DRAFT

Reconnaissance Report

Miami, Oklahoma, and Vicinity

Grand (Neosho) River, Oklahoma and Kansas

Main Report

U.S. Army Corps of Engineers
Southwestern Division
Tulsa District

March 1989

ADDENDUM
to the

May 1989

MIAMI, OKLAHOMA, AND VICINITY
RECONNAISSANCE REPORT

GRAND (NEOSHO) RIVER
OKLAHOMA AND KANSAS

U.S. Army Corps of Engineers
Southwestern Division
Tulsa District

This addendum revises data presented in the above report dated March 1989.

The substance of the revision is minor and is composed of expanded benefit evaluations and corrected flood damage reductions benefits.

The revision was prompted when, during review of the Economic and Social Analysis technical data, inconsistencies in the flood damage reduction benefits among the levee alternatives were identified. The inconsistencies were corrected. The correction resulted in a small decrease in the flood damage reduction benefits in most of the alternatives and generally shifted the most economical level of protection from the 100-year alternatives to the 50-year alternatives.

Two additional benefit categories had been under evaluation, but had not been completed at the time the subject report had been submitted. These two categories, affluence and emergency cost benefits, were completed while the flood damage reduction benefits were being revised and were included in the technical data.

The following table replaces Table 2, pages 34 and 35 of the Main Report. The format of the table has been changed to clarify the presentation of alternatives and the benefits consist of flood damage reduction, affluence, and emergency cost benefits.

The recommendation that Federal investigations should be continued was presented in the March 1989 Reconnaissance Report. That recommendation is unaltered by this addendum.

TABLE 2

SUMMARY OF ALTERNATIVE PLAN COSTS AND BENEFITS
Individual Measures
(October 1988 Prices, 8-7/8 Percent Amortization, 100-Year Project Life)
(In $1,000)

Alternative	Level of Protection (years)	First Cost ($)	Amortized Cost ($)	Annual Benefits ($)	Net Benefits ($)	Benefit-to-Cost Ratio (to 1.0)
Levee - Along Grand River and West Bank of Tar Creek						
	10	3,575	336	30	-	0.1
	50	9,575	900	2,456	1,556	2.7
	100	13,300	1,250	2,980	1,730	2.4
Levee - Along East Bank Tar Creek, "Southern Levee"						
	10	1,596	150	300	150	2.0
	50	2,926	275	390	115	1.4
	100	3,670	345	410	65	1.2
Levee - Along East Bank Tar Creek, "Rockdale Levee"						
	10	681	64	(30)	-	-
	50	1,330	125	(30)	-	-
	100	1,681	158	(20)	-	-
Levee - Along East Bank Tar Creek, "Sky Ranch Levee"						
	10	894	84	(30)	-	-
	50	1,404	132	(10)	-	-
	100	1,723	162	30	-	0.2
Levee - Along East Bank Tar Creek, "Birnamwood Levee"						
	10	133	13	(20)	-	-
	50	277	26	(10)	-	-
	100	372	35	(10)	-	-
Channel Improvement - Tar Creek, Burlington Northern to 22nd Street North						
	10	1,702	160	120	-	0.8
	25	1,915	180	120	-	0.7
	50	2,085	196	120	-	0.6
Upstream Reservoirs						
Quail Creek	25	764	72	10	-	0.1
Garrett Creek	25	546	51	50	-	1.0
Quapaw	25	1,036	98	150	52	1.5
Lytle Creek	25	1,254	118	90	-	0.8

TABLE 2 (Continued)

SUMMARY OF ALTERNATIVE PLAN COSTS AND BENEFITS
Levees in Addition to
the Levee Along the Grand River and Along the West Bank of Tar Creek
(October 1988 Prices, 8-7/8 Percent Amortization, 100-Year Project Life)
(In $1,000)

Alternative	Level of Protection (years)	First Cost ($)	Amortized Cost ($)	Annual Benefits ($)	Net Benefits ($)	Benefit-to-Cost Ratio (to 1.0)
AND a Levee - Along the East Bank of Tar Creek Includes: Southern, Rockdale, Sky Ranch, and Birnamwood Levee Areas						
	10	6,713	631	770	139	1.2
	50	15,160	1,425	2,939	1,514	2.1
	100	20,261	1,904	3,510	1,606	1.8
AND a Levee - Along the East Bank of Tar Creek, Southern Levee						
	10	5,171	486	700	214	1.4
	50	12,501	1,175	2,790	1,615	2.4
	100	16,970	1,595	3,310	1,715	2.1
AND a Levee - Along the East Bank of Tar Creek, Rockdale Levee						
	10	4,256	400	0	-	-
	50	10,905	1,025	2,370	1,345	2.3
	100	14,981	1,408	2,870	1,462	2.0
AND a Levee - Along the East Bank of Tar Creek, Sky Ranch Levee						
	10	4,469	420	470	50	1.1
	50	10,979	1,032	2,500	1,468	2.4
	100	15,023	1,412	3,050	1,638	2.2
AND a Levee - Along the East Bank of Tar Creek, Birnamwood Levee						
	10	3,708	349	400	52	1.1
	50	9,852	926	2,390	1,464	2.6
	100	13,672	1,285	2,890	1,605	2.2

Negative net benefits and negative benefit-to-cost ratio were not tabulated.

MIAMI, OKLAHOMA, AND VICINITY
RECONNAISSANCE REPORT

GRAND (NEOSHO) RIVER
OKLAHOMA AND KANSAS

U.S. Army Corps of Engineers
Southwestern Division
Tulsa District

March 1989

SYLLABUS

This report presents the first phase of a two-phase planning process in water resources investigations. The investigations were conducted to identify water resources and related problems and needs and to formulate and evaluate solutions. The data developed in these studies will be used to evaluate the economic feasibility of providing flood protection along the Grand (Neosho) River and Tar Creek at Miami, Oklahoma.

Miami is located in Ottawa County at the upper end of Grand Lake on the Grand River. The drainage area above Miami is about 6,071 square miles. The portion of the Grand River involved in this study extends from the Tar Creek confluence on the east to the Miami city limits on the west. Tar Creek flows through the eastern part of Miami and has a drainage area of about 50 square miles. The high flood damage portion of Tar Creek included in this study begins at the Grand River confluence and extends north through the city to the area just north of 22nd Avenue.

Flood damages occur with relative frequency along Tar Creek, and infrequently along the Grand River. Estimated average annual flood damages of about $3,000,000 will impact personal and public property and decrease the economic well-being of the community.

A potential problem was identified in connection with the extent of existing land acquisition for flood control operations of Grand Lake. The level of detail required to conduct a reexamination of flood control easement requirements was outside the scope and time frame of this reconnaissance investigation. A request for authority to initiate a flood control easement reexamination was initiated in November 1988.

Areas of development along Tar Creek may be eligible for the buyout program administered by the Federal Emergency Management Agency, as authorized by Section 1362 of the National Flood Insurance Act of 1968.

This study identified 15 economically feasible, structural solutions to flooding at Miami, Oklahoma. Fourteen of the alternatives were levee plans and one alternative was a 25-year flood control reservoir, the Quapaw Reservoir. The economic feasibility of these measures indicates a potential for implementation of a Federally supported project to reduce flood damages.

The potential project sponsor for Feasibility Phase studies is the city of Miami.

Federal investigations were recommended for continuation to develop a plan for flood damage reduction which is acceptable to the city of Miami. An NED plan, if different from the locally acceptable plan, would also be developed as the basis for Federal evaluations.

If authority is not provided to re-examine the adequacy of Grand Lake flood control easements, then it was recommended that investigation of nonstructural measures for the reduction of flood damages at Miami be continued under authority of Section 208 of the Flood Control Act of 1965 or under the authority of Section 205 of the 1948 Flood Control Act.

MIAMI, OKLAHOMA, AND VICINITY
RECONNAISSANCE REPORT

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MIAMI, OKLAHOMA, AND VICINITY
RECONNAISSANCE REPORT

INTRODUCTION

This report presents the first phase of a two-phase planning process in water resources investigations. Called the reconnaissance phase, the investigations involved are conducted to identify water resources and related problems and needs and to formulate and evaluate solutions.

The data developed in these studies will be used to evaluate the economic feasibility of providing flood protection along the Grand (Neosho) River and Tar Creek at Miami, Oklahoma. Miami is located in Ottawa County at the upper end of Grand Lake on the Grand River. Figure 1 is a location map of this area.

Grand River is a major tributary of the Arkansas River and drains an area of about 12,495 square miles in Kansas, Oklahoma, and Missouri. The river forms the southern boundary of the original part of Miami. The drainage area above Miami is about 6,071 square miles. The portion of the Grand River involved in this study extends from the Tar Creek confluence on the east to the Miami city limits on the west.

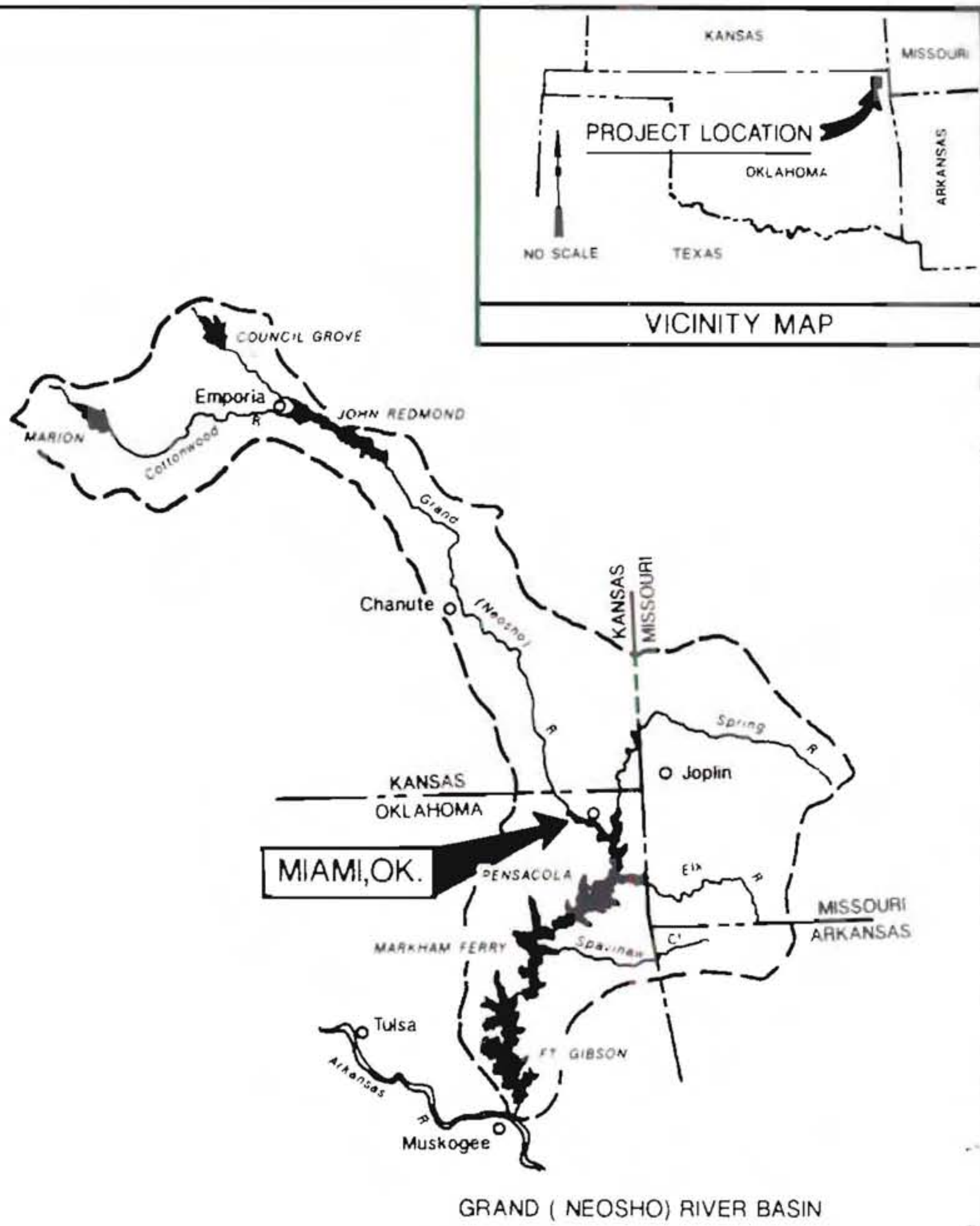


FIGURE 1

PROJECT LOCATION MAP

MIAMI, OK. RECONNAISSANCE STUDY

Tar Creek is a left bank tributary of the Grand River. It flows through the eastern part of Miami and has a drainage area of about 50 square miles. The high flood damage portion of Tar Creek included in this study begins at the Grand River confluence and extends north through the city to the area just north of 22nd Avenue (shown on Figure 2). The study area also includes the Tar Creek Basin to the Kansas/Oklahoma State line.

STUDY AUTHORITY

The study authority which encompasses the study area is Section 208 of the Flood Control Act of 1965, Public Law 89-298, approved 27 October 1965. The wording in the authority reads as follows:

> The Secretary of the Army is hereby authorized and directed to cause surveys for flood control and allied purposes, including channel and major drainage improvements, and floods aggravated by or due to wind or tidal effects, to be made under the direction of the Chief of Engineers, in drainage areas of the United States and its territorial possessions, which include the localities specifically named in this section. After the regular or formal reports made on any survey authorized by this section are submitted to Congress, no supplemental or additional report or estimate shall be made unless authorized by law except that the Secretary of the Army may cause a review of any examination or survey to be made and a report thereon submitted to Congress, if such review is required by the national defense or by changed physical or economic conditions.
>
> . . .
>
> Grand (Neosho) River, Oklahoma and Kansas (including navigation).

STUDY PURPOSE AND SCOPE

This study was conducted to identify feasible solutions to flooding problems in the Grand River Basin in the area from John Redmond Dam, Kansas, to Grand River's confluence with the Arkansas River in eastern Oklahoma. The scope of study was established to address any water resources problems which might be brought to the attention of the U.S. Army Corps of Engineers. To date, the stated interest is the flooding situation in Miami, Oklahoma. Therefore, this investigation evaluated Miami flood problems and formulated solutions for consideration by the city. Tar Creek was included in this study due to substantial development in its floodplains. The study area is shown in Figure 2.

Alternative solutions developed during this phase of study will show the economic, environmental, and social feasibility for the type of solution proposed.

The alternatives presented in this report are not intended to provide comprehensive or optimal solutions to flooding problems, but are intended to provide the Government and the potential sponsor with timely, pivotal information necessary to determine if continued study is warranted.

PRIOR STUDIES AND REPORTS

Prior studies and reports pertinent to this investigation are summarized below.

TAR CREEK FLOOD PROTECTION STUDY

Conducted under authority of Section 205 of the 1948 Flood Control Act, as amended, a reconnaissance study of alternative solutions to the Tar Creek flood problem in Miami, Oklahoma, was completed in February 1987. The study identified two economically feasible plans to reduce flood damages along Tar Creek. One of the plans consisted of improving Tar Creek from 22nd Avenue to the Burlington Northern Railroad, and the other consisted of constructing a levee around the Sky Ranch residential addition in conjunction with floodplain acquisition on the opposite bank along Tar Creek. Further action on the Section 205 study is dependent upon the findings of this interim reconnaissance investigation.

MIAMI FLOOD INSURANCE STUDY

Miami participates in the regular phase of the National Flood Insurance Program. A flood insurance study of Miami was completed by the Federal Emergency Management Agency (FEMA) in September 1988.

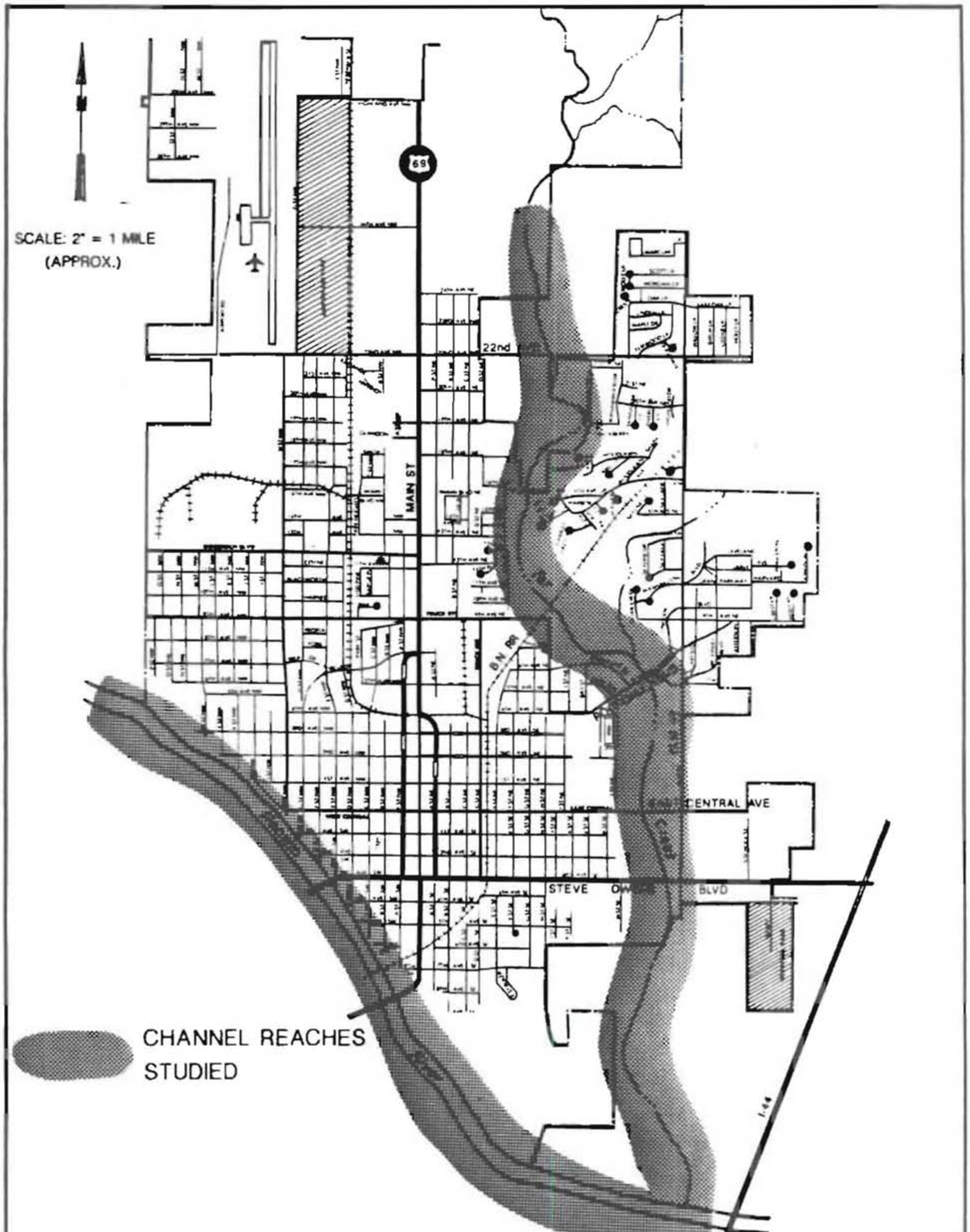


FIGURE 2
STUDY AREA
MIAMI, OK. RECONNAISSANCE STUDY

OTTAWA COUNTY FLOOD INSURANCE STUDY

Ottawa County Unincorporated Areas has participated in the emergency phase of the National Flood Insurance Program since November 1980. A flood insurance study of Ottawa County was completed by FEMA in December 1988.

PLAN FORMULATION

STUDY METHODOLOGY

This study was conducted following guidance provided in Economic and Environmental Principles and Guidelines for Water and Related Land Resources Implementation Studies (P&G), U.S. Water Resources Council, March 1983; the National Environmental Policy Act (NEPA), Public Law 91-190; and the 1986 Water Resources Development Act, Public Law 99-662.

STUDY PARTICIPANTS AND COORDINATION

The city of Miami initiated contact with the Corps of Engineers in September 1987 requesting a public meeting to discuss city flooding and the relationship of Grand Lake pool elevations to the level of flooding. At the public meeting held on September 22 in Miami, the Grand River Dam Authority (GRDA) and the U.S. Army Corps of Engineers, Tulsa District (Corps) presented information about the operation of Grand Lake. The Corps also reviewed information about Grand River flooding.

This reconnaissance investigation was initiated in March 1988. The city of Miami formed a Flood Committee to represent the interests of the city during the development and coordination of the Corps' reconnaissance studies. The Flood Committee reviewed proposed types of flood damage reduction measures and suggested alternative measures and project alignments.

One measure, small dams, was reviewed and the Flood Committee provided a set of alternate, smaller sites. The initial effort to evaluate the Corps-identified dams had been committed to separate hydraulic and design contractors and to the Soil Conservation Service who conducted the hydrology investigation. Although this effort could not be redirected without economic and temporal losses, an estimation of the alternate, smaller sites' costs and benefits has been developed. That estimate is discussed in Appendix A - Additional Studies.

The Flood Committee was also interested in examining the relationship of Grand Lake pool elevations at the start of a flood event to the extent of flooding at Miami. The relationship was investigated through computerized hydraulic model analysis. The analysis and relationship are also discussed in Appendix A.

EXISTING CONDITIONS

Grand River

The Grand River heads in the Flint Hills region of Morris County, Kansas, and flows southeasterly more than 300 river miles in Kansas, then southerly about 164 river miles across northeastern Oklahoma to its confluence with the Arkansas River near Muskogee, Oklahoma. The total drainage area of the Grand River is 12,520 square miles.

The headwater reach of the watershed is about 30 miles wide, increasing to about 80 miles to include the Cottonwood River. From the mouth of Cottonwood River to Miami, the watershed is 16 to 35 miles wide. Elevations in some parts of the headwater area are above 1,500 feet. The valley is flanked by rolling uplands that reach a height of about 150 feet above the valley floor, generally from 1 to 5 miles back from the river. The slope toward the valley proper is rather steep, resulting in rapid runoff from the tributary streams. In the vicinity of Miami, the hills have an elevation of about 850 feet National Geodetic Vertical Datum (NGVD) and the valley floor is about elevation 750. The topography of Miami and its general vicinity could best be described as gently rolling.

The Grand River channel is well defined and very sinuous. It varies in width from about 100 feet near Council Grove, Kansas, to about 300 feet near Miami, Oklahoma, and is occasionally obstructed by snags, debris, and gravel bars. Throughout its course, the river occupies a bed of gravel, boulders, and rock ledges. The banks are generally stable, vary in height from 15 to 30 feet, and are covered with brush and trees above the low water line.

The total fall of the Grand River from its headwaters to its junction with the Arkansas River is 1,000 feet. Throughout most of its length, excluding the upper reach, the average fall of the streambed is slightly over 1 foot per mile.

Tar Creek

Tar Creek is the only significant tributary of the Grand River within the reach of this study. The creek has a total drainage area of 53.3 square miles, and joins the Grand River just upstream of the U.S. Interstate 44 crossing. The stream originates north of Miami in Kansas and flows in a southerly direction through the eastern part of Miami to its junction with the Grand River.

The Tar Creek watershed lies within Ottawa County except for a small portion in Cherokee County, Kansas. The watershed is shaped somewhat like a fan. It is about 16 miles long, and averages about 3.3 miles wide. The extreme upper portion of the basin is devoted to agricultural purposes before the stream traverses about 6 miles of mining area. The lower portion of the basin is also devoted to agricultural purposes except that portion occupied by developments in Miami. This includes a rapidly expanding area along Oklahoma State Highway 10 and Northeastern A&M College.

Elevations in the basin range from a maximum of about 950 feet to about 730 feet in the streambed at its mouth at river mile 142.2 on the Grand River. The average slope is about 10.4 feet per mile. In the lower 7.5 miles of Tar Creek, the creek flows reasonably straight in a floodplain varying in width from about 1,800 feet to about 3,800 feet.

City of Miami

The city of Miami is located in northeastern Oklahoma in the northwestern portion of Ottawa County. The city is on the left (north) bank of the Grand River about 144 miles above its confluence with the Arkansas River, and is approximately 75 miles northeast of Tulsa, Oklahoma; 18 miles south of the Kansas State Line; and 30 miles west of the Missouri State Line. The majority of the city lies on the northern bank of the Grand River, while a fairgrounds and some residential areas lie on the south side of the river.

The left bank of the Grand River within the city of Miami is extensively developed. Except for scattered developments elsewhere, the remainder of the floodplain is devoted to agriculture or related purposes.

U.S. Interstate 44, a four-lane highway with twin bridges at the Grand River crossing, crosses to the east of Miami. Two other highway bridges cross the Grand River into Miami; U.S. Highway 69 and Oklahoma State Highways 10 and 66 cross on a common bridge from the west. Main Street bridge provides access across the Grand River to the area southwest of the city. The Burlington Northern Railroad and the abandoned Kansas, Oklahoma, and Gulf bridges cross the valley from the southwest to northeast. State Highway 60 and Connor Road bridge are also within the Grand River study reach.

Six bridges cross Tar Creek in the study reach. The Burlington Northern Railroad bridge is the only railroad crossing, while Oklahoma State Highway 10, locally known as Steve Owens Boulevard, crosses Tar Creek at the eastern edge of the city. Other bridges include the Central Avenue and Rockdale bridges near Northeastern Oklahoma State College and the 22nd Avenue bridge on the north side of Miami.

The area on the west side of Tar Creek from below Oklahoma State Highway 10 to about 22nd Avenue has been developed extensively.

Population and Economic Characteristics

In 1980, the population of Miami was 14,237. Ottawa County had a 1980 population of 32,870. Some out-migration has occurred as a result of a decline in the area's employment opportunities. The estimated population, based upon the Bureau of Economic Analysis OBERS 1985 projections, show the population of Miami will be 14,100 in 1990 and 17,000 by the year 2040.

