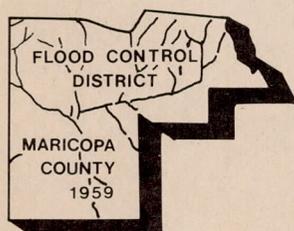


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AGUA FRIA RIVER STUDY - 1982



Prepared for the

Flood Control District of Maricopa County, Arizona Final Report

Contract FCD 81-2



WILLDAN ASSOCIATES
ENGINEERS, ARCHITECTS & PLANNERS

AGUA FRIA RIVER STUDY
MARICOPA COUNTY, ARIZONA

May 1982

Prepared For
The Flood Control District of Maricopa County
by
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FORWARD

This publication is an Executive Summary of the Agua Fria River Study. Those parts of the study which do not relate directly to the flood control aspects of the study have been omitted to produce a document of convenient and relevant volume that will respond to the needs of nearly everyone interested in the report.

The omitted parts are as follows:

Text -	Natural Environment	Pages 10-30
Tables -	Tables 2 through 4	Pages 15-21, and 31
Plates -	Plates 4 through 7	Pages 12- 14, 27, and 32
Appendix -	Appendix A (Published Under Separate Cover)	
Maps -	Maps 1 through 14	

The omitted parts may be reviewed at the office of the Flood Control District of Maricopa County

PREFACE

In accordance with contract FCD 81-2 of the Flood Control District of Maricopa County, Arizona, Willdan Associates has been requested to inventory existing conditions along the Agua Fria River from the Beardsley Flume to the confluence with the Gila River and seek feasible solutions to the flooding problems associated with the Agua Fria in this reach of the river.

PROJECT FUNDING

Projects developed from recommendations of this study will be funded by the Flood Control District of Maricopa County. The State of Arizona will be requested to share up to fifty percent of the project costs through the State's authorized Alternate Flood Control Assistance Program. Features of recommended projects which overlap approved Federal projects may be partially funded with Federal monies; however, it is anticipated that local and State revenues will be used primarily.

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INTRODUCTION

This report covers a 29-mile stretch of the Agua Fria River, in Maricopa County, located west and northwest of Phoenix, Arizona. The study area has been divided into five reaches owing to its length and the diverse nature of existing conditions. The study area includes all of the land that would be inundated by a 100-year flood. The five reaches are as follows:

- Reach 1** Beardsley Canal Flume, the northern boundary of the study, to Bell Road, a length of approximately 10.2 miles.

- Reach 2** Bell Road to Northern Avenue, a length of approximately 6.2 miles.

- Reach 3** Northern Avenue to Indian School Road, a length of approximately 5 miles.

- Reach 4** Indian School Road to State Route 85 (Buckeye Road), a length of approximately 4.4 miles.

- Reach 5** State Route 85 (Buckeye Road) to the confluence with the Gila River, about 10 miles west of Phoenix, Arizona, a length of approximately 3.4 miles.

The elevation at the Beardsley Canal Flume, the northern boundary of the study, is 1330 feet above mean sea level (msl) and the elevation at the confluence with the Gila River, the southern boundary of the study, is 925 feet above msl. The total

