are forage species.

Fishes Believed To Have Experienced Marked Population Increases.

| | |
|---|---|
| Gizzard Shad | Mississippi silverside |
| Threadfin Shad | White bass |
| Emerald shiner | Green sunfish |
| Red shiner | Bluegill |
| Smallmouth Buffalo | Longear sunfish |
| River carpsucker | Largemouth bass |
| Blue catfish | White crappie |
| Channel catfish | Sauger |
| Flathead catfish | Freshwater drum |

Zooplankton, Benthic & Phytoplankton Communities

Construction of the Arkansas River Navigation System involved building locks and dams, channel realignment, dredging, and bank stabilization. These activities produced profound effects on the velocity of current, volume of flow, and physical-chemical characteristics of the river, which in turn undoubtedly influenced the composition of the zooplankton and benthic communities of the river. The lack of sufficient baseline data on the biota of the river prior to construction of the Arkansas River Navigation System precludes an accurate scientific evaluation of the effects of the system on the zooplankton and benthos.

However, by way of a comparative analysis of a review of the literature and the results of their investigation, it is concluded that the construction of locks and dams on the Arkansas River significantly affected the production of zooplankton. The following conclusions concerning the zooplankton of the Arkansas River have been reached.

1. The rapid flow-through impoundments, especially in upper regions, have singificantly increased the density and production of zooplankton.

2. The construction of the Arkansas River Navigation System has not affected the overall seasonal abundance pattern of zooplankton.

3. The longitudinal decrease in abundance of zooplankton observed within a portion of the lower section of the system (river miles 201.2-10.3) is amplified by the decrease in backwater areas and the increase in water current and silt load.

4. Though the qualitative composition of the zooplankton community has not been affected, the community structure and diversity have been modified by increased production of certain dominant species due to habitat modification within the Arkansas River.

The construction of the navigation system has changed the Arkansas River from a lotic environment to one which has considerable lentic characteristics. It is possible that much of the running water benthic fauna has been eliminated and replaced by a more lacustrine fauna.

The following observations concerning the benthic communities can be made.

1. The benthic communities as a whole do not show the stability, composition, or diversity one would expect from a "natural" river.

2. Occasional maintenance dredging may not drastically alter the local benthic fauna, but repeated dredging of an area may reduce the density and diversity of benthic organisms.

3. On the basis of the unionid mussel fishery which once existed in the Arkansas River, some juvenile mussels were expected to appear in benthic samples. However, no unionids were present in the benthic samples, and "...circumstances seem to be present ... which are unfavorable for the continuance of unionid populations ..."

4. The introduced Asiatic clam, Corbicula, was the most abundant and widespread benthic organism.

5. The establishment and spread of Corbicula in the Arkansas River are probably recent events.

6. Corbicula has altered the benthic fauna of the river.

7. Corbicula apparently spreads with particular speed through disturbed waterways, and dredging may aid the distribution of juvenile Corbicula through extensive mechanical disturbance of the substrate.

The following recommendations are made for the protection of the zooplankton and benthic communities of the Arkansas River:

1. Protect backwater areas from destruction or harmful modification. These areas are critical for the production and maintenance of most biotic communities of the river.

2. Dispose of dredge spoil on land, not in backwater areas or tributary mouths.

3. Limit dredging activities to those necessary to maintain the navigation channel.

4. Protect streamside vegetation from clearing operations, excessive grazing, and bank erosion.

5. Establish a biomonitoring program on the Arkansas River, especially for the clam Corbicula.

6. Support pollution abatement in the Arkansas River drainage basin to whatever extent possible.

The synergistic effects of the development activities have also undoubtedly influenced the compositon of the phytoplankton assemblage. The river now contains a more diverse phytoplankton component than might be expected. Studies show a structurally diverse and complex plankton with definite seasonal and spatial patterns. The parameters of temperature and light, including turbidity, are considered to be major "controlling" factors. Fall and winter populations appeared to be most sensitive to these factors. Increased turbidity causes perturbation in phytoplankton assemblage abundance and composition throughout the year. However, factors other than dredging are considered to account for these observed changes.