Manufacturing has been one of the most important industries in the city and the county. Other important industries in the area include retail trade and services. The largest manufacturing firm in the city, a tire manufacturer, closed leaving over 1,900 employees without work. The plant closing has had a dramatic effect on all aspects of the local economy. Approximately 13,000 persons are currently in the labor force, which is substantially smaller than the labor force prior to the plant closure.

Estimated unemployment was 8.7 in November 1988 compared to the State of Oklahoma's unemployment rate of 6.3 percent and the national rate of 5.6 percent. As a consequence of the depressed local economy, income levels of the county and city are substantially less than the state and the nation. These conditions are expected to continue until new economic opportunities in the area are developed.

Geology

The floodplain soils of the Grand River and Tar Creek are associated with the Lighting Series described as deep, poorly drained, nearly level soils. The floodplains are forming in alluvium washed from soils of the prairies. The native vegetation is mainly tall grass requiring much water, but includes some hardwood trees.

Soils in the project area are primarily Verdigris silt loam with some Dennis silt loam and Kaw silty clay loam. Each of these soils has been classified by the U.S. Department of Agriculture as prime farmland. Coordination with that agency will be accomplished in accordance with Part 658 of Title 7 of the Code of Federal Regulations.

Climatology

The climate of northeastern Oklahoma can basically be classified as humid and sub-tropical. Spring and autumn months are mild with warm days and cold nights, and summers are long and not usually hot. Winters are comparatively mild, but brief periods of extremely cold weather do occur in some years.

Daily maximum temperatures average about 44 degrees Fahrenheit (F) in January and 92 degrees F. in July. Daily minimum temperatures are 26 degrees F. in January and 69 degrees F. in July.

Average yearly precipitation in Miami is 42 inches. Maximum precipitation occurs in late spring and early summer in the form of frequent thunderstorms. May is the wettest month, receiving 14 percent of the year's total precipitation. June follows closely with 13 percent of the total.

Environmental

The watershed is in a vegetation zone classified by R.G. Bailey (Ecoregions of the United States, U. S. Forest Service, 1976) as a mosaic of the bluestem prairie and the oak-hickory forest subdivisions of the eastern deciduous forest ecological province. Most of the land in the project area is pastureland or open land except for a narrow corridor of mature bottomland timber adjacent to Tar Creek. Large trees are common in residential yards. Dominant overstory vegetation along the creek consists of elm, pecan, ash, and cottonwood. The open land is used mainly for pasture with a few smaller areas being farmed.

No wetlands occur in the area and no significant aquatic habitat exists along the creek. Tar Creek is a heavily polluted stream and is listed by the Environmental Protection Agency as one of our nation's most polluted streams. Because of the water quality problems associated with this pollution, aquatic habitat along Tar Creek is poor.

Since the study area lies adjacent to the city of Miami, the only wildlife species that should be affected by the project are those tolerant of urban conditions.

Various species of wildlife use the area, including white-tailed deer, squirrel, woodcock, and numerous songbirds. Squirrels and numerous bird species are the most visible wildlife in the area. A few black phases of the fox squirrel are present.

A diverse vegetative community exists in the project area. A Shumard oak that approaches the size of the existing Oklahoma state champion is growing on the banks of Tar Creek south of 22nd Avenue. During a field reconnaissance on July 10, 1986, the following species were identified:

northern red oak	Shumard oak	pin oak	pepper vine
bur oak	post oak	slippery elm	poison ivy
American elm	hackberry	black cherry	Virginia Creeper
chittamwood	bois d'arc	river birch	trumpet vine
Kentucky coffee tree	sycamore	catalpa	morning glory
basswood	pecan	black walnut	buckbrush
bitternut hickory	shellbark hickory	black locust	buttonbush
honey locust	mulberry	redbud	ragweed
willow	cottonwood	silver maple	cattail
box elder	green ash	grape	sunflower
ironwood	Russian thistle	fescue	bahia grass
bermuda grass	white sweet clover	Johnsongrass	Canada wild rye
broadleaf uniola	white dutch clover		

It is unlikely that any endangered or threatened species of plants or animals would occur in the project area.

Cultural Resources

Numerous archeological investigations have taken place in northeast Oklahoma and Ottawa County. Previous investigations in Ottawa County identified 43 prehistoric and historic archeological sites. Several archeological investigations have taken place along the Grand River; however, the majority of lands affected by this project have never been surveyed by professional archeologists. It is estimated that less than five percent of the project area has been surveyed. Based on this sample and what is known from the archeological research conducted at Oologah and Fort Gibson Lakes, archeological sites associated with the Paleo-Indian, Archaic, Woodland, Village Farming, and Historic Periods may be present in the project area.

Sediment Quality Study

Because of a superfund site in the Tar Creek Area, a sediment sampling program was conducted to characterize the quality of the sediments in Tar Creek and its adjacent floodplain within that portion of the reach passing through Miami. Sediment and overbank soil quality data would provide information on the potential impacts of channelization and levees on the water quality of Tar Creek, and would provide information regarding dredge disposal options.

The sediments in Tar Creek and the soils in the adjacent floodplain were found to contain heavily contaminated levels of zinc, lead, and cadmium. In addition, contamination levels for arsenic, chromium, and nickel were high in many locations.

Any disturbance of these materials resulting from construction activities would result in aquatic disturbance downstream. However, since the contamination levels are already high throughout the study area, the environmental impact would be short-lived. Implementation of any of the alternatives, therefore, could be achieved without significant adverse environmental impacts.

Flood History

Tar Creek is the primary source of flooding in the city of Miami, Oklahoma, although storms over the Grand River Basin and high stages on the Grand River cause frequent flooding along the Grand River as well as Tar Creek. Flooding generally occurs in the spring and summer months. The majority of the large floods are the result of continuous, heavy rain; however, flooding on Tar Creek may be caused by intense local thunderstorms typically moving in a northeasterly direction across northeastern Oklahoma and southeastern Kansas.

Most of the residential properties and a larger part of Miami's business district are above flooding elevations, but numerous residential, commercial, and industrial areas on the Grand River and Tar Creek and tributaries have been inundated by floods.

Flooding on Tar Creek is often elevated downstream of the Burlington Northern Railroad bridge from the Grand River, due to backwater effects. Tar Creek is a relatively small creek and can produce flooding independent of the Grand River. These floods, caused by isolated storms on the Tar Creek watershed, are characterized by very rapid rates of rise of short duration. The estimated 100-year discharge for Tar Creek at its confluence with the Grand River is 15,400 cubic feet per second (cfs).

An investigation of local history sources, newspaper files, and interviews with local residents revealed numerous flood events on the Grand River and Tar Creek. Following are descriptions of large floods that have occurred on the Grand River and Tar Creek in the vicinity of Miami.

__May 1943__. The flood of May 1943 had two distinct phases. The first phase began on May 7 and continued for four days. This storm saturated the ground and filled Grand Lake. The second phase began on May 14 with a storm centered over Joplin, Missouri, producing 16.41 inches of rain in five days. Heavy precipitation occurred over the area immediately above and surrounding Miami. Although some rainfall occurred throughout the entire 5-day period, most of it occurred on May 19. The crest stage of the Grand River at the gage near Commerce was 25.12 and the estimated peak discharge was 105,000 cfs. The river rose to its crest stage above bankfull in 76 hours at an average rate of 0.13 foot per hour with a maximum rate of 0.6 foot per hour and remained above bankfull stage for about 11 days.

__July 1951__. A sequence of significant rainfall over the Grand River Basin began near the end of April, and culminated in the critical storm of July 9-13. Rainfall in May was considerably above normal, and the June rainfall was more than twice the normal amount. Three storm periods, June 20-24, June 28-30, and July 8-13, were particularly significant.

Considered separately, only the rainfall of the last period would be outstanding in magnitude; however, the occurrence of these storms in such rapid succession not only produced flooding, but saturated the soil and accounted for the phenomenal rates of runoff in the latter parts of the storm.

The flood actually began when the Grand River became bankfull on June 24 and gradually rose to about 5 feet over bankfull by July 1. The storms moved from north to south so that the rainfall followed the floods downstream.

Rainfall from July 9 to 13 consisted of a series of intense thunderstorms over the upper Grand River watershed. The rainfall was intense during the night and morning of July 10-11 when more than 7 inches of rain fell at many points in the upper watershed. Rainfall of 17.4 inches for the storm period was unofficially recorded south of Emporia, Kansas. The crest stage of the Grand River at the gage near Commerce was 34.03, and the estimated peak discharge was 267,000 cfs.

The river remained about 5 feet over bankfull until midday July 14, when it began to rise rapidly. The river rose to its crest stage in 36 hours at an average rate of 0.38 foot per hour with a maximum rate of 1.25 feet per hour and remained above bankfull until the evening of July 24.

Velocities in the channel of Grand River in the vicinity of Miami were estimated to have reached 10 feet per second. Overbank velocities reached 7 feet per second.

The July flood had an estimated peak of 267,000 cfs. The flood frequency for the 1951 flood was greater than the estimated 100-year flood peak of 197,000 cfs, but less than the estimated 500-year flood peak of 360,000 cfs.

A July 17, 1951, Muskogee Daily News account described the flood as follows: "The greatest flood in Miami's history was on the decline Monday night leaving in its wake an estimated $5 million in damage and some 3,000 persons homeless... The crest of 778.52 feet above NGVD was the highest in recorded history. It exceeded by 9.5 feet the great flood of 1943, the previous known all-time high."

April 1983. The flood of April 1983 was caused by rains which plagued the Miami area for weeks, sending streams out of their banks into low-lying areas. The Grand River topped flood stage on April 23, reaching the 18.6 feet level at Steppford bridge, west of Commerce, where the flood level is listed as 15 feet.

March 1984. Rainfall totaling 3.96 inches caused flooding in the Miami area on March 3 and 4. The Sky Ranch Estates area in northeast Miami was hard hit, and other areas were covered by 1 to 2 feet of floodwater from Tar Creek. The Grand River crested at 13.4 feet at Steppford bridge on March 4.

February 1985. Nearly 6 inches of rainfall sent water over the banks of Tar Creek and the Grand River on February 22 and 23. The Grand River crested at 766.95 feet at the Highway 66 bridge, and water from the river spilled over to cover much of George Francis Riverview Park and the Miami fairgrounds, closing down the Main Street bridge and flooding several nearby businesses.

Several bridges spanning Tar Creek were covered with water. The largest concentration of residential damage was in Miami's Sky Ranch Addition where approximately 35 homes were evacuated on February 22. Some houses were inundated by up to 5 feet of water. Dozens of homes and several businesses sustained damage; however, there were no reports of any injuries stemming from the flooding. No monetary estimates of the damages were available.

<u>October 1986</u>. The flood of October 1986 on the Grand River was caused by five days of heavy rain over the Grand River Basin. The five-day rain total for Miami was 11.29 inches. Total rainfall for September in Miami was 14.94 inches. The flood had a recorded discharge of 122,700 cfs at the Commerce gage. This flow was slightly less than the calculated 50-year flow of 150,000 cfs. High water elevations were documented in Miami by field surveys. The average flood elevation in Miami was about 772.5. The bridges on the Grand River were not overtopped; however, the Burlington Northern Railroad used a ballast train to keep their bridge weighted down during the height of the flood.

On September 30, as Tar Creek floodwaters rose, residents of 22 homes and 54 residents of a nursing home were evacuated. By noon, the lake level was 743.70 feet. On October 1, five main flood gates and five small gates of the dam on Grand Lake were open. Late in the day on October 1, Grand Lake measured 748.40 feet; however, the water was rising 1 foot every 8 hours. Water in the Grand River was measured at 759.83 feet at the Highway 66 bridge on the west side of Miami.

On October 6, Grand River floodwaters crept into Miami residential areas. Residents of over 300 homes in the Miami city limits were evacuated; outside the city limits, 80 homes were evacuated. Over 40 businesses were flooded. The Grand Lake level was 754.92 feet, and four large flood gates and four small gates at the dam on Grand Lake were open. The inflow was 113,000 cfs.

Existing Flood Protection Measures

Three Corps of Engineers multipurpose reservoirs are in operation in the Grand River Basin above Miami - Council Grove, Marion, and John Redmond. These reservoirs, completed since the July 1951 flood, reduce flood stages significantly at Miami.

The overall study area includes Grand Lake (Pensacola Dam and Reservoir, Lake O' the Cherokees), Lake Hudson (Markham Ferry Reservoir), and Fort Gibson

Lake. However, these projects are downstream of Miami, Oklahoma, and do not offer a potential for reducing flood damages.

Grand Lake

This project was authorized by the Flood Control Act of 1941, Public Law 77-228, and incorporated into the Arkansas River Multi-purpose plan by the River and Harbor Act of 1946.

The project is located on the Grand River at river mile 77.0 in Mayes and Delaware Counties near Disney, Oklahoma, and about 13 miles southeast of Vinita, Oklahoma.

The project was authorized for hydroelectric power and flood control and was constructed by the Grand River Dam Authority, an agency of the State of Oklahoma, pursuant to a license issued to the Authority by the Federal Power Commission with funds obtained through a loan and grant agreement with the United States. The project was completed in 1940 and became operational in 1941.

The Environmental Science Services Administration (ESSA) Weather Bureau, provides flood warning service to the city of Miami, Oklahoma, for crests on the Grand River. These warnings are based on the river gage near Commerce, Oklahoma, about 9 miles upstream. When flooding is expected at the Commerce gage, the police dispatcher at Miami is notified by telephone from the Tulsa River Forecast Center. The police dispatcher is asked to relay this information to the Miami City Engineer and the Ottawa County Civil Defense office. These warnings are also transmitted on the ESSA Weather Wire for further dissemination by news media who subscribe to this service.

PROBLEM IDENTIFICATION

Flooding in Miami is caused by two sources. Storms over the Grand River Basin cause infrequent flooding; however, high stages on the Grand River cause frequent flooding in the Tar Creek floodplain. The Grand River Basin between John Redmond Dam and the city of Miami covers almost 3,000 square miles. Heavy storms in this area can cause flooding on the Grand River which may also cause flooding along Tar Creek. Storms over the Tar Creek watershed cause additional frequent flooding along Tar Creek.

PLANNING OBJECTIVES

Planning objectives are defined and measured through problem and opportunity statements. Problem and opportunity statements list the study area's problems and needs and are presented as objectives and measurements. These statements were established from the concerns of the public, were developed for the 1990 to 2090 period of study, and were used to guide this study. The statements set the framework for the comparison and selection of alternatives and reflect the national concern for improving economic development and enhancing natural resources.

The flood control objective of developing water resource measures was to formulate alternatives to reduce economic losses and the threat to life due to flooding. The measurement of accomplishment was the percent reduction of damages.

The natural and cultural resources objective of developing water resource measures was to formulate alternatives to preserve and enhance the natural and cultural floodplain resources of the study area. The measure of accomplishment was the number of acres of habitat preserved or lost, and the number of culturally and environmentally significant sites preserved or lost.

PLANNING CONSTRAINTS

Physical, economic, and environmental constraints were identified to help evaluate the alternatives. In addition, alternatives were formulated to comply with Federal statutes, executive orders and memoranda, and other environmental review and consultation requirements.

The physical constraint was to limit this study to the Miami, Oklahoma, area. The hydrologic component of the physical constraint included all of the Grand River Basin, but analysis relied principally on available stream gage data immediately above and below Miami.

The economic bases of constraints are the Flood Control Act of 1936, Public Law 49-738; the Economic and Environmental Principles and Guidelines for Water and Related Land Resources Implementation Studies, March 1983; and the Water Resources Development Act of 1986, Public Law 99-662.

The bases of the environmental constraints are the National Environmental Policy Act (NEPA) of 1969; the U.S. Fish and Wildlife Service's mitigation policy; Executive Order 11990, Protection of Wetlands; and the Food Security Act of 1985, Public Law 99-198.

Fish and wildlife habitats that may be affected by the project would be avoided or minimized in accordance with existing Federal laws and policies. Any significant losses to fish and wildlife habitats which could not be avoided would require mitigation.

FORMULATION OF ALTERNATIVES

Several flood reduction measures were reviewed for potential solution to the flooding problem. After initial consideration, some measures were eliminated from further consideration. One of those measures, suggested by Miami residents, was a large flood control reservoir upstream of Miami. Realization of that measure would be severely hindered by several factors including very poor dam site conditions. Although the reservoir could potentially provide flood control, water supply, navigation, and recreation benefits, the cursory examination indicated benefits quite low compared to high estimated costs.

Other measures reviewed and dismissed included Grand River channelization, dredging, and small dams in the Grand River Basin upstream of Miami. These measures were determined to be ineffective in reducing flood damages.

Nonstructural measures were not examined because of the potential to re-examine the adequacy of easements required for flood control operations of Grand Lake. A request for authority to initiate flood easement reexamination was initiated in November 1988. If structures in Miami are impacted by flood control operations and mitigation of those damages are realized, the basis of several nonstructural plans could be significantly altered.

Based on the flooding history, several small areas of development along Tar Creek may be eligible for the buyout program administered by the Federal Emergency Management Agency (FEMA).

Section 1362 of the National Flood Insurance Act of 1968, as amended (Public Law 90-448), authorizes the acquisition of insured properties that are subject to heavy and/or repetitive flood damages.

Removal of structures from the floodplain is generally most appropriate in areas subject to repetitive flooding which results in substantial damage. Normally, relocation projects would involve a relatively small number of properties and be in areas in which structural flood control projects or floodproofing measures are too costly or impractical.

Alternatives were formulated to reduce the flood damages caused by the Grand River and Tar Creek. The alternatives were composed of structural measures which would either reduce flooding or reduce damage to existing floodplain property.

The structural alternatives would reduce flood levels or would contain flood flows. These measures would consist of:

A levee along the Grand River and along the west side of Tar Creek,

A series of levee segments (4) along the east side of Tar Creek,

A channel improvement segment along Tar Creek,

An excavated flood detention area on Tar Creek, and

A collection of four, small, dry reservoirs in the Tar Creek Basin.

The structural alternatives were evaluated for three levels of protection. The purpose in examining three levels of protection was to identify the relative merits of each alternative to reduce flood damages while comparing the costs and other impacts of different scales of projects. The dry reservoirs were evaluated for only one level of protection.

DESCRIPTION OF ALTERNATIVES

Levees

The levee plans included one levee along the north bank of the Grand River and along the west bank of Tar Creek, and four alignments along the east bank of Tar Creek. These alignments are shown on Figure 3. The levee plans were developed to provide protection along the urbanized reach of Tar Creek at Miami. Each of the levee plans was divided into segments to allow for easier cost estimating.

Three levee heights were selected for economic evaluation of each of the levee alignments. The levees were evaluated for 10-, 50-, and 100-year flood protection.

Channels

Three channel improvement plans on Tar Creek were selected for economic evaluation based on 10-, 25-, and 50-year levels of flood protection. The new channels would follow the same invert elevations as the existing channel. Channelization south of the Burlington Northern Railroad bridge was not studied because this area is affected by backwater effects from the Grand River.

The channel improvement plan would be located along Tar Creek from the Burlington Northern Railroad Bridge north to 22nd Avenue. This alignment is shown on Figure 4.

Excavated Detention Areas

The flood damage reduction measure of detention pond(s) was examined. Ponding, or temporary storage of flood flows, is an effective measure for reducing flood damages when the pond can be located and sized to intercept and slowly release flood flows that would otherwise inundate floodplain development.

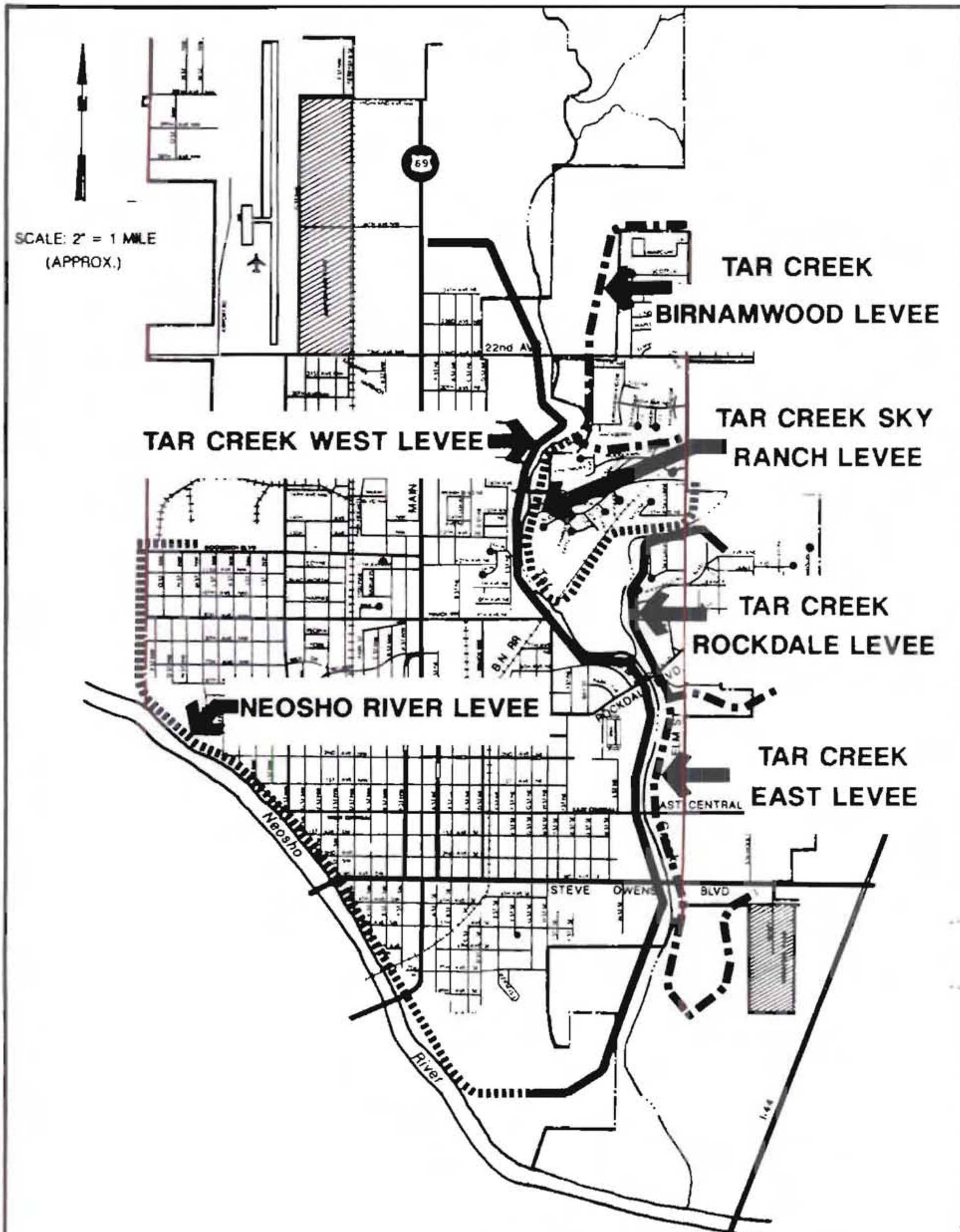


FIGURE 3
LEVEE PLANS
MIAMI, OK. RECONNAISSANCE STUDY

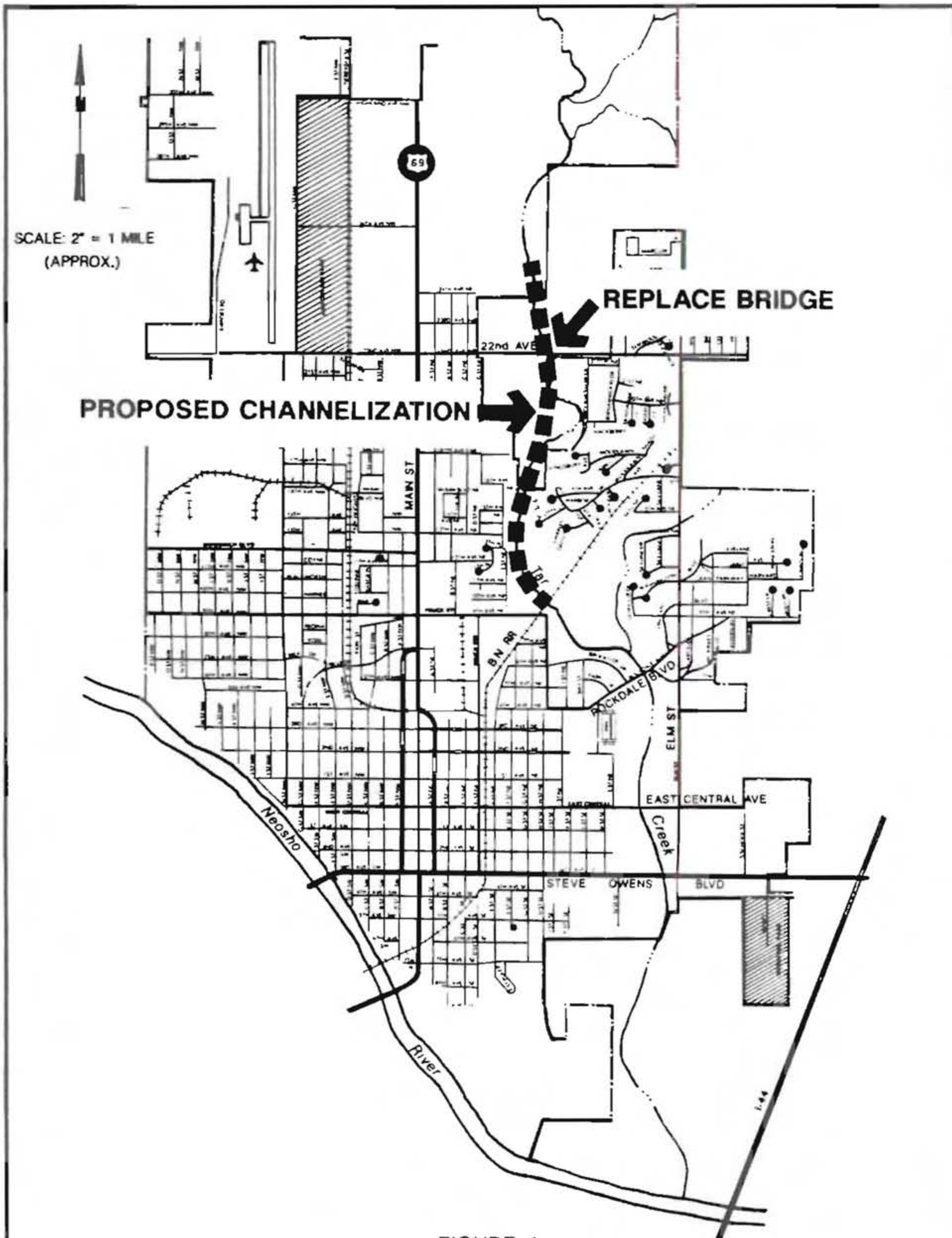


FIGURE 4
TAR CREEK CHANNELIZATION PLAN
MIAMI, OK. RECONNAISSANCE STUDY

Locations for a detention pond were examined through site visits, identification of previously flooded development, and the availability of undeveloped land. The detention pond area was sized for three levels of protection at one ponding area location. A general area upstream of 22nd Avenue along Tar Creek was selected.