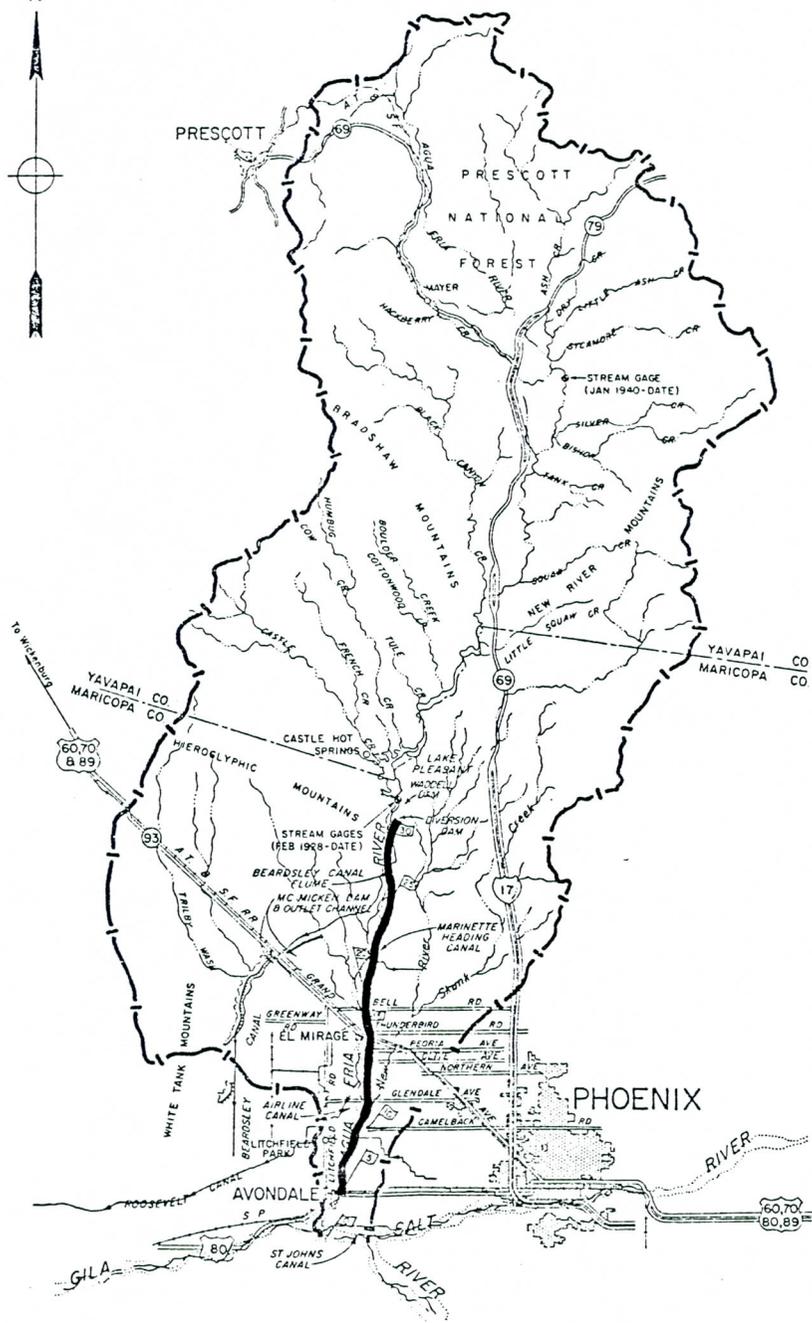
fall for the 29-mile study reach is about 415 feet, an average fall of about 14 feet per mile.

DESCRIPTION OF THE DRAINAGE AREA

The Agua Fria River watershed drains an area of approximately 2340 square miles, most of which lies in Yavapai County, Arizona (see Plate 1). Of this total area, 1650 square miles (approximately 70 percent) of the watershed lie above the New River confluence, and 1,460 square miles (approximately 62 percent) lie above Waddell Dam.

The Agua Fria River begins at the south base of Mingus Mountain in the Prescott National Forest located in Central Arizona and flows southward for approximately 130 miles to its confluence with the Gila River. The New River Mountains and the Bradshaw Mountains form the eastern and western boundaries, respectively, of the drainage area. The total fall in the Agua Fria River, from its headwaters (elevation about 7000 feet msl) to the upper limits of this report, the Beardsley Flume (elevation 1330 feet msl), is about 5670 feet. The river's slope ranges from about 300 feet per mile in the headwaters to about 14 feet per mile at the Gila River.