## Terrestrial Changes

A study of available literature indicates that alteration of original terrestrial vegetation of the Arkansas River area began in the first two decades of the 19th century. Early changes consisted mostly of removing snags followed by bank stabilization and other improvements of the channel for navigation purposes were possible. Progress in channel improvement and consequent changes in original vegetation generally proceeded from the mouth of the river toward Fort Smith and was accompanied by lumbering, and clearing, and farming of bottomlands adjacent to the river.

The original vegetation of the river and its environs were altered considerably by the time construction was started on the McClellan-Kerr Arkansas River Navigation System in the early 1950's, and results of the field work in July 1977 show that even more extensive changes have occurred since. Although plant species typical of the original plant communities grow along the river, natural ecosystems closely resembling original conditions are present today only as small relict communities mostly in isolated areas that have been least influenced by construction activities on the project. Examples of such areas include the lower end of Marrisach Lake south of Arkansas Post Canal which supports a stand of cypress and other wetland plants, oxbow lakes and bends in the river such as Holla Bend, and other places along the river which have been less altered and subsequently cut off from disturbance along the main stem.

The principal original vegetation types varied considerably. Vegetation along the river roughly below Little Rock was predominantly that usually associated with bottomland hardwood forest types typical of the Mississippi River floodplains. Bald cypress (*Taxodium distichum*) and tupelo (*Nyssa aquatica*)were common trees of areas inundated most of the year. Such vegetation grows today only in backwater areas and along slow-flowing rivers and streams. Forests composed of black willow (*Salix nigra*), sycamore (*Platanus occidentalis*), and cottonwood (*Populus deltoides*) were present in areas that were flooded frequently, and bottomland hardwood forest was present in moist areas of flats. Principal species of such areas included water hickory (*Carya aquatica*) and overcup oak (*Quercus lytata*), with southern hackberry (*Celtis laevigata*) and water locust (Gleditsia aquatica) as minor species. Areas of intermediate dryness on flats supported such species as American elm (Ulmus americana), persimmon (Diospyros virginiana), silver maple (Acer saccharinum), sweet gum (Liquidambar styraciflua), and ash (Fraxinus spp.).

Drier areas of the flats included such species as bitternut hickory (Carya cordiformis), water oak (Quercus nigra), willow oak (Quercus phellos), and honey locust (Gleditsia triacanthos).

The better drained areas on the floodplain near the river above Little Rock supported many of the same species and small areas of bottomland hardwood vegetation, but other community types were more common. Gravel bars and low banks of the river supported almost pure stands of cottonwood. Flat areas of the lower flood plain were dominated by elm (Ulmus americana), green ash (Fraxinus pennsylvanica), silver leaf maple (Acer saccharinum), or box elder (Acer negundo). Forests of these areas intergraded with species found on higher parts of the floodplains or low parts of the uplands. Principal species included bitternut hickory, southern hackberry, black walnut (Juglans nigra), burr oak (Quercus macrocarpa), or white oak (Quercus alba).

Vegetation immediately adjacent to the Arkansas River today can be characterized as generally typical of comparatively early stages of wetlands succession with the exception of relict areas. Exceptions also are present on the banks of the Arkansas Post Canal where upland herbaceous species have become established, and in some places along rocky cliffs or shorelines where, because of the elevation of navigation pools into the original upland forest areas, vegetation next to the shore is typical of upland forests.

Pre-project wetlands were altered by increasing drainage caused by channel modifications, by construction of dikes and levees, by being covered with river sediments, or by inundation caused by rising navigation pools.

The effects of inundation are particularly evident in tributaries that flow into the river where the water level was raised. Black willow was formerly present along the banks of many of these tributaries. Because black willow is intolerant of prolonged flooding, large concentrations of dead willow trunks protrude from the water along the former banks of these tributaries, which provide increased habitats for forage fish. Also, floodplain forests near these willows were killed, and willows and other wetland species are becoming re-established near the water's edge on bars created near the present usual water levels.

Although creation of new wetlands by raising the navigation pools is of some value for wildlife habitat, these new wetlands are much poorer quality habitats overall than the originals. However, such areas are likely to become more valuable in the future as natural ecological succession occurs and the new plant communities become more mature.