Hydrologic data indicating the temporary storage requirement for the three frequency protection plans were then developed. The amounts of storage required to protect downstream development at the 10-, 25-, and 50-year flood levels were computed to be 3,800, 5,900, and 7,700 acre-feet, respectively. Average depths of excavation to achieve these storage requirements in a 350-acre pond were determined to range from 11 to 22 feet. These volumes and the expense of excavation began to indicate that the detention pond would be an expensive measure.

To avoid compilation of unnecessarily detailed cost and benefit data, the economic justification was checked from preliminary data. Costs were estimated based on the cost of land and excavation and disposal of material. The amortized cost of the alternatives exceeded the total average annual flood damages of Miami. The measure was not economically feasible, and was dropped from further consideration.

Upstream Reservoirs

Upstream detention of floodwaters was studied as a means to reduce the amount of water flowing through the existing Tar Creek channel during a flood. Four sites were studied, all on tributaries of Tar Creek. These four sites would control an area of about 13 square miles, or about 26 percent of the total Tar Creek drainage area. Table 1 contains a summary of pertinent data for these four sites.

TABLE 1

PERTINENT DATA
UPSTREAM RESERVOIRS

	Site Number			
Item and Unit	Lytle Creek Site 1	Quapaw Trib Site 2	Garrett Creek Site 3	Quail Creek Site 4
Drainage Area, square miles	4.7	3.9	2.4	2.0
Streambed Elevation, M.S.L.	820.5	810.5	802.0	782.0
Low Stage Port				
Elevation, M.S.L.	823.0	814.0	806.0	785.0
Size, inches (h x w)	30x27	30x22.5	27x18	18x18
Cap. at Sed. Pool Elev., cfs	55	54	36	28
Static Pool				
Elevation, M.S.L.	824.[illegible]	815.4	807.2	786.1
Discharge (PSF-QRF), cfs	13	11	7	6
Sediment Pool				
Elevation, M.S.L.	828.4	820.9	812.7	792.4
Sediment Volume, acre-feet	239	197	124	102
Surface Area, acres	97	95	39	39
Principal Spillway Design				
Req. Fld. Stg, inches	4.57	4.65	4.70	4.89
Req. Fld. Stg, acre-feet	1142	957	609	522
Type of Conduit	RCP	RCP	RCP	RCP
Conduit Diameter, inches	36	30	24	24
Cap. at Emer. Spwy, cfs	110.0	79.9	47.2	48.8
Emergency Spillway				
Elevation, M.S.L.	833.9	826.9	819.2	799.2
Freq. of Oper., % Chance	4.0	4.0	4.0	4.0
Emerg. Spwy BW, feet	140	120	80	80
Emerg. Spwy Exit Slope, feet/feet	0.04	0.04	0.04	0.04
Top of Dam				
Elev. (0.5 PMP + 1.0 Feet Freeboard), M.S.L.	838.5	831.7	824.2	804.2
Max. Height of Dam, feet	8.0	21.2	22.2	22.2
Design Storm, % PMP	0.5	0.5	0.5	0.5
Rainfall Volume, inches	18.7	18.7	18.7	18.7
Runoff Volume, inches	16.6	16.6	16.6	17.1
Storm Duration, hours	24	24	24	24
Max. Wtr Surf.Elev., M.S.L.	837.4	830.7	823.1	803.2

TABLE 1 (Continued)

Item and Unit	Site Number			
	Lytle Creek Site 1	Quapaw Trib Site 2	Garrett Creek Site 3	Quail Creek Site 4
Max. Disch. (Prin. + Emer. Spwy.), cfs	1991	1965	1514	1528
Emerg. Spwy. Vel. of Flow (Ve), FPS	8.1	8.6	8.9	9.0
Emerg. Spwy. Attack (Oe/B), Ac-Ft/Ft	17.3	17.3	16.6	13.9

The upstream detention facilities would be located as shown on Figure 5. These sites would help reduce flood flows along Tar Creek. They would have no effect on flooding from the Grand River.

Each of the detention facilities would consist of an earthfill embankment; a grass-lined, emergency spillway located in an abutment; and a Soil Conservation Service type covered riser outlet works to control releases from the site. Figure 6 shows typical details of the major features of these projects.

The detention facilities would be the dry-type; they would not have a permanent pool and would only fill with water during a flood. The covered riser would have both a high level intake to control large discharges and a low level intake to allow the site to drain completely after the floodwaters go down. All discharges from the site would be through a reinforced concrete pipe conduit under the embankment. A stilling basin would be built at the downstream end of the conduit to reduce exit velocities.

COMPARISON OF ALTERNATIVES

As established by the problem and opportunity statements, the alternatives were evaluated for costs, benefits, and environmental impacts.

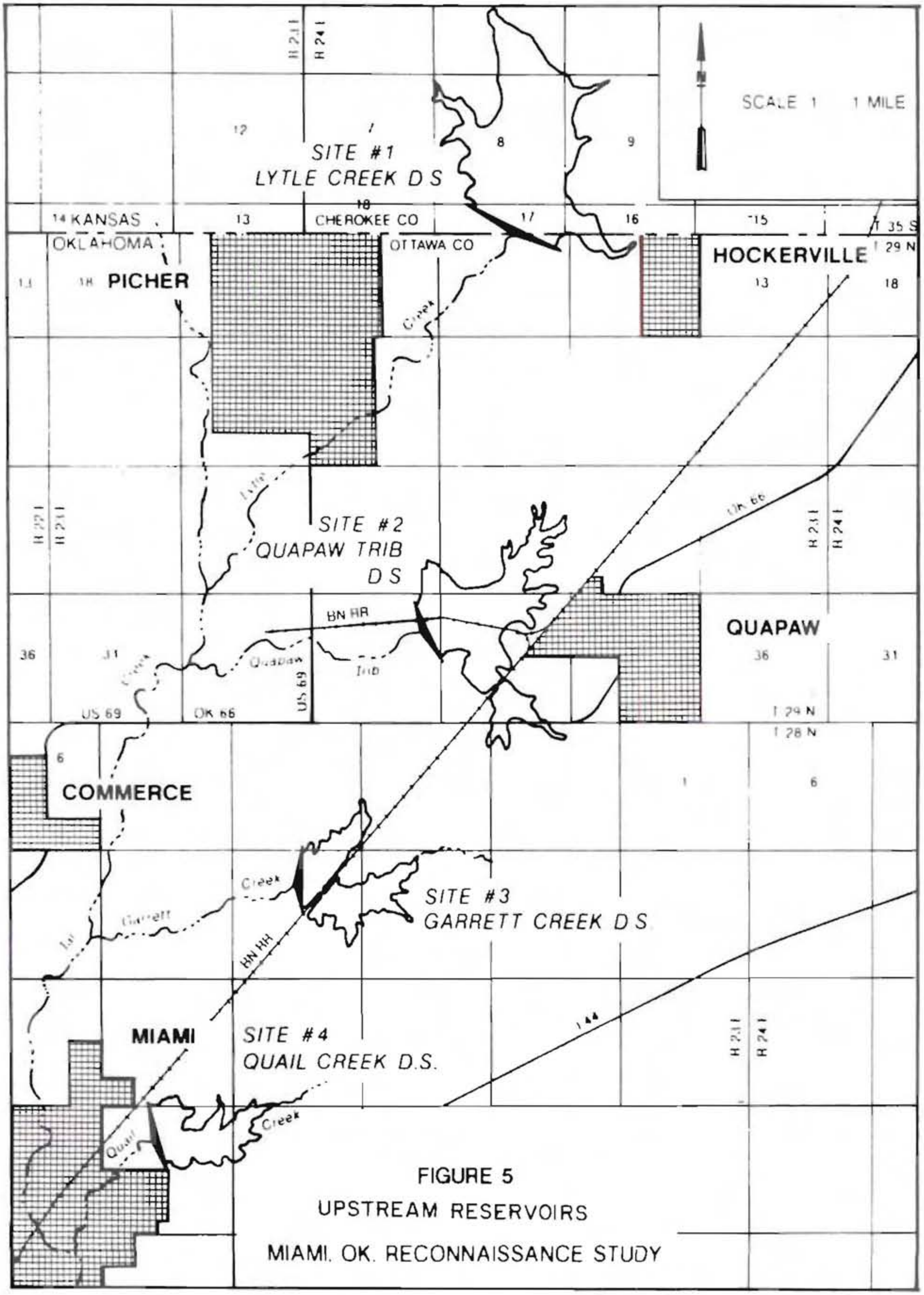
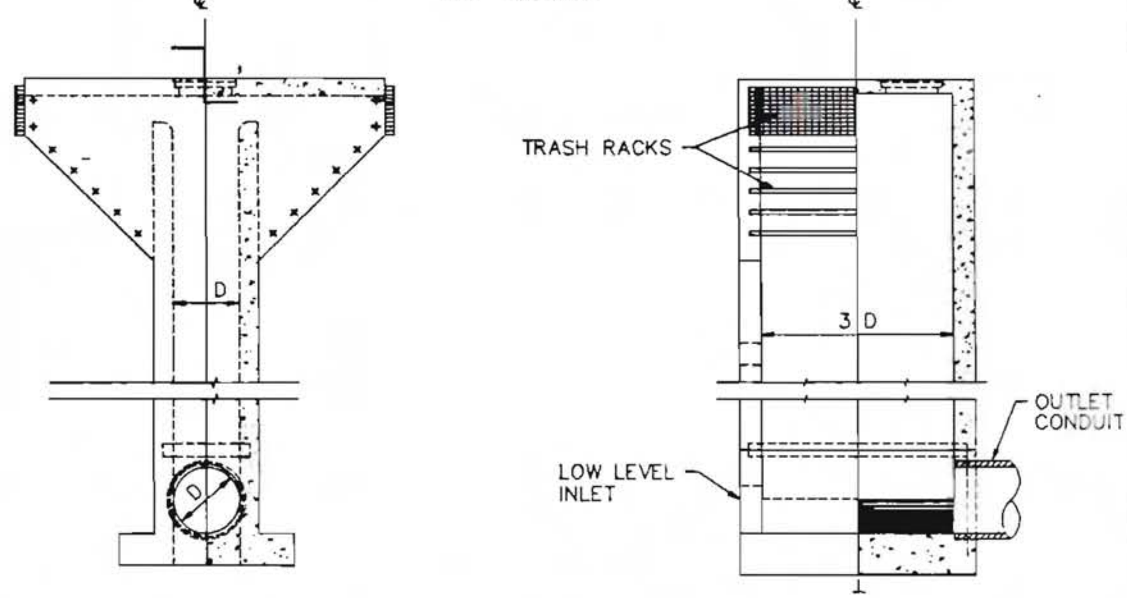


FIGURE 5

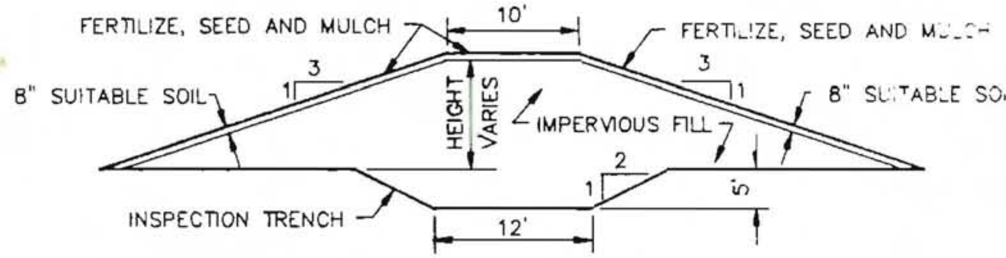
UPSTREAM RESERVOIRS

MIAMI, OK. RECONNAISSANCE STUDY

TYPICAL COVERED RISER DETAIL
NO SCALE



TYPICAL EMBANKMENT SECTION
NO SCALE



TYPICAL SPILLWAY SECTION
NO SCALE

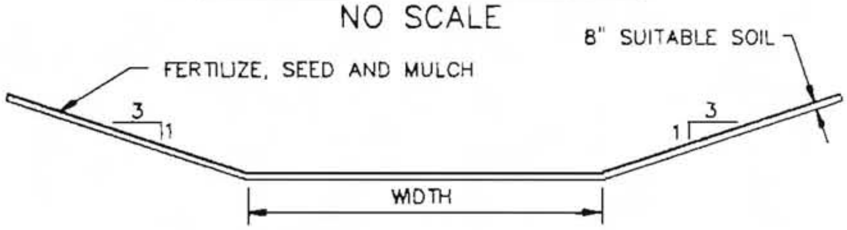


FIGURE 6
TYPICAL SECTIONS
UPSTREAM RESERVOIR PLANS
MIAMI, OK. RECONNAISSANCE STUDY

Design and Costs

The physical base condition was determined, in part, from 2-foot, vertical photography, United States Geological Service topography (10-foot intervals), and city planning maps. Primarily, the physical condition of the study area was determined from site examination during 1988 and through March 1989. Structural improvements were aligned with the intent of minimizing the collective construction impacts to social and environmental aspects.

Cost estimates were prepared for the levee and channel plans following the criteria contained in Engineering Memorandum 1110-2-1301, Cost Estimates-Planning and Design Stages. Costs were prepared for the following cost accounts: 01, Lands and Damages; 02, Relocations; 09, Channels and Canals; and 11, Levees and Floodwalls.

Methodology. Cost estimates for the alternatives were based on October 1988 prices. Amortized costs were developed for a 100-year economic life and an 8-7/8 percent interest rate.

The cost estimates were developed to form a detailed basis for cost-curve estimates of the individual structural measures. A separate set of cost estimates was produced for each levee segment along Tar Creek and the Grand River. The cost estimates were based on existing and expediently modifiable water surface profile computer models. (The level of protection, economic analysis, and interpolated costs were based on updated, alternative-specific water surface profiles.)

A summary of the procedures followed and assumptions made in determining the costs in each cost account follows. Unit costs were developed for each estimate from previous studies and bid tabulations on similar projects.

General Contingency Factor. Contingencies of 25 percent were added to accounts 01 through 11.

01 Lands and Damages. Lands and damages costs were based on site investigations in 1988 and estimated fair market property values.

02 Relocations. Relocation costs include the removal and replacement of utility lines (water, sewer, gas, etc.) which would hinder the construction or operation of a levee or channel project, a bridge replacement in connection with a channel alternative, and roadway ramps for levee alternatives.

Costs for roads and ramps were prepared by estimating construction quantities for the embankment, roadway surfacing, erosion control measures, and guardrails. Roadways would ramp up and down over the levees at a maximum grade of 8 percent. The existing bridges were left in place for the levee plans.

Bridge relocations would be required for the channel improvement plans. The only bridge which would be replaced would be the 22nd Avenue bridge which would be replaced with a 2-lane bridge. Its length would be the same as the top width of the proposed channel.

Utility relocation costs were estimated for the levee and channelization plans. Existing utilities which would be covered by a levee were either assumed to be re-routed away from the levee or encased in conduit to allow future removal and repair. Atlas sheets for the city of Miami were used to determine utilities affected by the plans.

No utilities would be affected by the upstream detention facilities. While numerous roads would cross the embankment alignments or the proposed pool areas, it was assumed that no roads would be relocated for these plans. Roads intersecting the embankments could be closed or ramped over the embankments. Roads in the proposed impoundment areas would be left open and a barricade plan could be developed to prevent access during flooding.

Detention site #2 would require the raising of about one mile of railroad track over the proposed embankment. The track is a spur line and is located just north of the main Burlington Northern tracks.

04 Dams. Costs for the embankment, spillway, and outlet works at each detention facility site were calculated. Embankment quantities were computed for the same construction items as the levee plans. It was assumed that the embankment slopes and the crown would be grassed to prevent erosion. No other slope protection costs were included in these estimates.

Spillway costs were estimated by determining the average depth of the spillway and multiplying the cross-sectional area of the spillway at that average depth by the total length of the spillway. The cost of planting grass on the bottom and side slopes to prevent erosion was also included.

Outlet works costs were based on data provided by the Soil Conservation Service (SCS). Concrete and reinforcing steel quantities were computed from SCS Technical Release 30, Standard Drawing ES-169. Miscellaneous metal quantities were calculated for grates, a trash rack pipe, and a manhole cover and ring for each riser. Concrete and reinforcing steel quantities were also estimated for a standard SCS impact type stilling basin at the end of the conduit, using Standard Drawing ES-186.

<u>09 Channels and Canals</u>. Costs for widening the Tar Creek channel were estimated by determining the construction quantities needed to excavate and finish the proposed channel. Estimated channel costs were based on bottom widths of 150-, 200-, and 250-feet. The proposed channels would be grass lined with 3 horizontal to 1 vertical side slopes. A concrete low flow channel would be built in the center of each channel to prevent low flow ponding and sedimentation. Excavation quantities were determined by computing the area of the proposed channel section drawn on a cross section of the existing channel. The existing channel cross sections were taken from a Hydrologic Engineering Center (HEC-2) model prepared for the 1986 Flood Insurance Study hydraulic analysis.

<u>11 Levees and Floodwalls</u>. Quantities estimated for this account fall into three categories: (1) levee materials, (2) drainage pipes and gates, and (3) closure structures at levee openings. Levee construction quantities were estimated from a typical section having a 10-foot top width and 3 horizontal to 1 vertical side slopes. An average end area method was used to calculate volumes between sections. The levees would be grass covered. Estimated channel velocities were sufficiently low to allow grass erosion protection.

Quantity estimates for drainage pipes and gates were included at all low points along the levee alignments. A 24-inch pipe with a flap gate was included for each drainage location. Larger drainage areas inside the levee would use multiple pipes. It was assumed that interior drainage ponding areas and/or pump stations would be required at various locations. However, because of the complexity of the hydrologic model required to size the interior ponding areas, these items were not included in the estimates. The total length of the outlet pipe at each location was computed as the bottom width of the levee at that point.

Closure structures are gates which can be used to close an opening in the levee. Closure structures were included for each location where a railroad track passed through the levee. Concrete retaining walls would be built to protect the earthen levees and to provide a hinge support for the gates. The gates would be constructed of steel and would be manually operated. Gates similar to the miter gates used for navigation locks would be built. Cost estimates for the closure structures were made by estimating concrete, reinforcing steel, and structural steel in each gate and wall. Unit costs were based on recent cost estimates prepared for navigation studies.

<u>30 Engineering and Design (E&D) and 31 Supervision and Administration (S&A)</u>. Costs for E&D and S&A were computed as 10 percent and 8 percent, respectively, of the total construction cost of each plan (less Lands and Damages). These percentages were based on the E&D and S&A costs experienced in similar types of completed studies.

<u>**Design and Cost Conclusions**</u>. The design and cost estimates of alternatives represent an accurate calculation based on a limited number of assumptions. The only component known to have been omitted was the cost of lands and habitat development for environmental mitigation. Because of the limited habitat value and the potential to avoid impacts through careful design of feature alignments, the cost of mitigation measures should not be significant.

The cost estimate of the channel alternatives is the most susceptible to error. The estimated channel costs were extrapolated from detailed, but smaller scale, channel improvement specifications. If the annual costs were estimated for the most optimistic cost procedure, the estimates could be reduced by $15,000 (10-year) to $70,000 (50-year) from the costs used in the economic evaluations. This variance would be from 9 percent (10-year) to 35 percent (50-year), but would not produce a change large enough to cause an indication of positive economic feasibility.

Benefits

Economic Feasibility. Economic investigations were conducted to establish the value of property within the Miami floodplain, the average flood losses under existing conditions, the residual flood losses, and the average annual reduction of flood damages. Evaluations were based on replacement value for improvements existing in the project area in October 1988. The physical inventory was developed from basic surveys conducted for the Section 205 study, discussed previously, and information collected for the Water Management Analysis Report, Flood of September - October 1986, Northeastern Oklahoma and Southeastern Kansas, August 1987, and from surveys conducted in 1988 for this reconnaissance investigation.

The floodplain was divided into ten reaches of similar flood impact areas. These reaches corresponded to areas of gradually changing hydraulic conditions and to areas to be protected by project elements, such as levee segments or channel improvement.

Inspection of the area determined the classification of property in eight categories: (1) Residential - Single and Multiple Family - Structures, (2) Residential - single and Multiple Family - Contents, (3) Commercial, (4) Industrial, (5) Public, (6) Transportation, (7) Communications and Utilities, and (8) Public Health and Relief. An estimate of residential and nonresidential property values was also established. The value of property was estimated to range from 50 to 75 percent of the value of structures. Personal interviews were conducted to determine the actual losses experienced by individuals from recent flooding to various depths.

About 30 percent of Miami's flood-prone land is located in the Tar Creek floodplain above the Burlington Northern Railroad. About 60 percent of the flood-prone land is in the common floodplain area inundated by Grand River and Tar Creek. The remaining 10 percent of flood-prone area is along the Grand River. Although most of the flood-prone area is in the common Grand River and Tar Creek floodplain, development in this area is sparse with a large portion having been established as Riverview Park. Development along Tar Creek, north of the Burlington Northern Railroad has encroached into the floodplain. This area has been flooded frequently in the past five years. Approximately 825 structures are subject to flooding with average annual damages of about $3,000,000. The October 1986 flood flooded 234 structures with single event damages estimated at about $11,600,000. The October 1986 flood on the Grand River had a peak discharge of about 123,000 cfs. This flood had a frequency discharge of about the 30-year flood.

Average annual damages reduced by each of the alternatives are shown in Table 2. Negative net benefits were not tabulated.

TABLE 2

SUMMARY OF ALTERNATIVE PLAN COSTS AND BENEFITS
(October 1988 Prices, 8-7/8 Percent Amortization, 100-Year Project Life)
(Costs and Benefits in $1,000's)

Alternative	Level of Protection (years)	First Cost ($)	Amortized Cost ($)	Annual Benefits ($)	Net Benefits ($)	Benefit-to-Cost Ratio (to 1.0)
Levee - Along Grand River and West Bank of Tar Creek						
	10	3,575	336	(110)	-	-
	50	9,575	900	2,493	1,593	2.8
	100	13,300	1,250	1,770	520	1.4
Levee - Along East Bank Tar Creek, "Southern Levee"						
	10	1,596	150	280	130	1.9
	50	2,926	275	370	95	1.3
	100	3,670	345	400	55	1.2
Levee - Along East Bank Tar Creek, "Rockdale Levee"						
	10	681	64	(30)	-	-
	50	1,330	125	(30)	-	-
	100	1,681	158	(30)	-	-
Levee - Along East Bank Tar Creek, "Sky Ranch Levee"						
	10	894	84	(30)	-	-
	50	1,404	132	(10)	-	-
	100	1,723	162	30	-	0.2
Levee - Along East Bank Tar Creek, "Birnamwood Levee"						
	10	133	13	(20)	-	-
	50	277	26	(10)	-	-
	100	372	35	(10)	-	-

TABLE 2 (Continued)

Alternative	Level of Protection (years)	First Cost ($)	Amortized Cost ($)	Annual Benefits ($)	Net Benefits ($)	Benefit-to-Cost Ratio (to 1.0)
Channel Improvement - Tar Creek, Burlington Northern to 22nd Avenue North						
	10	1,702	160	60	-	0.4
	25	1,915	180	60	-	0.3
	50	2,085	196	60	-	0.3
Reservoirs						
Quail Creek	25	764	72	10	-	0.1
Garrett Creek	25	546	51	30	-	0.6
Quapaw Creek	25	1,036	98	100	2	1.0
Lytle Creek	25	1,254	118	60	-	0.5
AND a Levee - Along the East Bank of Tar Creek Includes: Southern, Rockdale, Sky Ranch, and Birnamwood Levee Areas						
	10	6,713	631	280	-	0.4
	50	15,160	1,425	434	-	0.3
	100	20,261	1,904	2,280	376	1.2
AND a Levee - Along the East Bank of Tar Creek, "Southern Levee"						
	10	5,171	486	340	-	0.7
	50	12,501	1,175	1,880	705	1.6
	100	16,970	1,595	2,310	715	1.4
AND a Levee - along the East Bank of Tar Creek, "Rockdale Levee"						
	10	4,256	400	80	-	0.2
	50	10,905	1,025	1,480	455	1.4
	100	14,981	1,595	1,880	472	1.3
AND a Levee - along the East Bank of Tar Creek, "Sky Ranch Levee"						
	10	4,469	420	80	-	0.2
	50	10,979	1,032	1,480	448	1.4
	100	15,023	1,412	1,990	578	1.4
AND a Levee - along the East Bank of Tar Creek, "Birnamwood Levee"						
	10	3,708	349	90	-	0.3
	50	9,852	926	1,490	564	1.6
	100	13,672	1,285	1,900	615	1.5

Negative net benefits and negative benefit-to-cost ratio were not tabulated.

Economic Conclusions. The economic evaluations were based only on flood damage reduction benefits; therefore, the net benefit indicator of economic feasibility may be conservatively low. The addition of affluence and emergency cost reduction benefits would slightly increase the net benefits of all alternatives.