The 29-mile stretch of the river covered by this study runs through both rural and urban areas. Urban development is rapidly increasing in several areas adjacent to the river, particularly Avondale, Litchfield Park, and Sun City West. Communities near the river that are encroaching upon the floodplain include Surprise, El Mirage, Sun City, Youngtown, Peoria, Glendale, Litchfield Park, Cashion, and Avondale. Currently, agriculture, vacant land, and sand and gravel operations represent the major land uses along the Agua Fria's floodplain.



— REACH COVERED BY THIS REPORT
[5] MILES ABOVE MOUTH OF RIVER

PLATE I

AGUA FRIA RIVER WATERSHED



INTRODUCTION

Recent flooding of the Agua Fria River has warranted a re-evaluation of this watercourse as urban growth in western Maricopa County approaches the river. An assessment of social, economic, and environmental conditions has been undertaken in order that potential impacts of the various flood control alternatives, both direct and indirect, may be evaluated.

EXISTING AND PROPOSED FACTORS AFFECTING FLOODING

Waddell Dam, located about 34 miles upstream of the Gila River confluence, was completed in 1927 (see Plate 2). The dam is under the jurisdiction of the Maricopa County Municipal Water Conservation District No. 1, and its primary purpose is water conservation. In reference to the U.S. Army Corps of Engineers Report Agua Fria River Hydrology (April 1981), if sufficient water is available, the normal water surface lies at the top of the closed spillway gates (gage height 170). If the reservoir is full to normal water surface when a large storm occurs, releases would be made such that the outflow would approximate inflow until the spillway gates are fully open. Larger outflows would then be governed by the spillway rating. Pertinent characteristics of the dam are shown on Plate 2, and the elevation, storage, and outflow relationships used in this study are given in Table 1.

New River, a major tributary to the Agua Fria River, drains an area of approximately 350 square miles. New River originates near Cook's Mesa in the New River Mountains and flows southwesterly for approximately 40 miles to its confluence with the Agua Fria River between Bethany Home Road and Camelback Road. The proposed Arizona Canal Diversion Channel (ACDC) will expand the New River watershed by diverting flows from parts of the Cave Creek and Dreamy Draw watersheds to Skunk Creek and thence to New River. Four dams in the expanded New River Watershed (three completed and one pending completion) will regulate large flows normally reaching the Agua Fria River from the New River, and are designed to compensate for the diversion of flow by the

GAGE
HEIGHT

178.7'

175.7'

170.0'

154.0'

146.0'

TOP OF SPILLWAY DECK

175,000 AC-FT
TOP OF DAM

157,600 AC-FT
TOP OF CLOSED GATES

86,870 AC-FT
UPPER SPILLWAY CREST

LOWER SPILLWAY CREST
CAPACITY AT 170' = 155,000 CFS
(SECTOR GATE ASSUMED OPERABLE)

OUTLET WORKS
CAPACITY = 880 CFS



WADDELL DAM

PLATE 2

EMBANKMENT PROFILE
WADDELL DAM

U. S. ARMY ENGINEER DISTRICT
LOS ANGELES, CORPS OF ENGINEERS

TABLE I
 ELEVATION-STORAGE-OUTFLOW RELATIONSHIPS¹
 WADDELL DAM²

Gage Height (feet)	Storage ³ (acre-feet)	Spillway Flow Rate ⁴ (cubic feet per second)
170	157,600	155,000
172	163,000	180,000
174	169,000	205,000
175.67	175,000	225,000

¹Source: U.S. Army Corps of Engineers

²See Plate I.

³July 1965 Survey.