Maximum net benefits may be associated with an alternative providing a level of protection greater than the maximum 100-year levee studied. Identification of the National Economic Development (NED) level of protection would be accomplished in Feasibility Phase studies.

Environmental

Grand River Levee and Tar Creek West Bank Levee. The Grand River Levee would bend around the sewage treatment plant and extend northwesterly through Riverview Park which is mostly bermuda lawn with scattered large trees such as elm, cottonwood, mulberry, hackberry, pecan, and sycamore. Upstream of the park, the levee would follow the Grand River across Main Street through a small trailer park to above P Street Northwest where it would turn north to Goodrich Boulevard near M Street Northwest. Residential areas lie adjacent to the levee alignment from Riverview Park northward to its end.

The West Levee would begin near the 2800 block north and U.S. Highway 69 and run southeasterly to Tar Creek. Then the levee would turn south and follow along the west bank of Tar Creek. The levee would extend from the railroad southerly along the Tar Creek floodplain through residential, college, commercial, and farm property to the Miami sewage disposal plant. Habitat varies with each of these land uses. From the railroad southward to Rockdale Avenue, the quality of the streambank habitat improves. Backyard lawns with large oaks and pecan are common along this stretch and an area of riparian timber exists on the east bank. A fescue pasture with large post oaks lies adjacent to Tar Creek. Common species are walnut, American elm, slippery elm, and hackberry.

South of Rockdale Avenue, the levee would pass through the Northeastern Oklahoma A&M Junior College campus. Several large post oak trees are scattered throughout this area. South of the campus to Highway 10, the levee would pass through an abandoned borrow area and a sanitary landfill. This area is grown up in willow and cottonwood. Below Highway 10 to the sewage plant, the cover type changes to pasture with some cropland. Species identified in the pasture include fescue, bermuda, white sweet clover, Johnsongrass, ironweed, white Dutch clover, composites, and some willow, hackberry, mulberry, and Shumard oak.

Near the sewage treatment plant, the West Levee would meet the Grand River Levee. The amount of environmental damage caused by the West Levee is dependent upon alignment. The alignment would be coordinated with environmental elements within the Corps of Engineers and the U.S. Fish and Wildlife Service to avoid a significant amount of damage.

Tar Creek Southern Levee. The Southern Levee would begin in an abandoned pasture adjacent to an old borrow area. The levee would extend southwesterly through an introduced pasture that has a few elm, hackberry, and maple scattered along fence lines. The levee would curve west, then northward along the eastern edge of Tar Creek through an area of bottomland that is grown up in willows. A small grove of mature pecan trees exists where the alignment approaches East Central Road. North of East Central Road, the levee would extend upstream through a bermuda pasture to a point approximately one-half mile north where it would turn east across Elm Street. In the area of its turn are a few (15-18) mature pecan trees. After the alignment turns east across Elm Street, it passes through a 5-acre grove of smaller pecan trees. Although habitat in this pecan grove is not good because the understory is maintained like a lawn, a healthy population of fox squirrels is present.

Tar Creek Rockdale Levee. The Rockdale Levee alignment has been disturbed by urbanization and the site condition is generally poor. The north end of the levee would extend through an area that is mostly open savannah. Some water appears to remain in the channel of the small tributary draining the Rockdale Country Club golf course. Cattail, willow, cottonwood, and silver maple are scattered adjacent to the tributary, along with a few pecan and post oak. A housing addition is adjacent to the levee site on the east. A waste area is adjacent to the levee site on the west. The south end of the levee would pass through an area of Tar Creek bottomland that contains several large scattered pecan trees. A small pasture containing fescue with some bois d'arc, honey locust, ragweed, thistle, ironweed, and sunflower exists at the extreme south end. This levee should be selectively routed through the forested area along the south end to reduce impacts.

Tar Creek Sky Ranch and Birnamwood Levees. The Sky Ranch and the Birnamwood Levees would be located mostly in an open field that appears to be a waste area with evidence of recent disturbance. U.S. Department of the Interior wetland maps depict several small wetlands in the area. A recently constructed sewage treatment plant, operated by the city of Miami, is situated in the "V" of the levee alignment. Tar Creek was channelized along the stretch adjoining the treatment plant, and the old channel was filled with rock and dirt. Three-inch gravel is scattered throughout this area. Ragweed and curly dock are abundant on the drier sites, with some sedges, willows, and cottonwoods in the area. Eleocharis sp. and Potamogeton sp. are found in the wet areas. Because the area has already been disturbed, these levees would have little additional impact.

Channel Improvements. Good riparian habitat exists along the creek from 22nd Avenue downstream to Torbert Park. Both banks of Tar Creek in this area are forested. A dense understory provides excellent habitat with good diversity. Below Torbert Park, the understory generally is mowed and portions are kept in a park-like condition. Poison ivy, Johnsongrass, and ragweed are abundant in some sections of this site. The overstory consists of mature pecan trees with several other species of trees existing along a small tributary entering from the west. These species include slippery elm, hackberry, honey locust, mulberry, box elder, silver maple, black cherry, green ash, and river birch. A grove of pecan trees that appears to be the remnant of an old orchard is located between Tar Creek and Northeast E Street just upstream from the Burlington, Northern Railroad.

Excavated Detention Area. The Excavated Detention Area contains approximately 350 acres of varied quality habitat. It begins just upstream of 22nd Avenue. An area of high quality riparian habitat is adjacent to Tar Creek, just north of 22nd Avenue. It has an overstory of scattered pecan, oak, elm, cottonwood, and bois d'arc, and an understory of honey locust, oak, buckbrush, broomsedge bluestem, and fescue, with scattered patches of blackberry, greenbriar, and wild rose. East of the creek lies an abandoned bermuda pasture with ragweed, and asters. A shrubby undergrowth is adjacent to the creek. Several overstory species also occur near the creek. Midway upstream along the east side of the creek is mostly introduced pasture with forest species such as oak, pecan, hackberry, and trumpet vine along the tributaries. The understory is mostly bermuda pasture. At the upstream end of the detention site on the east side of the creek is an abandoned pasture with horseweed, Johnsongrass, ragweed, broomsedge, fescue, and asters. Timber along the creek includes river birch, catalpa, elm, hackberry, honey locust, ash, oak, and cottonwood. Understory plants include greenbriar, broadleaf uniola, and Japanese honeysuckle. Mitigation would be required for construction at the Tar Creek Detention Site.

Upstream Reservoirs. This alternative consists of four, small, dry reservoirs - Quail Creek, Garrett Creek, Lytle Creek, and Quapaw Creek.

The Quail Creek Dry Reservoir would directly impact approximately five acres of habitat. The north end of the dam site would tie into farmland on the north side of 22nd Avenue. South of 22nd Avenue, the dam alignment would extend across a fescue hay meadow, then into a small area of native prairie on each side of Quail Creek. Timber adjacent to the creek consists mostly of hackberry, with elm and bois d'arc. The understory consists of buckbrush, ragweed, fescue, wild rose, honey locust, and Japanese honeysuckle.

Garrett Creek Dry Reservoir would only impact poor quality habitat. The dam alignment runs adjacent and parallel to an abandoned track of the Burlington Northern Railroad. The only habitat of any quality is along the abandoned track immediately downstream of the dam site. It is grown up in small trees, shrubs, weeds, briars, and grasses and is excellent habitat for rabbits, quail, and small songbirds. The south end of the dam would begin in and extend through an overgrazed native pasture that has some fescue and scattered weeds. Garrett Creek has very few trees and a bermuda understory. North of the creek is a bermuda pasture. Other than along the abandoned track, very little wildlife cover exists.

The Lytle Creek Dry Reservoir would not have a significant effect on the environment. Both ends of the dam would tie into farmland with about an acre of riparian habitat along the creek. Species include elm, willow, hackberry, and honey locust in the overstory and ragweed, leadplant, fescue, bois d'arc, buckbrush, and broadleaf uniola in the understory.

The Quapaw Creek Dry Reservoir site includes some excellent wildlife cover and construction here would require mitigation. The south end of the dam alignment would begin in cropland and extend across a winter wheat field into a stretch of timber on each side of Quapaw Creek. Overstory species include cottonwood, hackberry, elm, maple, and oak. Understory species include sumac, peppervine, hackberry, maple, ragweed, and an abundance of grape vine. Numerous maple thickets, with honeysuckle, blackberry, willow, and leadplant are in the area. Both sides of the creek contain excellent habitat with scattered trees and saplings, numerous blackberry thickets, and scattered openings of native prairie. The north end of the dam site would tie into cropland. Just upstream of the dam site at the bridge on the county road is a large dump site that appears to have been used for years. Old and new trash is profuse in and adjacent to the creek.

Environmental Conclusions

Levees. Impacts arising from construction of the levees vary with the different levee alternatives. The Grand River Levee, the Southern Levee, and the Rockdale Levee could be routed to avoid habitat losses. Most of the impacts from these levees would be to mature bottomland trees that would be removed from the alignment of the levees. The majority of these impacts could be averted by routing the alignment of the levees to avoid the mature trees. If the alignment of these levees is adequately routed to avoid destroying mature trees, the establishment of native vegetation along the levees should provide sufficient mitigation. The West Levee, on the other hand, does contain high quality habitat that would be destroyed. Construction of the West Levee would result in the loss of important riparian habitat and would require mitigation. Construction of the Sky Ranch and the Birnamwood Levees would cause very little habitat loss. These two levees should not require mitigation other than the establishment of native vegetation along the levees.

Channel Improvement. Channel improvement would eliminate most of the forested and understory habitat in the reach from 22nd Avenue to the Burlington Northern Railroad. Where possible, the channel alignment could be shifted to preserve some of the more established forest areas.

Excavated Detention Area. The Excavated Detention Area would be the most environmentally damaging of the various alternatives. It contains approximately 350 acres of habitat, some of which is high quality riparian habitat. Mitigation would be required.

Upstream Reservoirs. Environmental losses at the Quail Creek, Garrett Creek, and Lytle Creek Dry Reservoirs would be minor. Habitat losses should be recoverable and mitigation requirements satisfied by establishing native vegetation on and adjacent to the embankments. Quapaw Creek Dry Reservoir would be the more environmentally damaging of the dry reservoir alternatives. It has several acres of high quality habitat on both sides of Quapaw Creek and mitigation would be required to offset project losses.

CONCLUSIONS

Flood damages will continue to occur with relative frequency along Tar Creek, and infrequent flooding will continue along the Grand River. Flood insurance will mitigate the tangible personal losses due to flooding, but the community's trauma and intangible losses resulting from flooding will continue. Floodplain zoning, adopted when the city joined the Federal flood insurance program, should ensure that no future floodplain development occurs. This will reduce the potential for increased levels of damages due to continued flooding. Estimated average annual flood damages of about $3,000,000 will impact personal and public property and decrease the economic well-being of the community.

A potential problem was identified in connection with the extent of existing land acquisition for flood control operations of Grand Lake. The level of detail required to conduct a reexamination of flood control easement requirements was outside the scope and time frame of this reconnaissance investigation. A request for authority to initiate a flood control easement reexamination was initiated in November 1988. If that authority is granted, the reexamination would reveal whether or not Grand Lake flood control operations impact Miami flooding.

Areas of development along Tar Creek may be eligible for the buyout program administered by the Federal Emergency Management Agency, as authorized by Section 1362 of the National Flood Insurance Act of 1968.

A conceptual project for local implementation was identified. This project could consist of small channel improvement measures along Quail Creek and a levee on the north and/or south side of Quail Creek to protect the Sky Ranch subdivision. This project would provide protection to 10 to 30 homes in the Sky Ranch subdivision. Because of the scale of the project, continued study of this area would be consistent with the scope of Federal involvement through the authority of Section 205 of the 1948 Flood Control Act. The hydraulic analysis of Tar Creek is available to the city for use in formulating this or other measures.

Development of small detention areas was also identified as a potential project for local implementation. Although the upstream reservoirs examined in this investigation were not shown to be economically feasible, the concept of smaller detention areas sited to provide localized protection in the city is technically feasible. Tar Creek is susceptible to flash flooding which could be reduced by properly delaying the release of runoff from entering Tar Creek.

This study identified 15 economically feasible, structural solutions to flooding at Miami, Oklahoma. Fourteen of the alternatives were levee plans and one alternative was a 25-year flood control reservoir, the Quapaw Reservoir. The economic feasibility of these measures indicates a potential for implementation of a Federally supported project to reduce flood damages.

The potential project sponsor for Feasibility Phase studies is the city of Miami.

RECOMMENDATIONS

Federal investigations should be continued to develop a locally acceptable plan for flood damage reduction. An NED plan, if different from the locally acceptable plan, would also be developed as the basis for Federal evaluations.

If authority is not provided to re-examine the adequacy of Grand Lake flood control easements, then it is recommended that investigation of nonstructural measures for the reduction of flood damages at Miami be continued under authority of Section 208 of the Flood Control Act of 1965 or under the authority of Section 205 of the 1948 Flood Control Act.

INTERIM RECOMMENDATION. Due to the large difference in the scale of feasible measures, it is recommended that the feasibility phase scope of work and cost estimate be developed after Division approval of this draft reconnaissance report, and subsequent to the coordination of these report findings with the city of Miami.

U.S. FISH AND WILDLIFE SERVICE
PLANNING AID REPORT

Planning Aid Report
on
Tar Creek
Local Flood Protection Project,
Miami, Oklahoma

Prepared By:

J. Allen Ratzlaff
Ecological Services Field Office
U.S. Fish and Wildlife Service

Tulsa, Oklahoma
December 1988

UNITED STATES
DEPARTMENT OF THE INTERIOR
FISH AND WILDLIFE SERVICE

Ecological Services
222 S. Houston, Suite A
Tulsa, Oklahoma 74127

December 20, 1988

District Engineer
U.S. Army Corps of Engineers
P.O. Box 61
Tulsa, Oklahoma 74121-0061

Dear Sir:

This letter transmits the planning aid report of the U.S. Fish and Wildlife Service (Service) on the Tulsa U.S. Army Corps of Engineers' Tar Creek Local Flood Protection Project, Miami, Oklahoma. The report provides a preliminary evaluation of flood control alternatives proposed for Tar Creek and the Neosho (Grand) River, and has been prepared under authority of the Fish and Wildlife Coordination Act (Act) (48 Stat. 401, as amended; 16 U.S.C. 661 et seq.) in cooperation with the Oklahoma Department of Wildlife Conservation. It is not intended as the official report of the Secretary of the Interior or the Service on the proposed project within the meaning of Section 2(b) of the Act.

We appreciate the cooperation of your staff in our investigation, and look forward to further participation in additional project planning.

Sincerely yours,

Stephen W. Forsythe
Field Supervisor

Attachment

cc:
Regional Director, Fish and Wildlife Service, Albuquerque, NM (AWE)
Director, Oklahoma Department of Wildlife Conservation, Oklahoma City, OK

JAR:dc

INTRODUCTION

This report constitutes the planning aid report of the U.S. Fish and Wildlife Service (Service) on the Tulsa U.S. Army Corps of Engineers' (Corps) Tar Creek Local Flood Protection Project, Miami, Oklahoma. It provides a preliminary evaluation of flood control alternatives proposed for Tar Creek and the Neosho (Grand) River. This report has been prepared under authority of the Fish and Wildlife Coordination Act (Act) (48 Stat. 401, as amended; 16 U.S.C. 661 et seq.) in cooperation with the Oklahoma Department of Wildlife Conservation. It is not intended as the official report of the Secretary of the Interior or the Service on the proposed project within the meaning of Section 2(b) of the Act. Information presented in this report is based on data supplied by the Corps, literature surveys, and field observations.

This report provides information specific to fish and wildlife resources impacted by each flood control alternative and the potential mitigation measures.

DESCRIPTION OF THE PROJECT AREA

The general project area, Ottawa County, Oklahoma, is described as oak-hickory-bluestem parkland by Bailey (1980) and tallgrass prairie by Duck and Fletcher (1943). Blair and Hubbell (1938) consider the area to be in the Cherokee Plains Biotic District and include the following description.

> " Physiography and geology: ...The surface is fairly even and slopes to the south and east. The elevation above sea level averages about 700 feet. There are east-facing limestone and sandstone escarpments with gentle slopes to the west, separated by broad valleys underlain with shale. The area is drained by the Verdigris River and tributaries of the Grand River. The streams are muddy and sluggish and are generally entrenched in broad flood-plains.
>
> Climate: The average annual temperature in the area is about 60 degrees Fahrenheit. The average annual rainfall varies from 43.15 inches at Vinita in the northern part of the area to 37.40 inches at Tulsa, at the western border of the district. The average length of the growing season is 200 days at Vinita and 218 days at Tulsa."

The specific project area, the City of Miami and vicinity, is within the Picher Mining District - a 60-square mile part of the Tri-State Mining Region which covers a 500-square mile portion of Kansas, Missouri, and Oklahoma. This area once contained one of the richest lead and zinc deposits in the U.S., most of which was mined out by the early 1950's. The landscape around the mining area is covered in enormous piles of crushed rock left behind from smelters and a number of filled-in sediment ponds. During the mining period, iron sulfides exposed in drift ceilings and walls were oxidized by exposure to atmospheric oxygen. After the mines were abandoned and water was no longer being pumped, groundwater filled the huge abandoned mine and came in contact with these pyritic materials to produce sulfuric acid which further dissolved the surrounding formation resulting in further dissolution of insoluble metal sulfides (lead and zinc) and the leachin_ out of additional heavy metals. In November 1979, water from the mine reached the surface through old air shafts and eventually flowed into Tar Creek. The discharge is very acidic and has high concentrations of iron, zinc, cadmium, lead, chromium, and fluoride.

Tar Creek, a small intermittent stream characterized by standing pools (Appendix A), is the principal drainage system in the Picher Mining Field. With its headwaters in Cherokee County, Kansas, Tar Creek flows south through the mining field between Picher and Cardin, passing Commerce and Miami on the east, to its confluence with the Neosho River, one of the two major rivers in northeast Oklahoma. With its major tributary, Lytle Creek, Tar Creek drains approximately 53 square miles (Figure 1). Tar Creek does not flow in its upper sections during extended dry periods. After heavy rains, Grand Lake can back up water in Tar Creek as far upstream as the Highway 10 bridge in southeastern Miami (Figure 2).

DESCRIPTION OF THE PROJECT

A 1986 reconnaissance study on Tar Creek determined three flood control alternatives to be feasible: 1) A grass lined ten-year channel from the Burlington Northern Railroad bridge to NW 22nd Ave (Alt. C1) - the channel will be 6000 feet long with a bottom width of 150 feet, an average depth of 10 feet, and side slopes of 1 vertical : 3 horizontal; 2) a 5,700 foot levee around the Skyranch Addition on the east side of Tar Creek north and west of the Burlington Northern Railroad (Alt. L1) - the levee would be an average of eight feet high with a top width of 10 feet, side slopes of 1 vertical : 3 horizontal, and a 100 year design with three feet of freeboard; and 3) a levee on the east side of the Neosho River around the southern tip of the City of Miami and north along the west side of Tar Creek to NW 22nd Ave (Alt. M1) - levee design as described for alternative L1 (Figure 2).

Floodproofing along the west bank of Tar Creek from the Burlington Northern Railroad Bridge to 22nd Ave. was added as an alternative (F1) in January, 1987. Additionally, as of August, 1988, the original alternatives were modified (Figure 3) to include: 1) extending the east end of alternative M1 north of NW 22nd Ave. to near the Grand Army of the Republic Cemetery and the west end northward around the southwest side of Miami to near the Goodrich Tire Company (Alt. M2); and 2) extending alternative L1 northeast approximately 0.75 miles and, south for about 2.5 miles along the east side of Tar Creek to south of Highway 10 (Alt. L2).

Additional alternatives, as of August, 1988, include an upstream detention area on Tar Creek (Alt. DR1) (Figure 3) and four dry reservoirs - one each on Quail (Alt. DR2), Garrett (Alt. DR3), and Quapaw (Alt. DR4) Creeks in Oklahoma (Figure 4) and one on Lytle Creek in Kansas (Alt. DR5) (Figure 5), all of which will detain water for a maximum of 10-14 days. Five separate levees on the east side of Tar Creek are also proposed; one each around the Burnamwood addition (L3a), Country Club estates (L3b), Sky Ranch addition (L3c), Rockdale addition (L3d), and the housing addition just north of 3rd Avenue (L3e) (Figure 6).

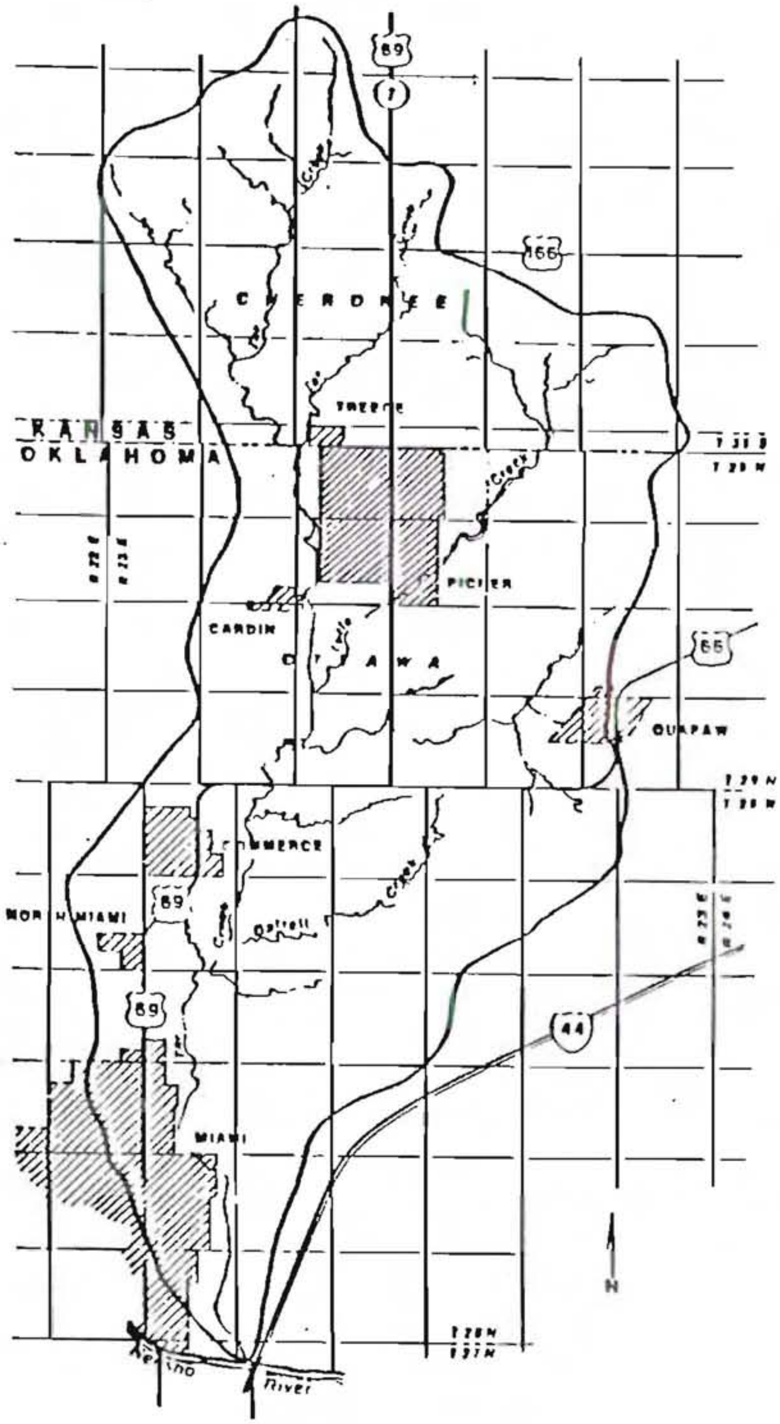


Figure 1. Tar Creek drainage basin.

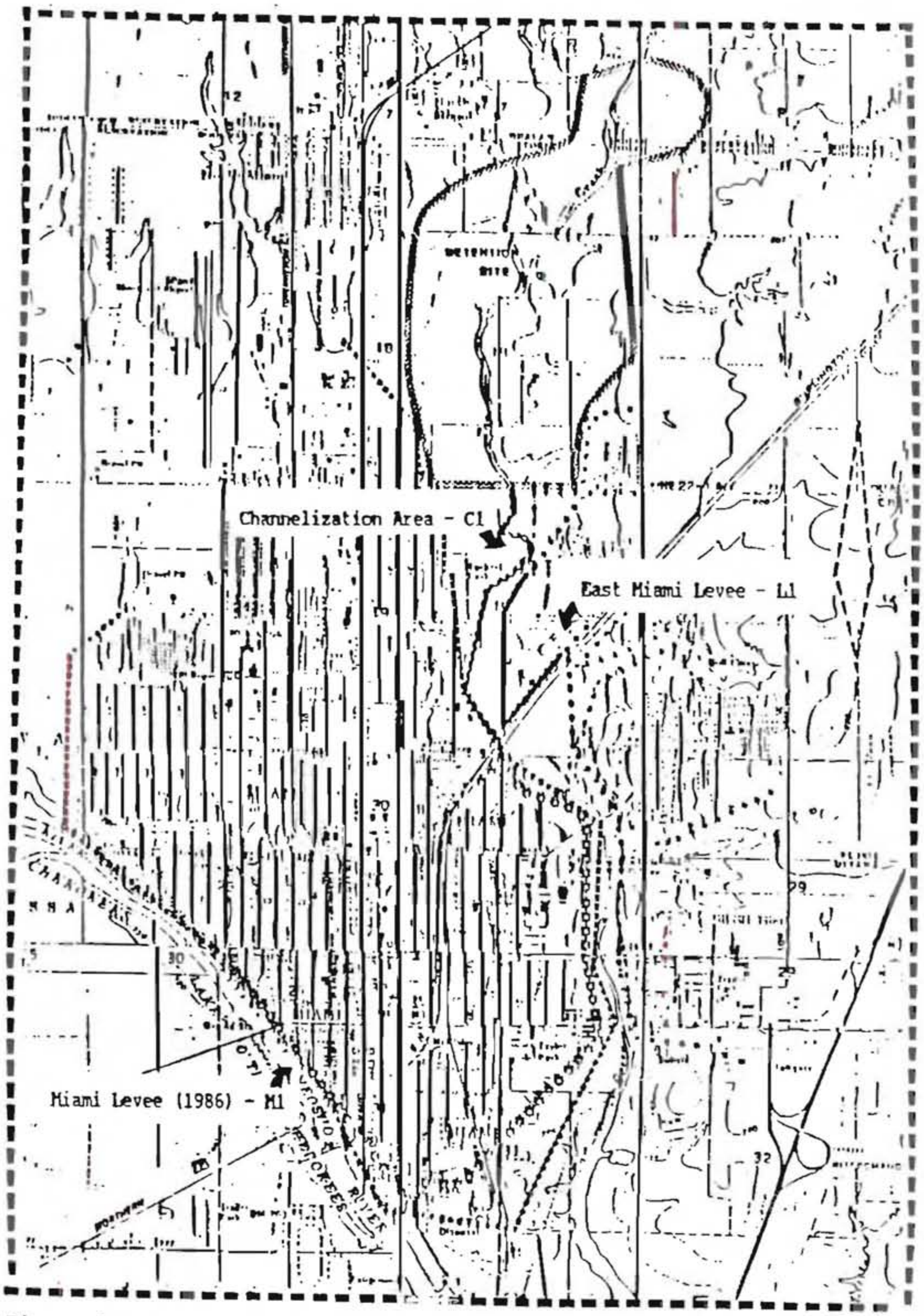


Figure 2. Tar Creek Flood Control Project Area; Alternatives C1, L1, M1.

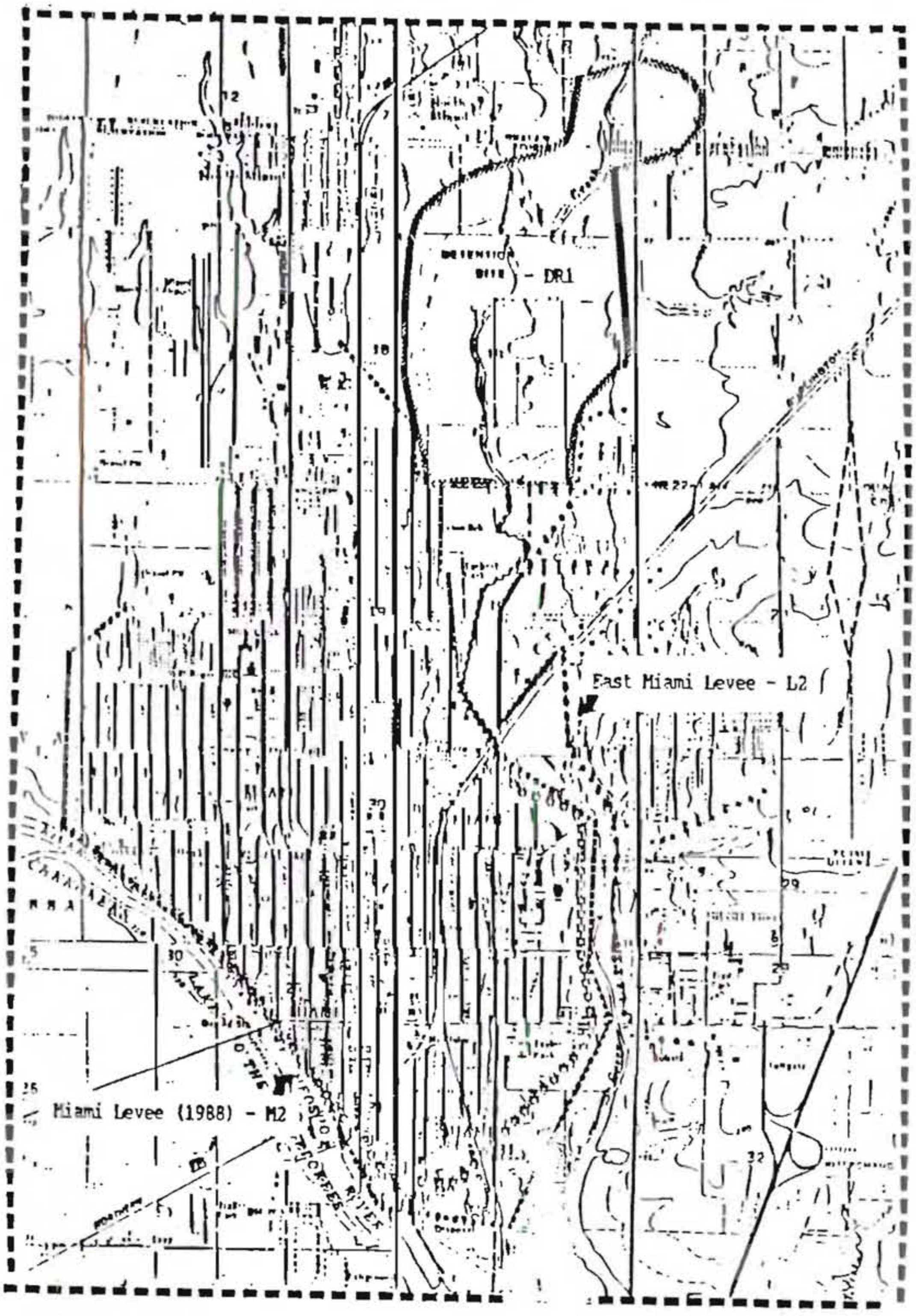


Figure 3. Tar Creek Flood Control Proje   ea; Alternatives DR1, L2, M2.

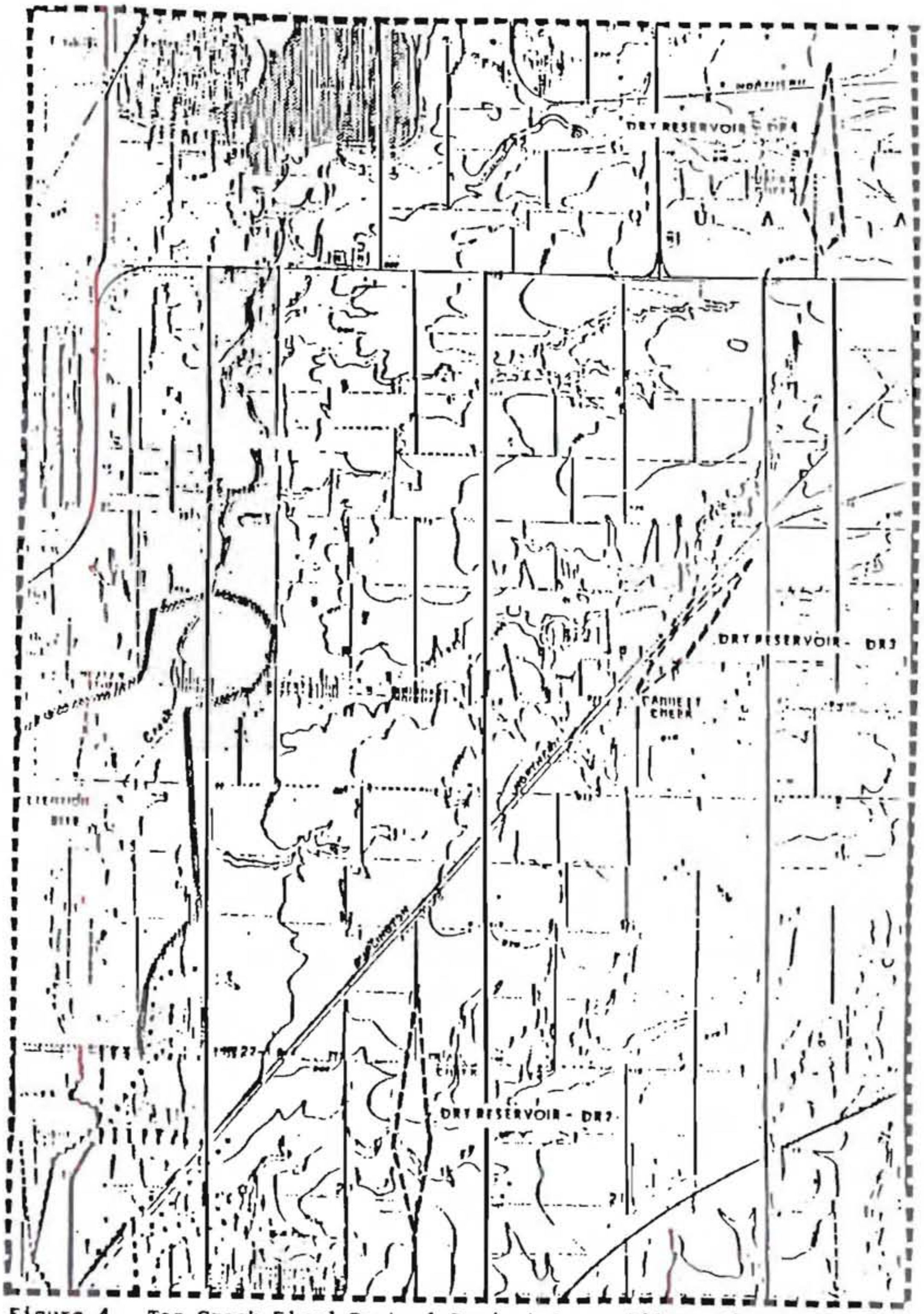


Figure 4. Tar Creek Flood Control Project Area; Alternatives DR2, DR3, DR4.

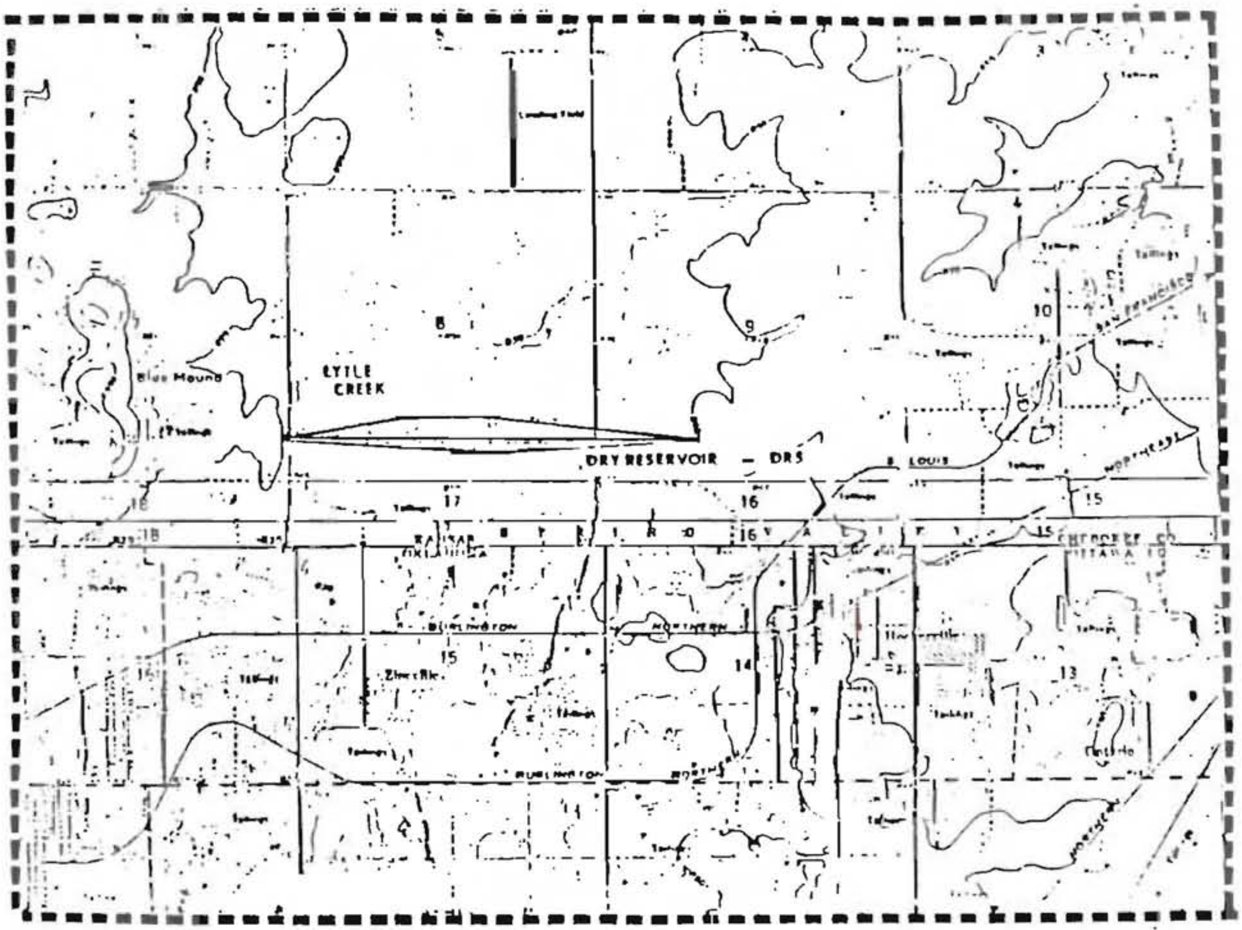


Figure 5. Tar Creek Flood Control Area; Alternative DR5.

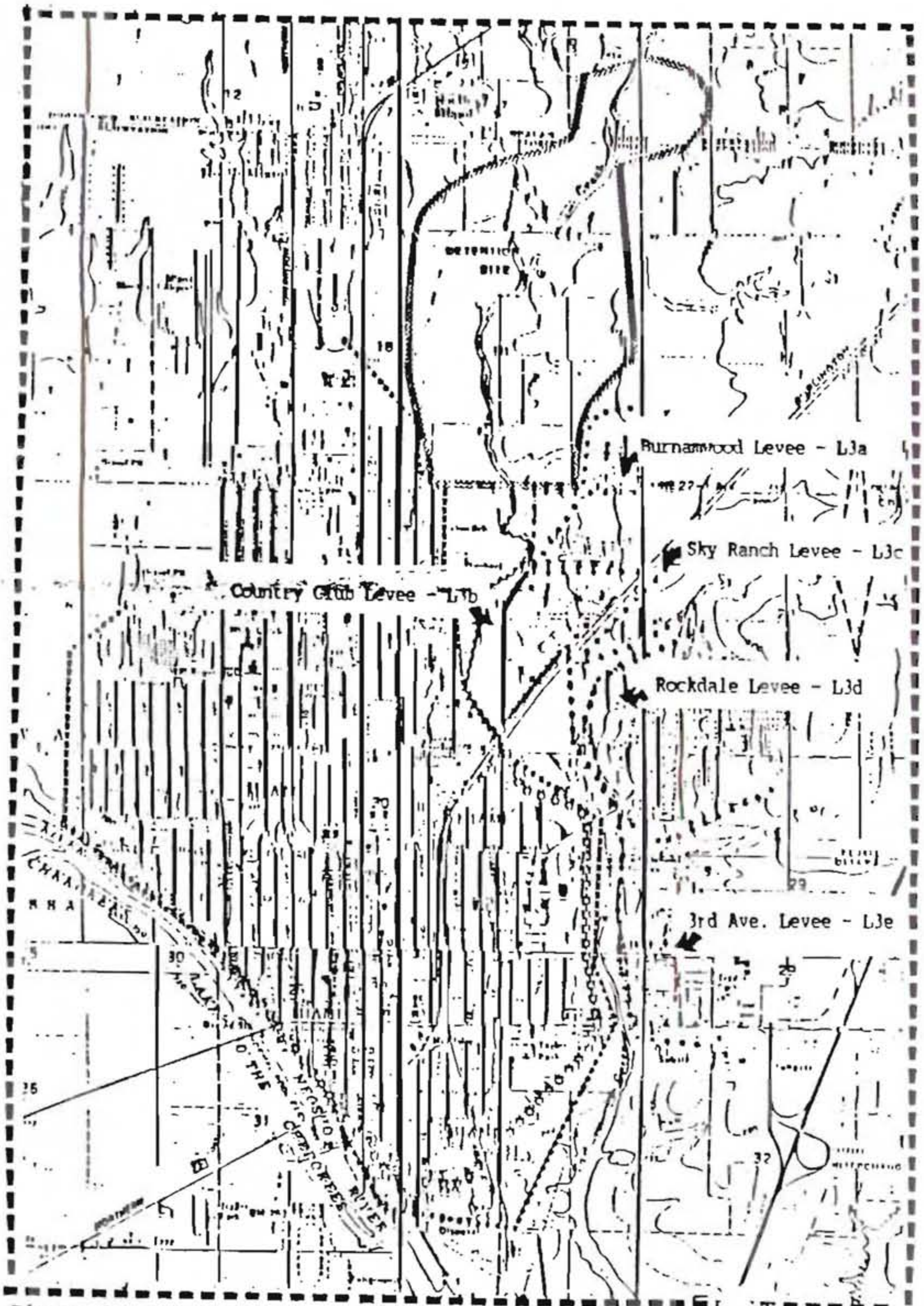


Figure 6. Tar Creek Flood Control Project Area; Alterna..ves L3a, L3b, L3c, L3d, L3e.

FISH AND WILDLIFE RESOURCES

Terrestrial Resources

The terrestrial resources (vegetation) of the area are quite diverse, ranging from heavy bottomlands to the rather sparse vegetation found in shallow soils over limestone. This diversity is largely attributable to the wide variety of soils and geology of the area (Appendix B).

Tallgrass Prairies support a unique assembledge of plants and animals and were at one time the dominant vegetation of the area. These areas are rapidly being lost to agriculture, urban development, and to some degree, fire suppression. Many prairies have been converted to "introduced pasture" by the planting of exotic grasses which are of little value to wildlife. Others, because of the productive soils, have been converted to cultivated crops.

In excellent condition, tallgrass prairies on the deeper soils are dominated by big bluestem (Andropogon gerardii), little bluestem (Andropogon scoparius), switchgrass (Panicum virgatum), Indiangrass (Sorghastrum nutans), gayfeather (Liatris pycnostachya), ashy sunflower (Helianthus mollis), leadplant (Amorpha canescens), and native legumes. In poor condition, dropseed (Sporobolus spp.), jointtail (Coelorachis cylindrica), silver bluestem (Andropogon saccharoides), broomsedge (Andropogon virginicus), ragweed (Ambrosia spp.), purpletop (Tridens flavus), windmillgrass (Chloris verticillata), and ironweed (Veronia baldwinii) are abundant. On the shallower soils, the dominant plants are sideoats grama (Bouteloua curtipendula), silver bluestem, broomweed (Gutierrezia dracunculoides), beebalm (Monarda spp.), pricklypear (Opuntia compressa), and ragweed (SCS 1964).

Traditionally, these prairies supported a great diversity of wildlife species, including great herds of bison (Bison bison), elk (Cervus elaphus), grizzly bears (Ursus arctos), wolves (Canis lupus) and prairie chickens (Tympanuchus cupido). Because the prairie has been so dramatically altered and/or fragmented, the only "deep prairie" species still found in the area is the prairie chicken, and it is found in only a few of the small, pristine prairies of the area. However, many other species, principally edge species, are now abundant in the area. Bobwhite quail (Colinus virginianus), skunks (Mephitis spp.), opossum (Didelphis virginiana), and a few red (Vulpes vulpes) and gray (Urocyon cinereoargenteus) foxes and bobcats (Felis rufus) can be found over much of the area. Also, many northern prairie birds, such as the longspurs (Calcarius spp.), winter on these southern prairies

Floodplain Forest – Riparian. Riparian Forest occur along tributary streams with no well defined floodplain. Riparian areas also may represent a secondary successional stage of a bottomland forest following clearing. Because of these two characteristics, the incidence of riparian forests is greater than that of bottomland forest. Riparian forest also support a mesic plant community, although species composition differs from bottomland forest. Riparian areas are generally a mix of upland vegetation (upland forest, prairie, pasture and cropland) and bottomland vegetation (floodplain forest) and thus blend into adjacent cover types. This increase in "edge" or "ecotone" has a corresponding increase in the diversity and number of wildlife species in the area. Many of our important game species are "edge species", such as the white-tailed deer and northern bobwhite, and thus rely heavily on the diversity of plant species provided by riparian areas.

Blackjack oak (Quercus marylandica), post oak (Q. stellata), red oak (Q. borealis), black locust (Robinia pseudoacacia) and hickory dominate the upland forest of the area. The project area is on the fringe of the crosstimbers, a transition zone between eastern deciduous forest and tallgrass prairie. However, because of the geology and rainfall of the area (the Ozark Plateau), the diversity of tree species is generally higher than that of "traditional crosstimbers" and has many qualities of the oak-hickory forest to the east. Other dominant species include white oak (Q. alba), walnut, shortleaf pine (Pinus echinata), purpletop, dogwoods (Cornus spp.), huckleberry bushes (Gaylussacia spp.) and grapevines. If disturbed, persimmons (Diospyros virginica), ash, scrubby blackjack and post oaks, sassafras (Sassafras albidum), and ragweed increase at the expense of other species (SCS 1964).

The profusion of nuts, principally acorns, in the upland forest of the area makes these areas of high value to many wildlife species. Many economically important species, such as white-tailed deer (Odocoileus virginianus), wild turkey (Meleagris gallopavo), squirrels (Sciurus spp.), and the fur bearers that prey on them [e.g. bobcats, coyotes (Canis latrans)], inhabit such areas.

The continual conversion of non-agricultural areas to cropland and pasture (introduced grassland) has dramatically decreased other types of terrestrial cover. Cropland is generally found on the more fertile soils, particularly floodplains. Small tracts of cultivated land can be beneficial to some edge species of wildlife, especially when located adjacent to other forest or wetland cover types or tallgrass prairies in good condition. However, larger tracts are generally of little or no value to almost all wildlife species. Introduced grasslands are low in plant diversity and cover potential, and therefore are of little value to wildlife.

Wetland Resources

Wetlands values are well documented. The biological functions of wetlands include nesting and wintering habitat for waterfowl, spawning and nursery areas for fish and other aquatic and amphibious species, and the complex provisions needed for furbearers. Wetlands afford immeasurable benefits for a myriad of game and nongame species. The dependence of amphibians and some reptiles upon a transition between terrestrial and aquatic conditions is well known. Wetlands have been found to be the most productive intensively managed agro-ecosystem known to man (Odum 1959). Wetlands also can play a major ecological role in pollution abatement and erosion control. Wetlands located in floodplains act as settling basins for sediment laden runoff and floodwaters. The water purification capabilities of wetlands help eliminate contaminants from agricultural and urban runoff.

Floodplain Forest - Bottomland Forest. Additional importance is placed on bottomland forest because of their continuing loss, both nationwide and within the project area. Documented losses of up to 93 percent of presettlement areas of bottomland forest have been shown in Oklahoma watersheds (Barclay 1978). It is estimated that about 70 percent of the original bottomland forests in the United States has been converted to other land uses (Brinson et al. 1981). Dominant trees on these sites are pecan (Carya illinoensis), walnut (Juglans nigra), and ash (Fraxinus spp.). Elm (Ulmus americana) and ash increase when walnut and pecan trees are removed. In excellent condition, bottomland forest of the project area are dominated by eastern gamagrass (Tripsacum dactyloides), prairie cordgrass

(Spartina pectinata), Florida paspalum (Paspalum floridanum), broadleaf uniola (Uniola latifolia), poison ivy (Rhus toxicodendron), and trumpet creeper (Campsis radicans). If the area is disturbed, giant ragweed (Ambrosia trifida), goldenrod (Solidago spp.), sumpweed (Iva ciliata), and morning glory (Ipomea purpurea) increase as the previously dominant grasses die out. In the more frequently flooded areas, elm, ash, walnut, pecan, poison ivy, and grapevines (Vitis spp.) are the common woody species. The climax herbaceous vegetation consists of switchgrass, prairie cordgrass, broadleaf uniola, and sedges (Cyperus spp.). When these wetter areas are disturbed, giant ragweed, sumpweed, goldenrod, asters (Aster spp.), sedges, rushes (Juncus spp.), and scrubby hardwoods become more abundant (SCS 1964).

The value of bottomland forests to fish and wildlife, ecological integrity, and ultimately to man are also well documented. Wooded bottomlands and associated wetlands act as storage reservoirs and nutrient assimilation sites. The structural diversity of woody plant communities, presence of surface water and abundant soil moisture, diversity and interspersion of habitat features (particularly due to the soil moisture gradient) and linear nature of bottomlands (which intensifies the "edge" effect and provides corridors for wildlife movement) all contribute to this ecosystem's high species abundance and diversity. Flooded bottomlands also provide spawning and feeding grounds for a wide variety of fish species. Fish populations in these flooded forests are not only diverse, but very abundant; they support some of the highest fish populations of any habitat (Harris et al. 1984).

Additionally, bottomland forest, particularly in drier zones (such as in Oklahoma), support a great abundance and diversity of both resident and migratory birds. During the winter months (November–December) migratory bird density is about 35 birds/hectare in bottomland hardwoods and one acre of bottomland forest may provide overwintering habitat for summer breeding birds from six acres of northern forest (Harris and Gosselink 1986). In addition, forested areas in northeastern Oklahoma provide habitat for the majority of the warbler species, as well as many other bird species, that migrate through the state.

Palustrine wetlands (Cowardin et al. 1979) are found primarily in the floodplains of major river systems and their more important tributaries (USFWS-NWI Maps 1980). Included in this cover type are oxbows, wet meadows, backwaters and overflow areas, and natural depressions. Land use changes such as drainage or inundation have greatly altered or eliminated much of the original wetland habitat in the area. Remnants of these wetlands are closely associated with other cover types and provide excellent habitat for terrestrial and aquatic species.