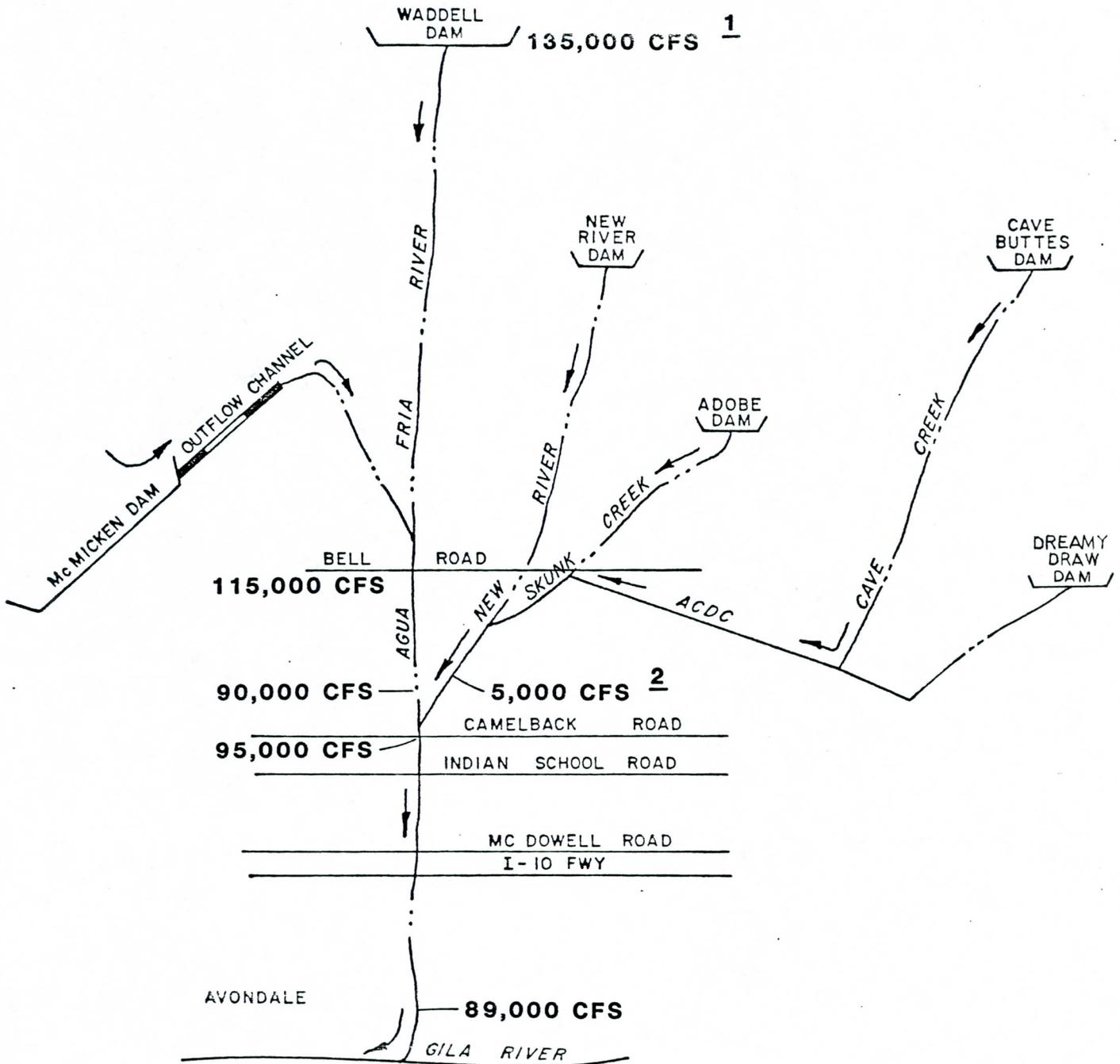
⁴Drawing No. 1507. (Corps of Engineers)

Arizona Canal Diversion Channel. The four dams, their status and their maximum design outflows are listed below (see Plate 3):

Name	Status	Maximum Design Outflow (cubic feet per second)
Dreamy Draw Dam	Completed	220
Cave Buttes Dam	Completed	486
Adobe Dam	Completed	1890
New River Dam	Scheduled for construction beginning in January 1983; completion set for mid-1984	2665

McMicken Dam, which controls the runoff from about 240 square miles of Trilby Wash watershed, is located at the northeast base of the White Tank Mountains about 25 miles northwest of Phoenix. The dam, completed in 1956, was constructed by the U.S. Army Corps of Engineers as a flood control dam. The reservoir capacity at the spillway crest was approximately 19,300 acre-feet when the dam was constructed, and maximum design outflow is about 4450 cubic feet per second (cfs).