Aquatic Resources

Lentic aquatic habitat is represented by major main stem impoundments, Soil Conservation Service upstream flood control impoundments, farm ponds, and municipal and industrial impoundments. These deep water habitats, that have a surface area greater than 20 acres, are identified as lacustrine waters on the Service's National Wetland Inventory maps. These bodies of water are primarily man-made and have replaced many acres of terrestrial cover. Much of this lentic habitat is productive of both fish and wildlife although it probably has lesser value to the overall resource than the habitats present prior to inundation. However, the presence of small impoundments in many cases has added to habitat diversity and as a result has been valuable to some wildlife and fish communities.

Increasing acreage of lentic habitat has generally been accomplished at the expense of lotic habitat (USFWS-NWI Maps 1980). Additionally, many of the major streams in the area are of diminished importance to fish and wildlife due to degradation of water quality as a result of a combination of municipal, industrial, and agricultural effluent. The mine discharge flowing into Tar Creek has resulted in severe stress to the faunal community. In 1983, no fish species and only four species of benthic invertebrates occupied Tar Creek, while a nearby unaffected stream (Four Mile Creek) yielded 19 species of fish and 14 species of macroinvertebrates (Aggus et al. 1983). The effects of the contaminated water on the faunal community appear to diminish as the water flows into the Neosho (Grand) River, though concentrations of heavy metals in sediment and fish tissue are highly variable between sampling locations and at different times of the year.

Cover Types/Wildlife Associations

A wide variety of game and nongame fish and wildlife occur within the project area. Rather than include an exhaustive list in this report, a list of key species indicative of each cover type discussed in the previous section has been prepared (Table 1). This approach identifies some of the important species but does not represent all species found in a particular cover type. Actual species composition may vary considerably within each cover type at different locations.

Important Fish and Wildlife Resources

Floodplain forests, other wetlands, and upland forest provide the most important fish and wildlife resources within the immediate project area. Although these habitats are generally not of high quality in the vicinity of Miami, their existence in or near an urban setting has definite environmental benefits. Additionally, important fisheries (recreational and commercial) are found downstream and adjacent to the project area in the Neosho River - Grand Lake system.

A number of high quality streams occur in the general project area that maintain a diverse community of fish and other aquatic organisms. These resources are being lost to impoundments, channelization, and diversion of water for out of stream uses, and environmental contaminants. Because of the uniqueness of associated biological communities and the recreational potential of remaining reaches of high quality free flowing streams, they are an important resource to preserve.

There are several other areas of high quality fish and wildlife resources in close proximity to the project area (on both public and private lands). These areas are noted in this report to insure awareness and avoid possible conflicts, as many of these unique or high quality fish and wildlife areas receive no formal protection. A number of these have been identified as high quality natural areas for Oklahoma (Zan[illegible]al et al. 1979) by the Oklahoma Natural Heritage Inventory and as unique ecosystems by the U. S. Fish and Wildlife Service (USFWS 1979) (Appendix C). These areas of ecological significance constitute a resource for the future

Table 1. Floral and faunal indicator species associated with the cover types found in the northeast Oklahoma Tar Creek project area.

Cover type	Indicator flora	Indicator fauna
tallgrass prairie	big bluestem, little bluestem, Indiangrass, switchgrass	northern bobwhite, northern flicker, eastern meadowlark, red-tailed hawk, northern harrier
upland forest	blackjack oak, post oak, black locust, bluestems, sassafras, hickory, persimmon, elm	Carolina chickadee, fox squirrel, wood rat, white-tailed deer
floodplain forest	ash, walnuts, elms, pecan, grapevine	white-tailed deer, fox squirrel, mink, barred owl, wood duck, pileated woodpecker, American robin, tufted titmouse, red-shouldered hawk
riparian forest	cottonwood, elm, hackberry, persimmon, switchgrass, pecan	white-tailed deer, northern bobwhite, fox squirrel, red-tailed hawk
cropland	soybeans, wheat, alfalfa, sorghum	white-tailed deer, white-footed mouse, eastern meadowlark
introduced pasture	Bermuda grass, fescue, ragweed, buffalobur, nightshade	cotton rat, eastern meadowlark
palustrine wetlands	cattails, rushes, smartweeds, spikerushes, sedges, muskgrass, buttonbush, pondweeds	bullfrog, wood duck, mallard, great blue heron, red-winged blackbird, muskrat, beaver, blotched water snake
lentic (lacustrine) aquatic habitat	algae, coontail, bladderwort	largemouth bass, bluegill, white crappie, channel catfish, muskrat, mallard
lotic aquatic habitat	algae, periphyton water willow	green sunfish, mosquitofish, mollusks, stoneflies, mayflies, beaver, belted kingfisher, cliff swallow

that should be valued and sustained in a manner comparable to mineral and agricultural reserves. The functions of these areas include serving as facilities for environmental research and monitoring, as reserves for conservation of genetic diversity, and for recreational and educational purposes.

Also, Brabander et al. (1985) identified an area of significant (>500 acres) bottomland forest adjacent to the project area (Appendix D). This 4600 acre area is composed of several bottomland hardwood parcels situated along both sides of the Grand River. It has a mix of mature oak stands, younger stands of oak-ash-maple, and pecan orchards with lush emergent ground cover. This area has the highest known concentration of red shouldered hawks (Buteo lineatus) in the state of Oklahoma and also contains many oxbows and other wetland features that make it of high value to waterfowl and other wildlife species.

Threatened and Endangered Species

Largely due to the small size and primarily urban nature of the project area, relatively few federally listed threatened or endangered species occur within its boundaries. Listed species that occur in/or migrate through the project area include the endangered bald eagle (Haliaeetus leucocephalus) and interior least tern (Sterna antillarum), and the threatened piping plover (Charadrius melodus). Though least terns and piping plovers generally only migrate through the project area (April 25 - September 21, and July 19 to October 2 and April 18 - May 13, respectively), large concentrations of wintering bald eagles (October 20 - March 20) are found at the northern end of Grand Lake adjacent to the confluence of Tar Creek and the Neosho River (Grzybowski 1986). Also, the Neosho madtom (Noturus placidus), a federal Category 1 species, occurs upstream of the project area in the Neosho River (and formerly in the Spring River to the east). Category 1 species are those species for which the Service has sufficient information to proceed with listing but for which listing has been precluded by other higher priority species. Formal listing of the Neosho madtom as a threatened species is expected in the near future (≈1 year).

The above information on threatened and endangered species is informal in nature and should not be considered the official species list as required by Section 7(c) of the Endangered Species Act. Should a specific plan be developed for construction of the Tar Creek project, consultation with the Service regarding threatened and endangered species will be necessary.

The State of Oklahoma has an official state list of endangered species and species of special concern (Table 2). These species should also be taken into consideration because their populations are known to be declining in the state.

Fish and Wildlife Recreational Use

Largely because of its polluted condition, the Tar Creek drainage provides little in the way of consumptive wildlife values and virtually no sport fisheries value. Some small game hunting (squirrel, rabbit, quail) may occur in areas outside city limits. However, recreational wildlife uses are generally restricted to wildlife viewing, partially because of the pollution problem and principally because the area is in an urban-suburban setting that limits the use of firearms. Fisheries

Table 2. State (Oklahoma Department of Wildlife Conservation) Endangered Species (E) and Species of Special Concern (S) found in the Project Area (Compiled by the Nongame Technical Committee, 7/1/88)

Common Name	Status	Common Name	Status
Mammals		Reptiles	
Small-footed myotis	S 1/	Alligator snapping turtle	S 1/
Keen's myotis	S 1/	Texas horned lizard	S
Meadow jumping mouse	S		
Woodchuck	S	Amphibians	
Mexican free-tailed bat	S		
		Oklahoma salamander	S 1/
Birds		Grotto salamander	S
Prairie falcon	S	Fish	
Swainsons hawk	S		
Migrant loggerhead shrike	S 1/	Arkansas darter	S
Upland sandpiper	S	Neosho madtom	E 2/
Bell's vireo	S	Shovelnose sturgeon	S
		Invertebrates	
		Regal frittilary butterfly	S 1/

1/ Federal Category 2 Species
2/ Federal Category 1 Species

values in the adjacent Neosho River (Combs 1982, Ambler 1987) and Grand Lake (Summers 1978) however, are considerable and could be influenced by Tar Creek to the degree contaminants are transported downstream.

EVALUATION OF THE PROJECT

In any development study conflicting use of the resource must be addressed. Losses of wildlife habitat could result from direct destruction due to construction, drainage, habitat fragmentation, or secondarily as a consequence of related development. Impacts can also occur through impairment of operational efficiency of existing public fish and wildlife facilities (i.e. possible degradation of water quality by increasing siltation in steams and lakes during construction).

In an attempt to identify important fish and wildlife resources at potential project sites, a preliminary evaluation of these resources was performed. The first phase was conducted using available literature, previous Fish and Wildlife Service reports, National Wetland Inventory maps, and our own experience. Phase two involved an on-site evaluation to ground truth literature findings and identify any areas of special concern not previously noted.

For each alternative we estimated the acreage of the cover types that would be affected by construction using a "best guess" of project routing. Alternative F1, floodproofing, was not addressed in this report due to a lack of detail about the floodproofing procedures at the time of report preparation. Much of the area that would be affected is in pasture, cropland, and urban/other habitat (Table 3). Though considerable acreage would be lost in these cover types, these types of habitat are abundant and of low value to fish and wildlife resources in most cases. However, upland forest and wetlands would also be affected, though most of these affected areas are relatively small (Table 3). Many of these sensitive areas that could be impacted may only be affected temporarily, but care should be taken to avoid any losses. The majority of wetlands that could be impacted are palustrine forested areas (Alt. M2, C1, L1, L2, DR1, L3d, and L3e) and riverine areas (Alt. C1, DR1, DR2, DR3, DR4, DR5, and L3d). Several other palustrine areas also would likely be affected (Table 4).

At this stage of the planning process, only a preliminary attempt has been made to rank the alternatives according to the amount and quality of fish and wildlife resources which would be affected. However, using general criteria, a preliminary ranking (Table 5) based on the quantity and quality of upland forest and wetland resources was developed. Dry reservoirs were ranked on the assumption that vegetation would only be cleared in the immediate vicinity of the dam sites. If construction of these reservoirs does entail clearing of vegetation from additional areas a reevaluation/reranking of their impacts would be necessary. The impacts of alternatives M1 and M2 could increase if; 1) levee construction lessens the use of Riverside Park to wildlife viewing by either destruction of habitat or limiting access; or 2) levee construction lessens fishing access to the Neosho River. It should be noted that the ranking may change as additional information becomes is available.

DISCUSSION/PROBLEMS/NEEDS

The Service's principal fish and wildlife objective at this stage of the project is avoidance of unnecessary habitat loss or degradation. This will involve protection of the most valuable habitats for fish and wildlife resources in the project area, which are generally those associated with the floodplains of streams, including the streams themselves, floodplain forest, and other lacustrine and palustrine wetlands.

In order to facilitate early planning and avoid unnecessary conflicts and delays, we have conducted a preliminary categorization of cover types or habitat areas within the project area in accordance with our Mitigation Policy (U.S. Fish and Wildlife Service 1981). In the development of this policy the Service followed two general principles: 1) that impact avoidance or compensation be recommended for the most valued resources, and 2) that the degree of mitigation correspond to the value and scarcity of habitats or species impacted by any particular development proposal. Habitat values and abundance, as determined through the use of selected evaluation species (Table 1), are the key elements in setting appropriate planning goals for mitigating habitat losses. The following preliminary categorization includes both specific area of habitat as well as general cover types in an attempt to provide the most useful information as possible.

Table 3. Acreage of cover types affected by construction of flood control alternatives.

Alternative	Wetland	Upland Forest	Pasture	Cropland	Urban/other	Total
M1	2	-	-	-	31	33
M2	20	-	2	4	50	76
C1	48	-	-	-	-	48
L1	2	-	-	-	11	13
L2	9	-	2	-	31	42
DR1[1]	2	-	4	-	-	6
DR2	2	-	32	39	-	73
DR3	1	-	-	65	-	66
DR4	1	9	-	34	-	44
DR5	5	-	-	90	-	95
L3a	-	-	7	4	-	11
L3b	-	-	9	1	-	10
L3c	-	-	11	-	-	11
L3d	6	2	9	4	-	22
L3e	3	-	2	3	-	8

[1] Dry reservoir alternatives include only the cover types expected to be impacted directly by dam construction. Because of the brief flooding time (10-14 days), upstream effects were not considered significant.

Table 4. Wetland type and acreage affected by construction of each alternative.

Alt.	Palustrine Forested	Palustrine Shrub/Scrub	Palustrine Emergent	Riverine (intermittent)	Riverine (lower perennial)	Total
M1	0	2	0	0	0	2
M2	19	1	0	0	0	20
C1	23	0	0	0	25	48
L1	1	0	1	0	0	2
L2	5	4	0	0	0	9
DR1	1	0	0	0	1	2
DR2	0	0	0	2	0	2
DR3	0	0	0	1	0	1
DR4	0	0	0	1	0	1
DR5	0	0	0	5	0	5
L3a	0	0	0	0	0	0
L3b	0	0	0	0	0	0
L3c	0	0	0	0	0	0
L3d	1	0	4	1	0	6
L3e	3	0	0	0	0	3

Table 5. Preliminary ranking of potential project sites based on the potential loss of fish and wildlife resources [least (1) affect to greatest affect (4)]

Ranking	Alternative(s)	Reason
1)	L3a, L3b, L3c	No loss of wetlands, floodplain forest, or upland forest
2)	M1, L1, DR1, DR2 DR3, DR5, L3e	Minimal loss of wetlands
3)	L2, DR4, L3d	Small loss of wetlands and/or upland forest
4)	M2, C1	Moderate loss of wetlands

As previously mentioned, our preliminary study indicates wetlands (including flood-plain forest) would be affected by most of the proposed alternatives. Our goal in mitigating project-related floodplain forest and wetland losses (and other high quality habitats) is to insure no net loss of in-kind habitat value. Generally, these cover types, in the project area, provide medium value food, cover, and reproductive habitat for evaluation species such as barred owl (Strix varia), fox squirrel (Sciurus niger), and pileated woodpecker (Dryocopus pileatus). Additional emphasis is placed on these types of habitat because they are becoming scarce on a local, ecoregion, state, and national basis. However, because the water in Tar Creek is in such a degraded condition, the riverine wetlands [25 acres of lower perennial stream (NWI R2OWh) on Alt. C1 and one acre on Alt. DR1] are of low value to fish and wildlife and mitigation goals would only be to minimize loss of habitat value.

The upland forest within the project area, including the areas that would be lost to alternatives DR4 and L3d, provide medium to high value habitat for evaluation species such as barred owl, fox squirrel, and northern flicker (Colaptes auratus). This habitat type is relatively abundant on a local, ecoregion, state, and national basis. Therefore, our mitigation goal for resources of similar value and abundance is no net loss of habitat value while minimizing loss of in-kind habitat value.

In general, the pasture/cropland within the study area is very abundant and provides medium to low value for evaluation species such eastern meadowlark (Sturnella magna), and red-tailed hawk (Buteo jamaicensis). Our mitigation goal for these resources is to minimize loss of habitat value.

As previously stated, the major fish and wildlife resource needs in the study area is protection of high quality wetlands. These resources are being lost at an alarming rate throughout the U.S. However, for most of the alternatives the impacts are generally small, and mitigating such losses leaves several options open. Land acquisition is a viable option because there are several areas that could be used to mitigate project losses [areas near existing federal reservoir sites as well as those areas identified as high quality natural areas and unique ecosystems (Appendix C) and Oklahoma Department of Wildlife Conservation Lands] in this instance. However, with this project it may be preferable to achieve mitigation through increased management at an existing Corps of

Engineers reservoir site (or other important fish and wildlife areas) within the general project area. The potential for increased fish and wildlife management should be considered in further planning.

Another mitigation possibility that should be considered during planning is the creation of palustrine wetland during project construction. Though this alternative is less desireable than avoidance of wetland losses, this could be accomplished by (but not limited to) two different methods: 1) Palustrine wetlands could be created by altering the flow regime of the proposed dry reservoirs so that water is held for longer periods of time and/or so that they do not completely drain. This option, however, is only feasible if the water quality of the creek is such that it poses no health hazards to wildlife. This likely limits the sites where this can be considered to Quail and Garrett Creeks; 2) Palustrine wetlands could also be created (TVA 1988) during the excavation of material for levee construction and other earth-moving construction. This would probably involve shallower borrow pits and more borrow pits but could negate the cost required for acquisition of mitigation lands.

The Tar Creek drainage poses some rather unique problems in fish and wildlife planning. Toxic levels of elements found in the stream render it virtually useless to aquatic species, though mosquitofish (Gambusia affinis) have recently been noted as far upstream as NW 22nd Street. However, terrestrial wildlife still use the area and reap what benefits they can from the wetland condition. This is further complicated by the fact that while many species do persist in the area, and many others migrate through, some wildlife are likely to pickup, at least, sublethal doses of contaminants; the effects of which are at present unknown. Additionally, sediments within the streambed and in the floodplain are also known to contain high levels of contaminants, often much higher than in the water column (Table 6). This necessitates the need to avoid resuspension and/or reintroduction of the contaminants into the system so that they do not flow to downstream areas. Measures will need to be taken during any dredging operations, with a series of dams and filters or other proven methodology, to ensure that the substantial fisheries in downstream areas, and public health, are not affected. The contaminated sediments also limit the possibilities and/or add to the cost of what can be done with dredge or fill material taken from the floodplain. To date, three alternatives have been discussed: 1) hauling the material to a hazardous waste site; 2) putting the material into the abandoned mine; and, 3) using the material in the construction of flood control levees. The third alternative would necessitate the use of a proven methodology to prevent reintroduction/recontamination of the stream area, such as encapsulating the material in a "clay cap" or other synthetic material. Simply revegetating the levees could prove hazardous as animals inhabiting revegetated metalliferous mine sites have been shown to have higher than normal concentration of cadmium (Andrews et al. 1984) – an element now abundant in the Tar Creek drainage. These confounding factors make mitigation for this project a trade-off between saving a diminishing resources and not exposing fish and wildlife to contaminants.

Table 6. Concentrations of elements found at sampling sites in Tar Creek, June 1988 (Tulsa Army Corps of Engineers).

	NW 22nd		Channelization Area		Rockdale Blvd.		Highway 10	
Element	W	S	W	S	W	S	W	S
Arsenic	BDL	40	BDL	14	BDL	BDL	BDL	BDL
Cadmium	0.012	24.9	0.017	17.8	BDL	24.7	BDL	39.4
Chromium	BDL	158	BDL	92.9	BDL	19.4	0.14	18.3
Lead	0.006	108	0.009	119	BDL	242	BDL	710
Mercury	BDL	BDL	BDL	BDL	BDL	BDL	0.0015	0.05
Nickel	0.490	104	0.560	62.1	0.450	51.5	1.510	109
Selenium	BDL	—	BDL	—	BDL	—	BDL	—
Zinc	23.0	1640	33.5	1780	16.7	5750	15.7	10800

W = Water Column
S = Stream Sediment
BDL = Below Detectable Level
All values shown as milligrams/liter (parts per million)

CONCLUSIONS

Though all alternatives contain elements of interest to the Service, the majority of the alternatives would have relatively minor impacts on small areas of important fish and wildlife resources and would require only straightforward mitigation procedures. The preferred alternatives at this date are levees L3a, L3b, and L3c. Should avoidance prove infeasible, mitigation for most other areas is preferred at an existing Corps of Engineers reservoir or other previously described area. However, because of the contamination problem in the Tar Creek drainage, alternatives that could result in the resuspension or reintroduction of contaminants into the environment will require particular attention. Of special concern are the channelization alternative (Alt. C1) and any alternative that involves the use or disturbance of sediment from within the Tar Creek floodplain. These alternatives not only pose a threat to the immediate area but could have detrimental effects on important downstream commercial and recreational fisheries, migratory waterfowl and other wildlife species, other recreational activities, and possibly endangered species (bald eagle). If any of the alternatives that would affect downstream areas are opted for, a proven methodology to prevent downstream contamination will be necessary to prevent possible deleterious effects on fish and wildlife resources.

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07185095 TAR CREEK AT 22ND STREET BRIDGE AT MIAMI, OK

LOCATION.--Lat 36°53'00", long 94°52'05", in NE 1/4 NE 1/4 sec.19, T.28 N., R.23 E., Ottawa County, Hydrologic Unit 11070206, near downstream left abutment of 22nd Street bridge in Miami, 0.5 mi east of intersection of Main and 22nd Street.

DRAINAGE AREA.--44.7 mi².

PERIOD OF RECORD.--January 11, 1984 to current year.

GAGE.--Water-stage recorder. Datum of gage is 762.23 ft, National Geodetic Vertical Datum of 1929.

REMARKS.--Estimated daily discharges: Apr. 9 to May 6. Records fair. Several unpublished observations of water temperature, specific conductance, and pH were made during the year and are available at the District Office.

EXTREMES FOR PERIOD OF RECORD.--Maximum discharge, 4,390 ft³/s, Sept. 30, 1986, gage height, 13.73 ft; minimum daily discharge, 0.07 ft³/s, Aug. 15, 1984.

EXTREMES FOR CURRENT YEAR.--Maximum discharge, 4,390 ft³/s, Sept. 30, gage height, 13.73 ft; minimum daily discharge, 0.46 ft³/s, July 21.

DISCHARGE, IN CUBIC FEET PER SECOND, WATER YEAR OCTOBER 1985 TO SEPTEMBER 1986
MEAN VALUES

DAY	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
1	16	45	397	13	6.0	90	11	17	4.1	6.4	2.5	3.8
2	12	29	110	13	5.8	90	12	14	4.6	12	12	3.8
3	10	23	48	12	169	9.4	21	13	9.1	5.9	4.5	3.2
4	8.2	19	37	12	150	9.2	509	12	25	3.6	2.6	3.8
5	6.9	18	34	11	60	8.3	145	10	31	2.8	2.3	6.4
6	6.2	17	30	11	130	8.2	60	9.3	41	2.0	21	6.2
7	3.6	15	28	9.9	134	7.8	118	9.0	30	1.8	7.0	5.6
8	3.3	14	26	8.3	67	7.3	1450	8.7	26	1.5	3.9	3.4
9	3.4	14	25	7.8	45	7.6	150	8.3	22	1.2	4.3	3.7
10	5.5	13	126	8.0	33	8.9	70	8.1	12	1.2	15	6.4
11	9.3	12	754	8.5	23	27	35	13	124	1.4	4.7	6.2
12	10	768	169	8.7	19	316	33	8.3	62	2.3	2.7	6.7
13	17	2570	67	8.3	17	91	30	6.9	28	9.8	2.3	7.1
14	220	2970	40	8.3	18	43	110	6.4	17	5.8	2.1	7.1
15	155	935	32	8.2	19	28	50	13	11	2.7	1.9	17
16	56	309	32	8.3	42	22	35	11	8.6	2.0	2.3	58
17	32	121	33	8.7	60	19	32	48	6.9	1.2	2.8	43
18	653	1170	30	8.9	36	19	31	37	5.8	.92	2.7	27
19	628	1270	26	8.9	25	17	29	21	5.2	.70	2.5	19
20	118	405	22	8.2	20	14	26	15	4.4	.65	2.3	15
21	60	114	20	7.9	16	13	24	12	9.8	.46	2.3	12
22	41	73	23	6.9	15	12	22	11	3.2	.51	2.1	12
23	30	56	25	6.3	15	12	20	9.7	2.7	.67	2.2	12
24	24	45	24	6.5	14	12	17	8.7	2.8	.67	2.5	12
25	20	42	18	6.1	12	11	16	7.8	2.8	.56	2.9	11
26	18	47	16	5.9	12	11	15	7.0	2.7	.49	2.9	390
27	16	47	15	5.0	12	11	24	6.3	18	.79	4.4	362
28	15	34	14	5.4	11	11	30	6.9	99	.59	4.9	83
29	186	30	14	5.7	---	11	26	6.0	18	.69	4.7	543
30	293	33	14	5.3	---	10	21	5.2	8.9	1.3	4.0	3340
31	87	---	14	5.6	---	10	---	4.7	---	1.8	3.9	---
TOTAL	2774.8	11153	2263	257.8	1187.8	806.7	3172	376.7	644.8	73.60	137.6	4876.8
MEAN	89.5	373	73.0	8.32	42.4	26.0	106	12.2	21.5	2.37	4.44	163
MAX	653	2970	754	13	169	316	1450	48	129	12	21	3340
MIN	3.4	12	14	5.0	5.8	7.3	11	4.7	2.7	.46	1.9	3.8
AC-FT	5500	22180	4490	511	2360	1600	6290	747	1280	146	273	9370

CAL YR 1985 TOTAL 37724.58 MEAN 103 MAX 3580 MIN .40 AC-FT 74830
WTR YR 1986 TOTAL 27704.17 MEAN 75.9 MAX 3340 MIN .46 AC-FT 54950

Appendix A. USGS Data for Tar Creek, Oklahoma
(Hauth et al. 1988)

Range Sites and Soil Types Associated
With Project Area Terrestrial and Some Wetland Cover Types

Range Sites (*Cover Type*)

Claypan Prairie Sites (*Tallgrass prairie*) consist of soils with a surface layer of silt loam or silty clay loam and a subsoil of very compact clay. The subsoil has very slow permeability and hinders the growth of roots. Soils of these site include:

Parson silt loam, 0 to 1 percent slopes.
Parson silt loam, 1 to 3 percent slopes.
Parson silt loam, 1 to 3 percent slopes, eroded.
Woodson silty clay loam, 0 to 1 percent slopes.[1]

Loamy Prairie Sites (*Tallgrass prairie*) are medium textured or moderately fine textured soils on nearly level to strongly sloping uplands. They have slow to rapid permeability. The soils have good moisture storage capacity and good depth for plant root development. Soils of these site include:

Bates loam, 1 to 3 percent slopes.
Bates loam, 3 to 5 percent slopes.
Breaks-Alluvial land complex.
Choteau silt loam, 1 to 3 percent slopes.
Dennis silt loam, 1 to 3 percent slopes.
Newtonia Sogn complex (Newtonia part).
Taloka silt loam, 0 to 1 percent slopes.

Very shallow sites (*Tallgrass prairie*) are in Sogn soils, which are part of the Newtonia complex. Sogn soils are loamy, very shallow, and are formed over limestone. In places they have limestone flagstones on the surface. These soils are droughty, and their moisture-storage capacity is limited. Space for growth of roots is also limited. Sogn soils are the very shallow portion of the Newtonia-Sogn complex; the Newtonia portion of the complex is in the Loamy Prairie range site.

Loamy bottomland sites (*Floodplain forest*) are made up of deep, nearly level, moderately permeable or slowly permeable soils that are subject to flooding in places. The soils take in moisture readily and store large quantities of water available to plants. The soils in the project area included in this range type are Kaw silty clay loam and Verdigris silt loam[2].

Heavy bottomland sites (*Bottomland forest*) are made of deep, poorly drained, very slowly permeable, alluvial soils that are subject to flooding. They have a surface layer of silt loam or silty clay and a subsoil of dense clay. The only soil types

---

[1] May be hydric soil in depressions near drainageways.

[2] May be a hydric soil in depression near drainageways.

Appendix B. Range Sites and Soil Association found in Tar Creek Project Area

In the project area included in this range type are Osage silty clay[3] and Lightning silt loam[3].

The alluvial land[4] soil type (*Bottomland forest*) and mine pits were not assigned a range type as the are not suited to range. Alluvial land is made up of miscellaneous land types of nonarable areas of alluvial soils. Along the Neosho River and its tributaries, it consists of Osage and Verdigris soils. The narrow band of this land is flooded several times a year. Most of this land is covered with pin oak (Quercus palustris), pecan, elm, and other bottomland species.

Mine pits are a miscellaneous land type that include piles of rock and chat from lead and zinc mines. In some places this is a relatively thin area but in others, drainageways are blocked and areas are ponded or made swampy.

---

[3] Hydric soil.

[4] Hydric soil

Appendix C. High Quality Natural Areas and Unique Ecosystems in General Project Area.

Appendix D. Significant Tracts of Bottomland Forest in General Project Area.

LOCATION: Grand (Neosho) River, Ottawa County
USGS QUAD: Miami NW, Miami SW 7.5'
TOTAL AREA: 4,600 acres± (2,990 acres forested wetland)

1. Forested wetland habitat types and acreages (NWI classification):

A.	Palustrine, forested, broad-leaved deciduous temporarily flooded	937 ac.
B.	Palustrine, forested, broad-leaved deciduous seasonally flooded	1,014 ac.
C.	Palustrine, forested/shrub scrub	230 ac.
D.	Palustrine, forested/emergent	770 ac.
E.	Palustrine, forested/open water	38 ac.

2. General habitat description: This area is composed of somewhat disjointed BLM parcels strung out along both sides of the Grand River. It has a mixture of mature oak stands, younger stands of oak-ash-maple, and pecan orchards with lush emergent ground cover. There are a number of oxbows, river scars and other wetlands with seasonal to permanent water regimes. Timber tracts are interspersed with cropland and some pasture.

3. Hydrological Regime: Good - the Grand River floods mostly in the spring. Several tributaries also supply water and oxbows, etc. contain water most of the time.

4. Waterfowl value: (High, Medium, Low)

   A. Wintering - Medium   B. Production - Medium (wood ducks)

5. Value for Threatened/Endangered Species or State Rare Species: Grand River and perhaps oxbows have value for bald eagles. Swamp rabbit occurs in area.

6. Value for special species/groups (High, Medium, Low):

White-tailed deer	- High
Turkey	- Medium
Squirrel	- High
Furbearers	- High
Raptors	- High (large concentration of nesting red shouldered hawks - also Cooper's hawk)
Songbirds	- High

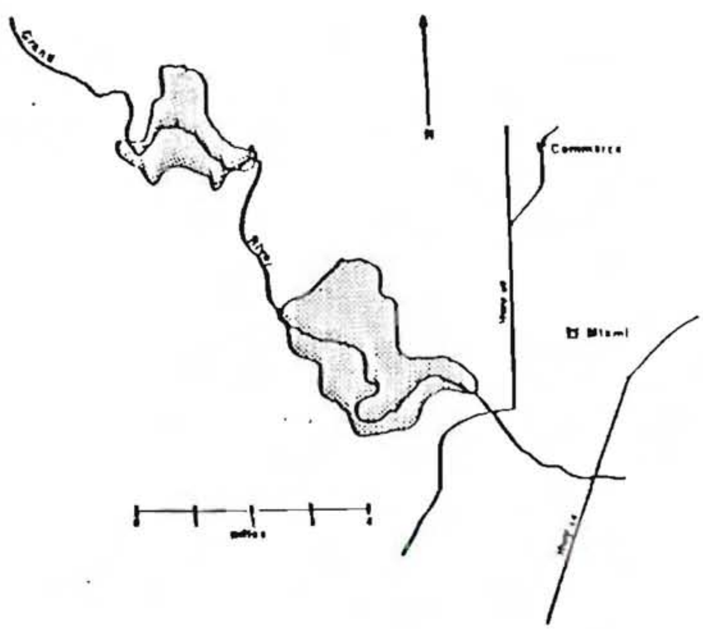
7. Development Needs (High, Medium, Low): Medium - greentree reservoir and crop development could be applied.

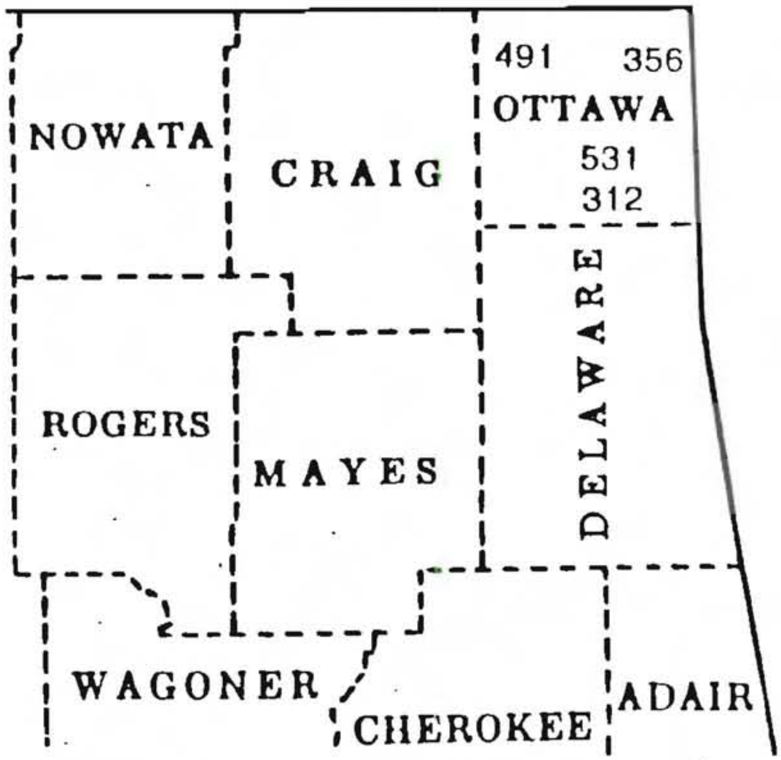
8. Ownership: Private, some by B. F. Goodrich Tire Co.

9. Degree and Type of Threat: Moderate threat to increase in cropland, more intensive grazing and pecan production.

10. Comments: Area is diverse and varies from fair to good in quality but discontinuous nature of tracts reduces value as a manageable unit. Good representation of BLH in northeast Oklahoma. Without protection, gradual "chipping away" at resource will occur.

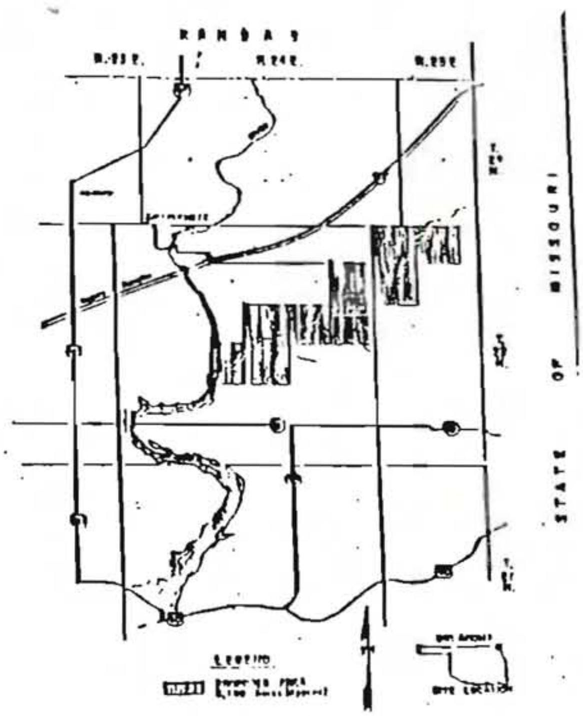
Grand (Neosho) River, Ottawa County





County	Area No. 1/	Natural Areas or Special Species	Acres
Ottawa	312	Ozark plateau stream, northeastern Oklahoma bottomland forest, limestone caves, unique fish	160
	356	Post oak-blackjack oak-black hickory-black oak forest, unique birds	920
	491	Northeastern Oklahoma bottomland forest, oxbows, ponds, lakes	35
	531	Mixed oak-hickory forest, northeastern Oklahoma bottomland forest, Ozark plateau lake	1095

1/ Zanoni et al. (1979) assigned these areas an identification number instead of specific locations to protect private landowners. Locations are on file with the Oklahoma Natural Heritage Inventory.



PROPOSED UNIQUE ECOSYSTEM

CAVE SPRINGS CAVE AND WARREN'S BRANCH OF SPRING RIVER

OTTAWA COUNTY, OKLAHOMA

1. Location: Warren's Branch and Cave Springs Cave are located approximately 3 miles west and 1 mile south of Peoria, Oklahoma.

2. Uniqueness - Wildlife and Habitat: Warren's Branch of Spring River originates in Arkansas and is one of many similar streams flowing through the western foothills of the Ozark Plateau. The difference is Cave Springs Cave, along Warren's Branch, contains the only known population of the cave Ozark cavefish (Amblyopsis rosae) in the State and one of the few southern cavefish (Typhlichthys subterraneus) populations in Oklahoma.

   a. Endangered and Threatened Species: The federally endangered gray bat (Myotis grisescens) probably occurs in Cave Springs Cave in small numbers. [illegible] reported from caves along Spring River in the past. Bald eagles may also use the area.

   b. Species of Concern: The Ozark cavefish is nowhere abundant but is found in the caves of northwestern Arkansas, southwestern Missouri, and northeastern Oklahoma. Its range is restricted to these areas including northeastern Oklahoma which are considered to be in the Ozark Biotic District.

   Another rare species, the southern cavefish, was only recently discovered in Cave Springs Cave. One collection represents the only known population in Oklahoma. This cavefish is adapted for life in the pools of subterranean streams of limestone caves.

   The Rare and Endangered Committee of Oklahoma list of rare and endangered Oklahoma species lists the following species as occurring in or around the stream area: Mammals - gray bat; Fishes - southern cavefish, Ozark cavefish, bluntface shiner, Illinois darter, [illegible] darter; Birds - golden eagle, bald eagle; Amphibians - grotto salamander.

3. Habitats (Types): The 3,760 acres proposed for acquisition are primarily composed of riparian habitat and Ozark woodland.

4. Development Needs: Fencing and posting initially.

5. Facilitate Administration of Existing Refuge: No.

6. Identified by Others as an Area of Concern: Oklahoma Natural Heritage Committee.

7. Ownership and Acreage: The proposed 3,760 acres is primarily owned by one owner.

8. Acquisition and Development Costs: Estimated project cost is approximately $4.5 million.

9. O&M Funding Estimate: $65,000

10. Threat of Destruction: Residential development of the area will no doubt escalate in the near future. The site is only a few miles from the town of Miami with a population of 15,000. The proposed area is also located several miles from Grand Lake, one of the more heavily used recreational lakes in Oklahoma.

11. Will P&S Be Required? Principles and standards will be required.

12. Reaction of Others (Including Previous Preservation Efforts): Unknown at this time.

13. Nominated by: Oklahoma Natural Heritage Committee.

APPENDIX A

ADDITIONAL STUDIES

APPENDIX A

ADDITIONAL STUDIES

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TABLES

FIGURES

APPENDIX A

ADDITIONAL STUDIES

This appendix presents the results of additional studies conducted at the request of the city of Miami.

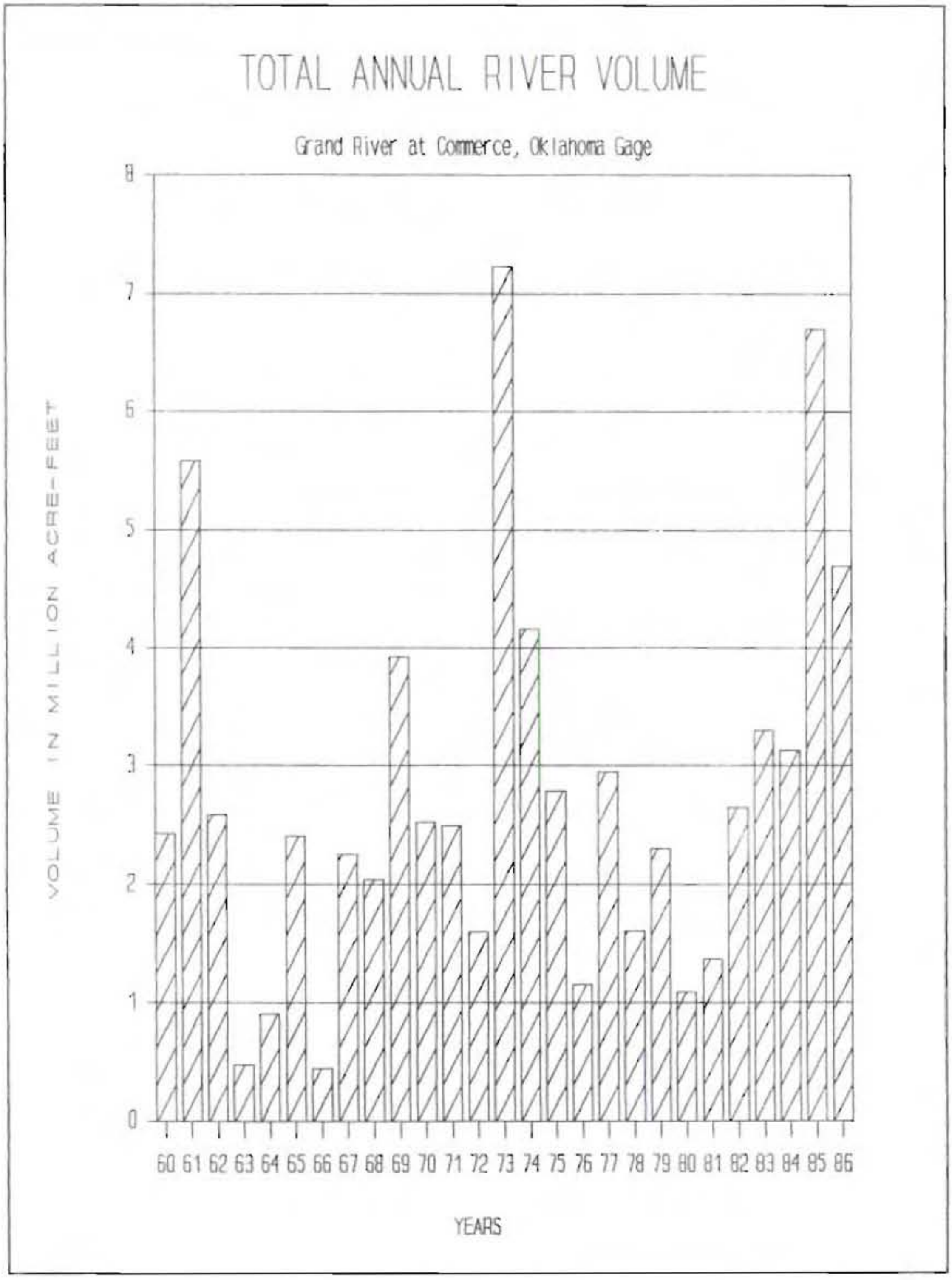
IMPACT OF GRAND LAKE POOL LEVELS ON MIAMI FLOODING

BACKGROUND

During the period 1984 through 1988, Miami experienced a high recurrence of flooding which significantly impacted many individual property owners and added to the city's general economic depression.

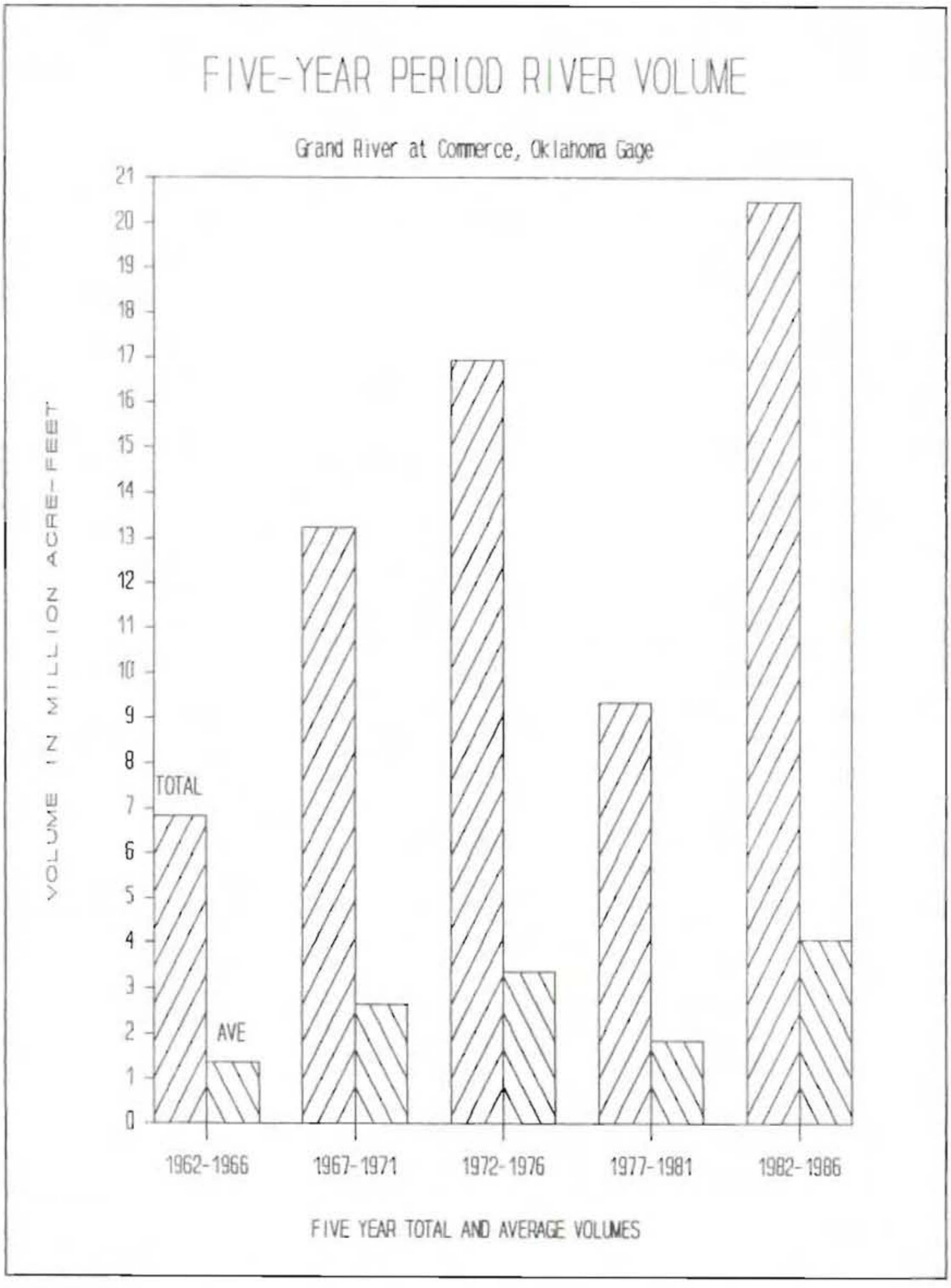
The increased occurrence of flooding was, in part, known to be the result of higher than average rainfall causing higher than average river flows. This situation is demonstrated in the recorded river discharges-over-time (volume) that passed the Commerce gage on the Grand River. The Commerce gage is about eight miles upstream of Miami. The volume data, recorded in million acre-feet, is shown in Figure A-1 for the period 1960 through 1986. Figure A-2 represents this same data in five year periods from 1962 to 1986. From Figure A-2 it can be seen that river flows during the 1982-1986 period were significantly greater than the previous 40 years. Water surface profile data for the Grand River at Miami, Oklahoma, are shown in Table A-1.

In seeking to identify other causes for the increased recurrence of flooding, the city looked to operational procedures of Grand Lake (Grand Lake O' the Cherokees or Pensacola Reservoir). A widely held public impression in recent years was that the Grand River Dam Authority (GRDA) had changed the level of the lake which, in turn, had caused an increased incidence of flooding. Although the GRDA has changed the regulation procedures for generation of hydropower, those procedures only involve pool operations below the top of the conservation pool (elevation 745.00). The elevation of the conservation pool has remained at elevation 745.00 since 1946.



TOTAL ANNUAL RIVER VOLUME
Grand River at Commerce, Oklahoma Gage
VOLUME IN MILLION ACRE-FEET
0
1
2
3
4
5
6
7
8
60 61 62 63 64 65 66 67 68 69 70 71 72 73 74 75 76 77 78 79 80 81 82 83 84 85 86
YEARS

Figure 1



FIVE-YEAR PERIOD RIVER VOLUME
Grand River at Commerce, Oklahoma Gage
VOLUME IN MILLION ACRE-FEET
0
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
TOTAL
AVE
1962-1966
1967-1971
1972-1976
1977-1981
1982-1986
FIVE YEAR TOTAL AND AVERAGE VOLUMES

Figure 2

TABLE A-1

WATER SURFACE PROFILE DATA
GRAND RIVER AT MIAMI, OKLAHOMA

FREQUENCY	2-YR	2-YR	2-YR	FREQUENCY	25-YR	25-YR	25-YR
STARTING ELEVATION	735.00	740.00	745.00	STARTING ELEVATION	735.00	740.00	745.00
RIVER MILE				RIVER MILE			
142.35	757.79	757.85	758.04	142.35	768.12	768.14	768.19
143.47	758.90	758.95	759.09	143.47	769.67	769.69	769.73
144.02	759.29	759.33	759.47	144.02	770.32	770.33	770.38
144.23	759.47	759.52	759.65	144.23	770.62	770.64	770.68
145.06	760.19	760.23	760.35	145.06	771.48	771.50	771.53

FREQUENCY	5-YR	5-YR	5-YR	FREQUENCY	50-YR	50-YR	50-YR
STARTING ELEVATION	735.00	740.00	745.00	STARTING ELEVATION	735.00	740.00	745.00
RIVER MILE				RIVER MILE			
142.35	761.16	761.19	761.3	142.35	771.64	771.65	771.69
143.47	762.27	762.30	762.38	143.47	773.53	773.53	773.53
144.02	762.70	762.72	762.80	144.02	774.06	774.06	774.06
144.23	762.93	762.95	763.02	144.23	774.45	774.45	774.45
145.06	763.79	763.82	763.88	145.06	775.15	775.15	775.15

FREQUENCY	10-YR	10-YR	10-YR	FREQUENCY	100-YR	100-YR	100-YR
STARTING ELEVATION	735.00	740.00	745.00	STARTING ELEVATION	735.00	740.00	745.00
RIVER MILE				RIVER MILE			
142.35	763.41	763.44	763.52	142.35	775.03	775.03	775.06
143.47	764.56	764.58	764.65	143.47	776.49	776.50	776.52
144.02	765.00	765.02	765.08	144.02	777.02	777.02	777.05
144.23	765.24	765.26	765.32	144.23	777.45	777.45	777.48
145.06	766.17	766.19	766.24	145.06	778.11	778.11	778.13

LAKE OPERATIONS

The Grand River Dam Authority has full control of the reservoir when the lake is in operation below elevation 745.00. When the lake is above elevation 745.00, the U.S. Army Corps of Engineers has the responsibility for operation of the flood control storage in the reservoir in accordance with Section 7 of the Flood Control Act of 1944. The flood control storage is between elevations 745.00 and 755.00.

Because the project is not operated for flood control releases until it has filled to elevation 745.00, past changes by GRDA in hydropower generation operations have had a negligible effect on flood control operations.

SCOPE OF STUDY

The city of Miami, through the city appointed Flood Committee, requested an examination of the backwater effect caused by Grand Lake at Miami. To accomplish this examination, a computer program was utilized to model the Grand River water surface profiles from Grand Lake to Miami. This model was applied to three starting elevations in the Grand Lake pool area: 735.00, 740.00, and 745.00. For each of these starting conditions, profiles were modeled for the 2-, 5-, 10-, 25-, 50-, and 100-year peak flood flows. The results of the study are illustrated in the six graphs, Figures A-3 through A-8. Each graph shows one frequency flood's relationship of water surface elevation to river mile locations along the Grand River. The graphs show three water surface profiles resulting from starting the model at the three lake elevations. Where less than three profiles can be identified, the water surface profiles are identical. The river mile references are shown on Figure A-9.