The proposed Interstate 10 (I-10) collector channel is the southernmost major structure contributing to flows in the Agua Fria. Planned for a location immediately north of and parallel to the proposed freeway, the channel will deliver flood flows from 27th Avenue to the Agua Fria River, draining an urbanized area of about 45 square miles with a maximum design outflow of about 9300 cubic feet per second (peak flow-100 year flood). This outflow will not, however, contribute significantly to the large peak flows in the Agua Fria River since runoff from this 45-square-mile watershed will normally have emptied into the Agua Fria several hours before its mainstream peak discharge arrives.



- 1 FLOWS SHOWN ARE FOR A 100 YEAR FLOOD
- 2 FLOW SHOWN IS CONTRIBUTION TO PEAK FLOW DURING A 100 YEAR FLOOD

Source:
U.S. Army Corps of Engineers

AGUA FRIA RIVER
SCHEMATIC FLOW
DIAGRAM
PLATE 3

Several other smaller drainage channels empty into the Agua Fria River. These channels are considered to have a negligible effect on the peak discharge of the Agua Fria since they will have normally drained well before the peak discharge of the mainstream arrives.

The contributing drainage area below Waddell Dam is assumed to be fully urbanized for future conditions.

HISTORY OF FLOODING

Information about the history of flooding along the Agua Fria River was taken from the following sources:

1. Floodplain Information, Agua Fria River, Maricopa County, Arizona, prepared by the Corps of Engineers, Los Angeles District, California, March 1968;
2. Preliminary Draft Report, prepared by B. N. Aldridge, USGS, May 1980;
3. Agua Fria River Below Waddell Dam, prepared by the Corps of Engineers, Los Angeles District, California, 1981; and
4. Phoenix City Streams, Arizona, Agua Fria River, Hydrology, prepared by the Corps of Engineers, Los Angeles District, California, April 1981.

Floods have been recorded along the Agua Fria River since 1889. The two greatest reported floods on the Agua Fria occurred in January of 1916 and in November of 1919, both with estimated flow of 105,000 cubic feet per second (cfs). Records indicate seven floods with flows between 50,000 and 100,000 cfs, five floods with flows between 30,000 and 50,000 cfs, six floods with flows between 10,000 and 30,000 cfs, and several additional floods with unsubstantial flows.