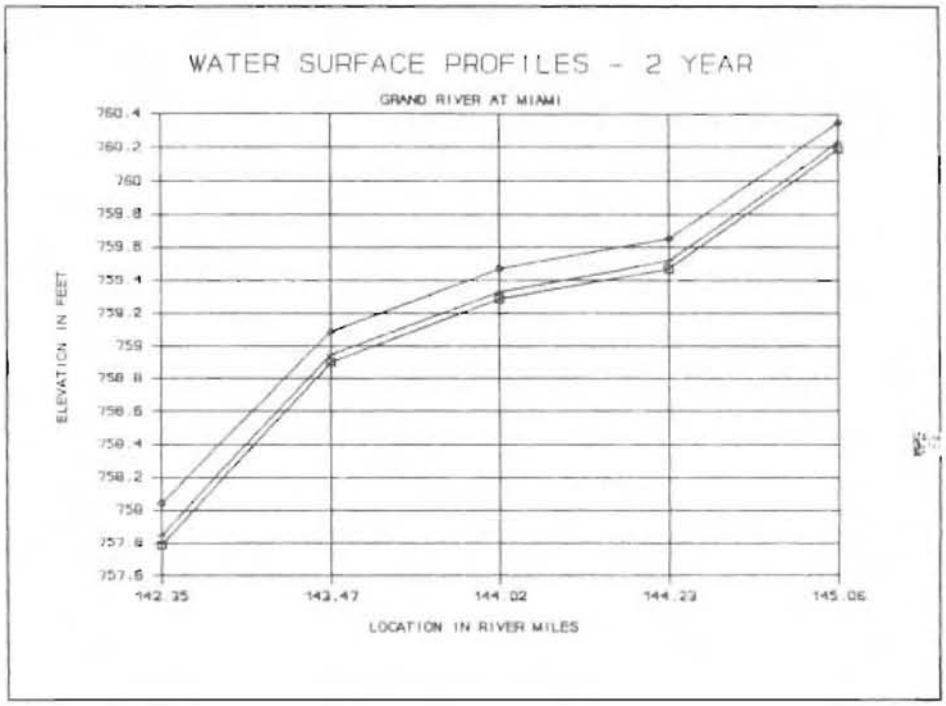


Figure 3

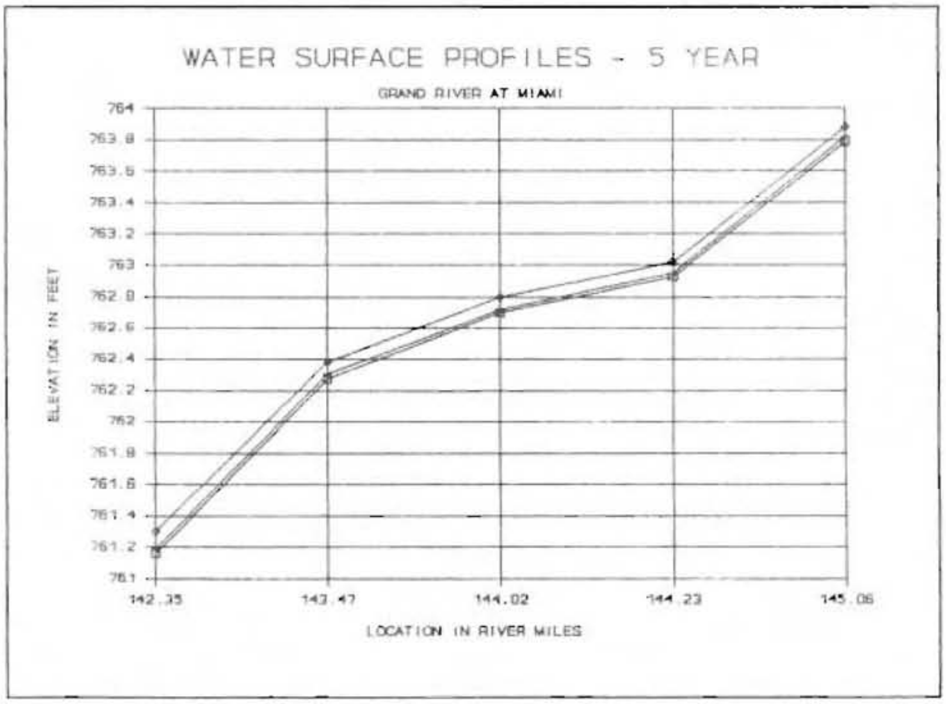


Figure 4

Curves, shown from top to bottom on each graphic, represent the Grand Lake starting conditions of the conservation pool at elevation: 745.00, 740.00, and 735.00.

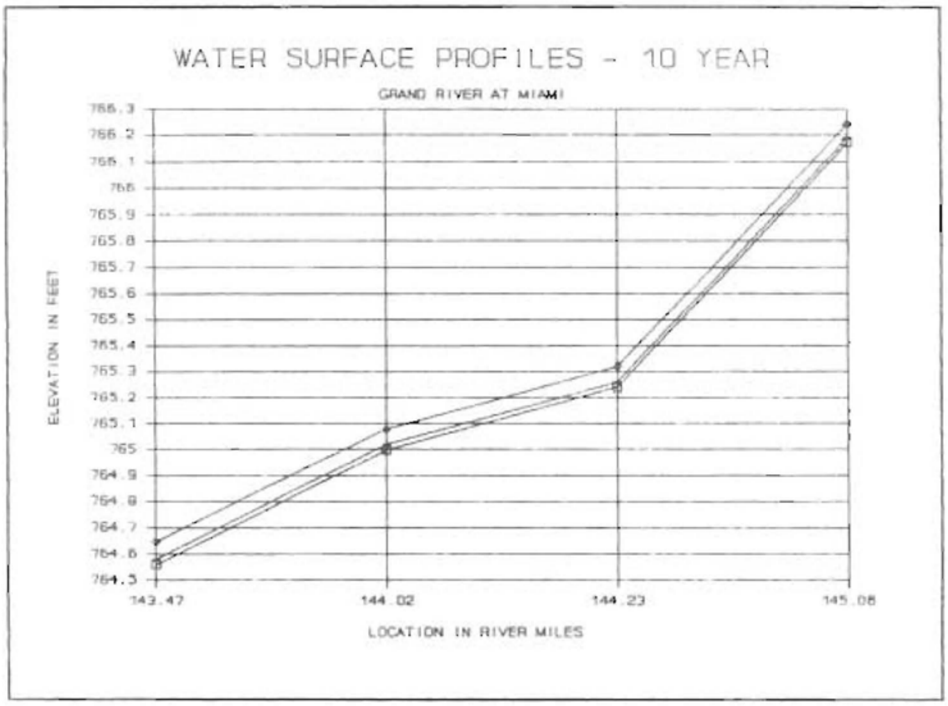


Figure 5

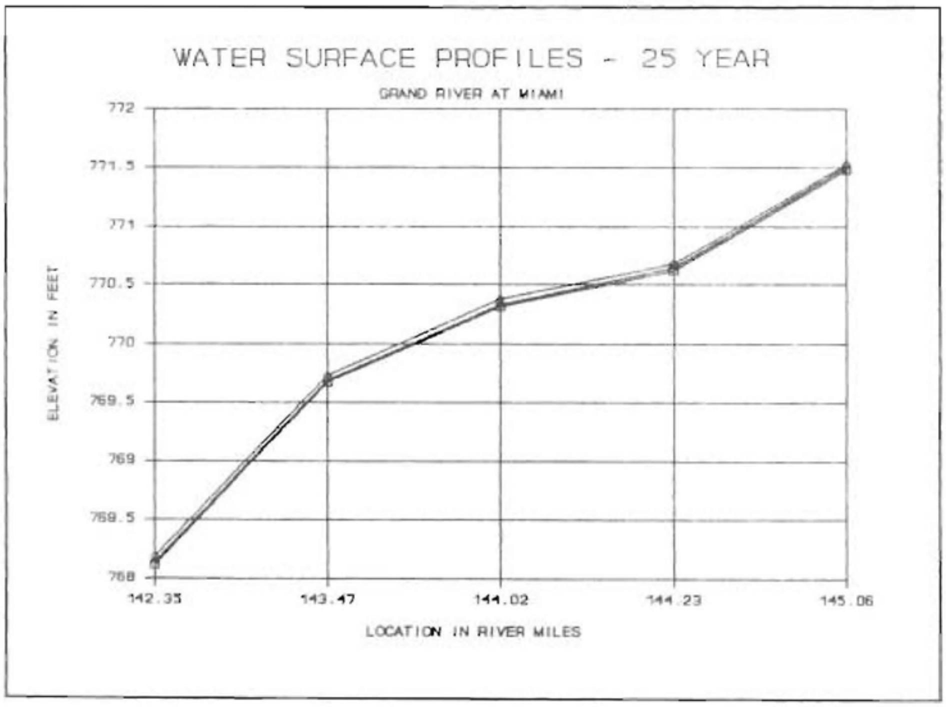


Figure 6

Curves, shown from top to bottom on each graphic, represent the Grand Lake starting conditions of the conservation pool at elevation: 745.00, 740.00, and 735.00.

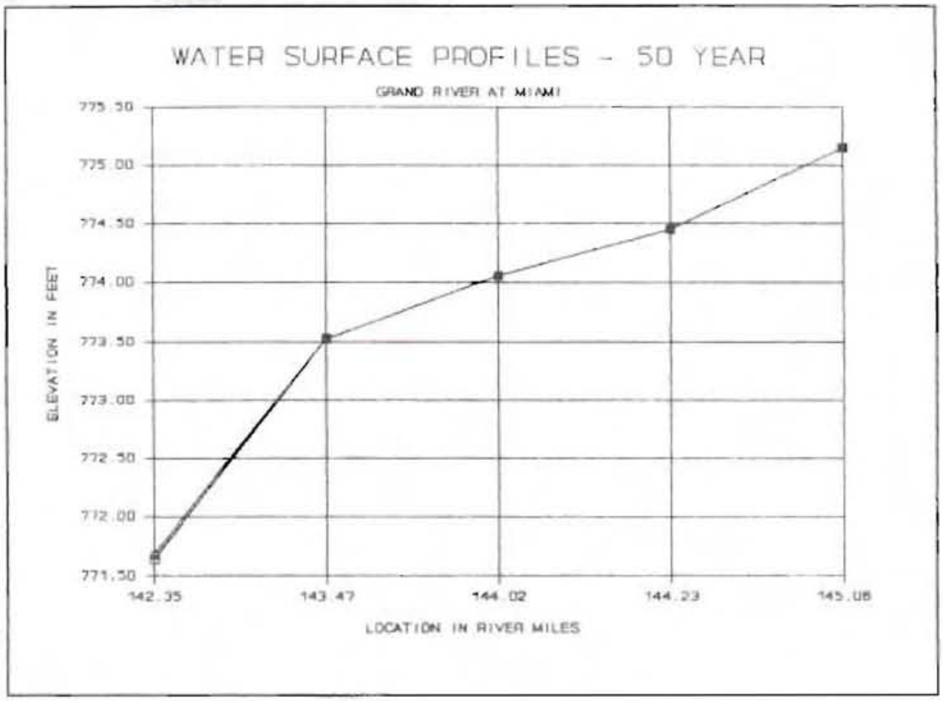


Figure 7

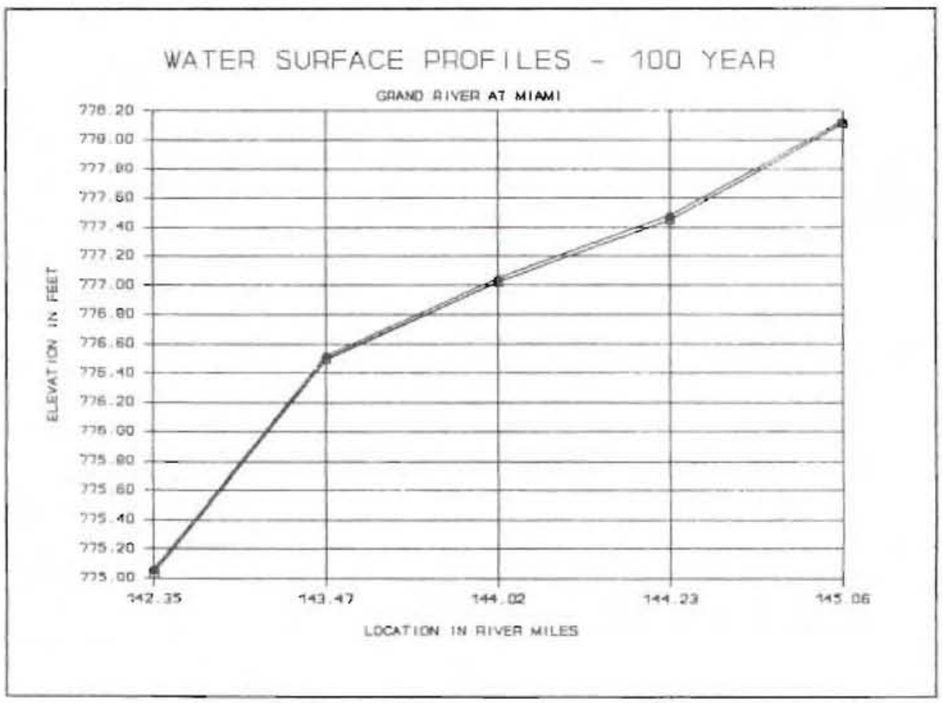
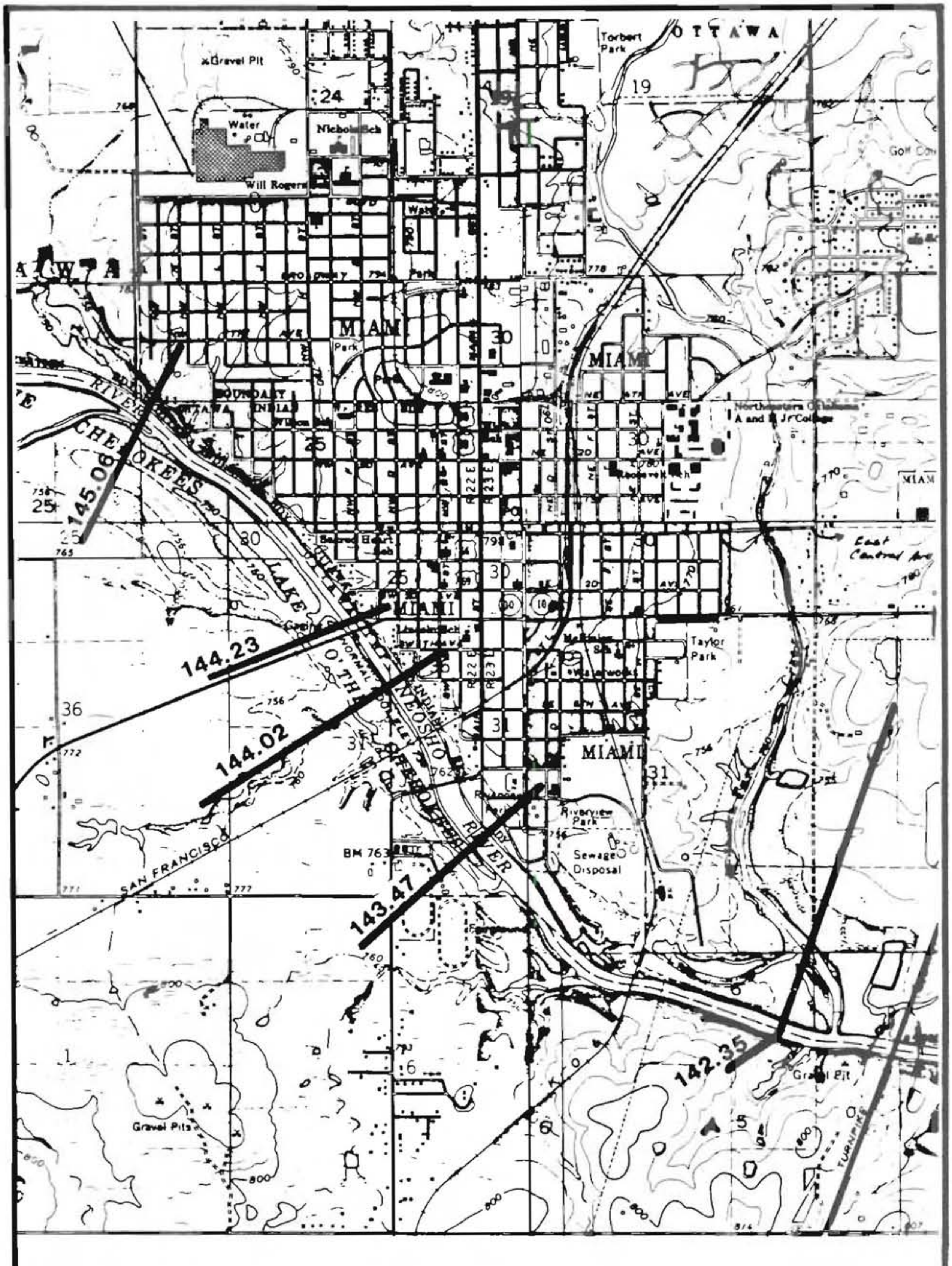


Figure 8

Curves, shown from top to bottom on each graphic, represent the Grand Lake starting conditions of the conservation pool at elevation: 745.00, 740.00, and 735.00.



145.06
144.23
144.02
143.47
142.35
MIAMI
OTTAWA
NEOSHO RIVER
LAKE O' THE CHEROKEES
Will Rogers
Torbert Park
Taylor Park
Riverview Park
Sewage Disposal
Gravel Pit
Gravel Pits
Northeastern Oklahoma A and M Jr College
Sacred Heart Sch
SAN FRANCISCO
TURNPIKE
BM 763

The graphs indicate that the lower flood flows are affected by the pool elevation in Grand Lake; however, these flows would not produce damaging flood stages. The higher flood flows which would produce damaging flood stages are not affected by the Grand Lake starting conditions. While developing the computer model and analyzing the results, it was observed that a potential flood plain restriction exists at the State Highway 60 bridge crossing Grand Lake. The highway crossing has a greater influence on the flood profiles than does the elevation of the lake at or below the conservation pool.

The circumstance of increased flooding caused by starting pool elevations higher than the conservation pool has been projected from previous studies. To model that condition accurately, it would be necessary to conduct dynamic modeling studies rather than the static peak flow models discussed above. The studies to evaluate Miami flood impacts from Grand Lake flood control operations (above the conservation pool) are discussed below.

PROPOSED ADDITIONAL STUDIES

During the background research for the reconnaissance phase studies, information from a 1977 study was reviewed. This study identified a potential inadequacy of Grand Lake flood easements. The easement areas in question involve the major tributaries of Grand Lake, but are concentrated in the Miami area along the Grand River and Tar Creek. As discussed in the main report, the lake has been under the control of several different agencies. After flood control operations of the lake were assigned to the U.S. Army Corps of Engineers in 1944, the adequacy of flood easement acquisitions were examined in 1947 and found to be insufficient. A preliminary planning report was submitted to the Chief of Engineers in 1948 which indicated a need for the acquisition of flowage easements on 11,750 acres of land located above lands and easements previously acquired by the GRDA and the Department of the Interior. Action on the preliminary planning report was deferred until studies of the 1951 flood had been completed and the effects of John Redmond Reservoir could be determined. The backwater effects of the 1951 flood would not have been significant above the land already acquired.

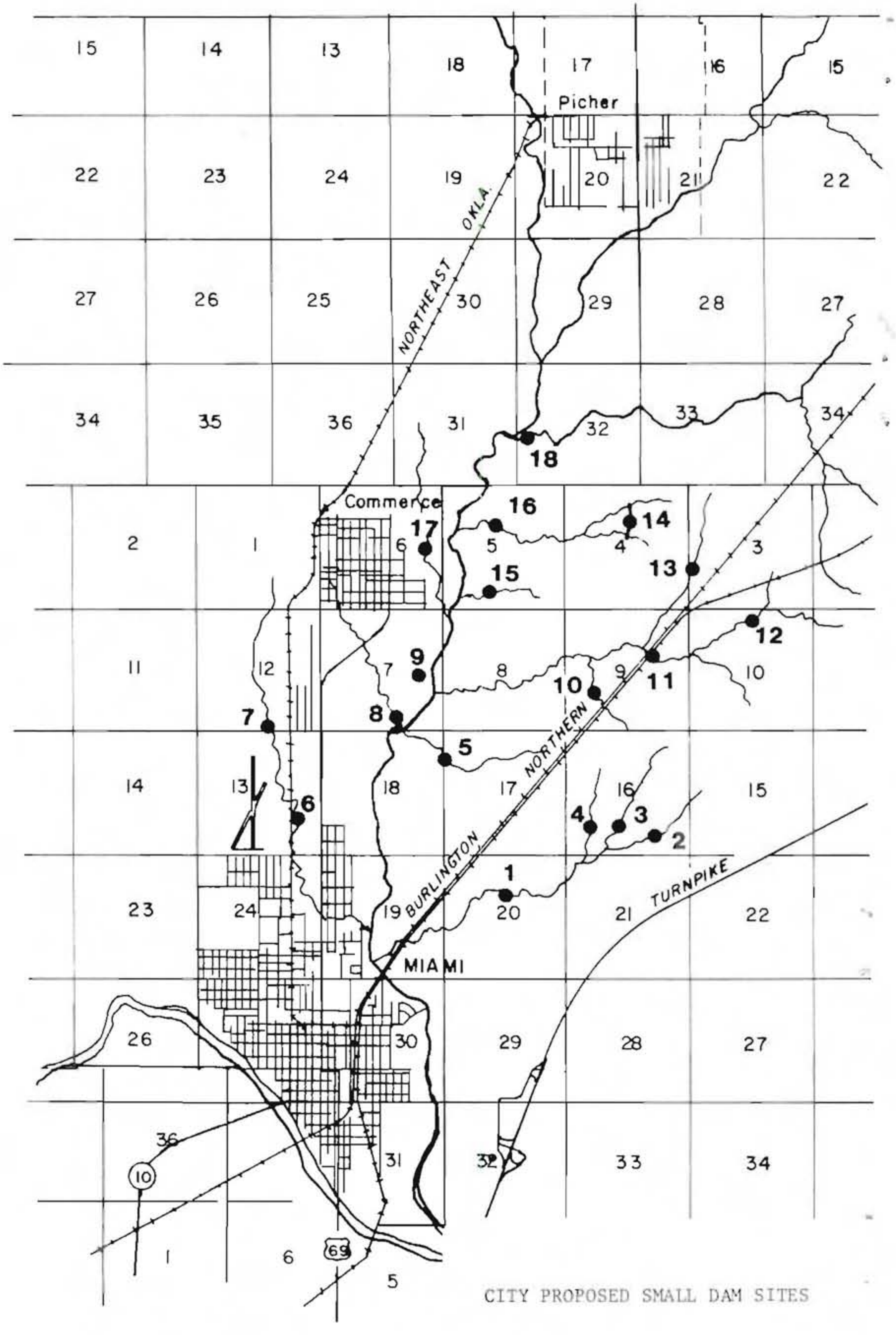
With the advent of recent flooding in Miami, the issue of the adequacy of flood easements has resurfaced. At the September 22, 1987, public meeting in

Miami, the issue was discussed along with the need to determine solutions to continued general flooding. At that time, the level of detail required to conduct the real estate studies necessary to determine acquisition boundaries was known to be significantly greater than the level of detail required to conduct the reconnaissance studies. In addition, the time and expense required to obtain extensive aerial photography and topographic mapping, hydrology and hydraulic modeling, and property ownership mapping would exceed the financial and time constraints of the reconnaissance process. Therefore, at that and subsequent coordination meetings with the city of Miami, the need for two separate studies was presented. The reconnaissance study would focus on existing conditions and formulate solutions to reduce flood damages from the Grand River and Tar Creek. The proposed real estate study would examine the adequacy of existing flood easements and, if necessary, determine an acquisition plan. A request for authority and funds to initiate the real estate study was submitted to the Southwestern Division (SWD) office of the U.S. Army Corps of Engineers for consideration in November 1988. At this time, the request is under consideration.

(Note: All elevations referencing Grand Lake pools are 1.1 feet below the National Geodetic Vertical Datum [the common base for referencing elevation]; the continued use of the erroneous base line information is now a traditional procedure followed, in part, due to references in the Project Document - House Document [HD] 107, 76th Congress, 1st Session.)

ALTERNATE SMALL DAM STUDY

During the early examination of types of measures to be examined to reduce flood damages, the concept of small dry dams was proposed. Initially, four dam sites were proposed during meetings with the city Flood Committee. After initial approval of the sites, design and hydrology contracts were awarded to develop pertinent data and analyze the discharge reduction of the four sites. Subsequent to award of the contracts, the city proposed a collection of 18 smaller dam sites as an alternative. At that point, it would have been impractical to revise the design and hydrology contracts, so the city agreed that the costs and benefits of the 18 sites would be based on the larger four sites. Figure A-10 is shows the location of the 18 dam sites.



CITY PROPOSED SMALL DAM SITES

TABLE A-2

ESTIMATED COSTS AND BENEFITS
(October 1988 Prices, 8-7/8 Percent Amortization)

Dam Site No.	Total Cost	Annual Cost	Benefits	BCR
1	284,500	26,900	9,900	0.4
2	142,100	13,500	1,800	0.1
3	434,800	41,000	2,100	0.0
4	203,700	19,300	900	0.0
5	84,900	8,100	2,600	0.3
6	34,100	3,300		
7	95,900	9,100		
8	159,300	15,100	2,400	0.2
9	207,700	19,700	1,300	0.1
10	102,000	9,700	700	0.1
11	255,300	24,100	9,800	0.4
12	102,200	9,700	3,600	0.4
13	215,200	20,400	2,300	0.1
14	536,800	50,700	3,400	0.1
15	152,500	14,500	1,300	0.1
16	110,300	10,500	8,400	0.8
17	220,800	20,900	4,900	0.2
18	621,200	58,600	59,600	1.0

The only site for which annual benefits exceeded costs was site #18. A brief sensitivity analysis was conducted to determine how variations in the site's design would potentially affect the project's cost. It was found that a 5-foot increase in dam height would double the project cost. Only one other site, #16, indicated economic potential. That site was found to have a benefit-to-cost ratio of 0.8.

A basis for Federal interest in development of small dams was not demonstrated. No further study of small dams is recommended.