TABLE 5
FLOOD DATES AND ESTIMATED DISCHARGES

Date	Estimated discharge (cfs)	Approximate Location
1889, March	Unknown	
1890, February 20-23	Unknown	
1891, February 19	80,000	Castle Hot Springs
1895, January	Unknown	
1905, March	Unknown	
1905, November	Unknown	
1906, March	Unknown	
1907, March 6	Unknown	
1911, February	Unknown	
1912	28,450	Above Lake Pleasant
1915, January 29	60,000	Above Lake Pleasant Site
1916, January 19	45,000	Near Lake Pleasant Site
1916, January 27	105,000	Near Lake Pleasant Site
1917, April 18	26,000	Near Lake Pleasant Site
1917, July 27	80,000	Near Lake Pleasant Site
1918, August 6	39,600	Near Lake Pleasant Site
1919, September 8	53,500	Near Lake Pleasant Site
1919, November 27	105,000	Near Lake Pleasant Site
1920, February 22	30,000	Near Lake Pleasant Site
1922, January 3	25,000	Near Lake Pleasant Site
1922, September 2	60,000	Near Lake Pleasant Site
1923	26,300	Near Lake Pleasant Site
1923, December 27	39,000	Near Lake Pleasant Site
1925, September 19	18,600	Near Lake Pleasant Site
1927, February, Waddell Dam completed	62,000	Above Lake Pleasant
1931, February 13	Unknown	
1941, March 15	11,000	In flow at Lake Pleasant
1943, August 3	Unknown	
1951, August 27	23,144	In flow at Lake Pleasant
1964, July 30	1,200	Out flow at Waddell Dam
1965, April 4	460	Out flow at Waddell Dam
1965, December 23	800	Out flow at Waddell Dam
1967, December 12	20,000	Out flow at Waddell Dam
1970, August 6	20,600	Out flow at Waddell Dam
1971, August 21	8,200	Out flow at Waddell Dam
1972, July 17	5,180	Out flow at Waddell Dam
1972, October 7	5,000	Out flow at Waddell Dam
1978, March 2	13,100	Out flow at Waddell Dam
1978, December 19	60,000	Out flow at Waddell Dam
1980, February 20	66,600	Out flow at Waddell Dam

Source: U.S. Army Corps of Engineers Reports dated as follows:
 1889 through 1964, except 1912 and 1923 - March, 1968
 1912 and 1923 - March, 1981
 1912 and 1923 - March, 1981
 1965 through 1980 - April 1981

HISTORY OF FLOODING

A list of flood dates and estimated flows is shown in Table 5. It should be noted, however, that a complete record of flows in the Agua Fria River does not exist. The information used in formulating the flows as shown are from records of the gaging stations at Waddell Dam, the gaging station at Mayer, newspaper files, historical documents and records and field investigations.

The duration of floods depends upon the type of storms that occur. Flood stages can rise from the riverbed to uppermost flood crests in less than 8 hours following an intense local thunderstorm, whereas it may take as long as 36 hours for flood stages to crest during and after winter or summer storms.

The "100-Year Flood" is defined as having an average frequency of occurrence of once in 100 years, at a designated location, although it may occur in any year. Table 6 lists the 100-year flood peak flows at several locations along the Agua Fria River. These determinations indicate that the 100-year flood would create depths ranging from about 8 to 25 feet in the channel. Velocities in the channel during 100-year floods would range from about 4 to 20 feet per second, and velocities on the floodplain would range from about 2 to 10 feet per second.

The "Standard Project Flood" (SPF) represents the flood that would result from the most severe combination of meteorologic and hydrologic conditions considered reasonably characteristic of the region. The SPF normally is larger than any past recorded flood in the area, and can be expected to be exceeded in magnitude only on rare occasions. The first column of Table 6 lists the SPF peak flows at several locations along the Agua Fria River. Determinations of SPF flows on the Agua Fria River indicate that the Standard Project Flood would create depths ranging

TABLE 6

ESTIMATED PEAK DISCHARGE

Location Along the Agua Fria River	Peak Discharge (cubic feet per second)					
	SPF	500-Year Flood	100-Year Flood	50-Year Flood	25-Year Flood	10-Year Flood
Inflow - Waddell Dam	158,000	190,000	135,000	110,000	90,000	60,000
Outflow - Waddell Dam	158,000	182,000	135,000	110,000	90,000	60,000
Bell Road	151,000	182,000	115,000	87,000	60,000	37,000
U/S New River Confluence	135,000	177,000	90,000	66,000	48,000	30,000
D/S New River Confluence	142,000	184,000	95,000	69,000	50,000	32,000
Camelback Road	142,000	184,000	95,000	69,000	50,000	31,000
Indian School Road	140,000	183,000	94,000	69,000	49,000	30,000
McDowell Road	137,000	182,000	91,000	68,000	48,000	29,000
I-10 Freeway	135,000	181,000	91,000	68,000	48,000	29,000
Avondale	131,000	179,000	90,000	67,000	47,000	28,000
Gila River	130,000	179,000	89,000	67,000	47,000	27,000

Source: U.S. Army Corps of Engineers, Los Angeles, Hydrology Agua Fria 1981

HISTORY OF FLOODING

from about 8 to 27 feet in the channel. Velocities in the channel during the Standard Project Flood would range from about 5 to 22 feet per second, and velocities in the floodplain would range from about 3 to 10 feet per second.

It should be noted here that velocities greater than 5 feet per second combined with depths of 3 feet or greater are generally considered hazardous to life and property.

Historical documents and records have indicated several floods along the Agua Fria River as far back as 1889. Waddell Dam was constructed in 1927 to create a storage reservoir for the Maricopa County Water Conservation District No. 1. Since 1927, there have been four floods of substantial size along on the Agua Fria, recorded in December 1967, August 1970, December 1978, and February 1980. Of these, the two most recent floods had the greatest magnitudes. Flood damages incurred as a result of the 1978 and 1980 floods are summarized in Table 7. Figures include physical damage, income losses, and emergency costs.

TABLE 7
SUMMARY OF FLOOD DAMAGES BY LAND USE

Land Use	Flood Damages	
	December 1978	February 1980
Agricultural	\$ 355,000	1,542,000 ¹
Commercial	435,000	31,000
Industrial Sand and Gravel	1,277,000	62,000
Industrial & Commercial Income Losses		239,000
Industrial & Commercial Emergency Costs		192,000
Public Roads and Bridges	1,999,000	4,244,000 ²
Public Utilities	280,000	1,037,000
Other	263,000	16,000
Residential	<u>880,000</u>	<u>248,000</u>
TOTALS	\$ 5,489,000	\$ 7,611,000

¹ Includes emergency costs of \$39,000.

² Includes emergency costs of \$2,000

Source: U.S. Army Corps of Engineers

SOCIAL ENVIRONMENT

POPULATION

The population of the greater Phoenix area has been steadily increasing for many years and is expected to continue indefinitely. Most of the communities located along the Agua Fria River are experiencing an appreciable amount of urban growth, as reflected in Table 8. Factors contributing to this growth include natural increases, migration, and favorable climate.

Several of these communities are expanding near the floodplain of the Agua Fria River and control of future flooding along the river has become a growing concern of the affected jurisdictions. Flood control measures for the river will become even more critical as development activity near the river increases.

The majority of people near the river reside in the previously mentioned communities. In addition, a major concentration of people is found at Luke Air Force Base. Population densities for these communities average ten or more persons per acre, with densities for the rest of the study area less than ten persons per acre. A 1977 consumer survey reports the median age for the greater Phoenix area as 27.1 years, with over 49 percent of the population between the ages of 16 and 64 years.

TABLE 8
FUTURE POPULATION DISTRIBUTION FOR
COMMUNITIES ADJACENT TO THE AGUA FRIA RIVER

Community	1975	1980	1985	1990	1995	2000
Avondale	11,405	12,000	14,400	24,800	30,000	39,600
Cashion*		2,296*				
El Mirage	3,827	3,950	6,000	7,600	10,100	12,900
Glendale	71,292	92,000	105,900	123,900	139,500	170,700
Litchfield Park*		3,529*				
Luke Air Force Base*		4,398*				
Peoria	13,527	17,900	23,000	40,300	54,500	73,900
Phoenix	699,006	791,000	830,700	900,000	985,300	1,093,000
Sun City*		40,149*				
Sun City West*		3,388*				
Surprise	3,400	3,450	3,700	4,700	5,900	7,000
Youngtown	2,000	2,000	2,000	2,000	2,100	2,200

*Arizona Department of Economic Security, Preliminary 1980 Census Estimates.

Sources: Maricopa Association of Governments, Guide for Regional Development and Transportation, July 23, 1980.

EMPLOYMENT

Much of Maricopa County is experiencing a decrease in agriculture and mining employment as urbanization continues to expand. Employment trends reveal an increase in jobs which relate to services, wholesale-retail trade industries, construction, and manufacturing. Luke Air Force Base accounts for several thousand government employees. Major employment categories common to the Agua Fria River area are indicated in the following section, "Economy."

An increase in nonagricultural employment and a concomitant decline in agricultural employment result in part from the rapid urbanization of the area. Tourism, retirement, industry, and trade continue to provide a base for growth in Maricopa County and the study area.

ECONOMY

Currently, Maricopa County's economy is primarily based upon agriculture, manufacturing, tourism, and retirement. Three principal factors for urban growth in Maricopa County have been: (1) the natural increases in population, (2) the migration to the southwest, and (3) the growth of defense and aerospace industries. Agriculture has declined in relative importance in the area, in terms of both employment and value of production. Manufacturing, led by the electronics industry, has made steady gains in the Salt River Valley. These trends are expected to continue as urbanization expands.

For those communities along the Agua Fria River area, miscellaneous services constitutes the major economic activity. Wholesale-retail trade, construction,

manufacturing, government, and agriculture also represent significant employment categories. Growth ratios for all sectors of the economy are expected to approach the national average as the local economy matures.

LAND USE

Agriculture represents the predominant land use in the study area, with vacant land/open space accounting for a majority of the remaining area. Some residential uses are found next to the river, primarily in the Sun City, Youngtown and Avondale areas. Approximately eleven sand and gravel operations occupy the floodplain as industrial uses.

Future land use is not expected to change very much over the short term, except for the southernmost region of the study area. Agriculture will eventually be replaced by urban development as Maricopa County continues to grow. The Maricopa County Association of Governments' Guide for Regional Development and Transportation predicts that by the year 2000, nearly all land east of the Agua Fria will be urbanized, along with most of the land adjacent to and west of the river.

Land ownership for the Agua Fria area varies from primarily public (approximately 50 percent of which is State Trust Land) along the northern third, to predominantly private along the lower two-thirds of the study area. The Agua Fria floodplain has numerous owners, both public and private. Land ownership patterns for this area have changed slowly over the past years, a pattern not expected to endure as urban development approaches the river.

CULTURAL RESOURCES

ARCHAEOLOGICAL RESOURCES

The Phoenix metropolitan area was a major population center during prehistoric times and contains abundant archaeological remains. The earliest sites in the general southern Arizona area belong to the Paleo-Indian or big game hunting tradition, dating between approximately 10,000-6,000 B.C. Local variants of the archaic tradition replaced the Paleo-Indian tradition during the period between approximately 6,000 B.C. - A.D.I. This tradition was represented by small groups of transient hunter-gatherers who utilized a wide variety of plant and animal resources. Appearing around 300 B.C., the Hohokam tradition represents the principal cultural complex within the greater Phoenix area, one of sedentary village dwellers practicing irrigation agriculture.

During the summer of 1976, a regional archaeological overview was prepared by the Office of Cultural Resources Management, Department of Anthropology, Arizona State University for the U.S. Army Corps of Engineers' Phoenix Urban Study. Archaeological sensitivity was mapped as a product of this overview based on the overall density and quality of the archaeological resources known and/or expected to exist within the study area. A systematic field survey has never been conducted along the entire lower reach of the Agua Fria River. The Agua Fria River floodplain was rated as being moderately sensitive from the Agua-Fria/Gila confluence up to the Calderwood Butte area, very highly sensitive in the Calderwood Butte area, and highly sensitive between Calderwood Butte and Lake Pleasant. These sensitivity ratings represent generalizations and serve to alert

CULTURAL RESOURCES

planners and developers to potential problem areas. In the event that a flood control project is proposed, areas subject to disturbance would require a field survey and mitigation would be required if significant resources were discovered.

HISTORICAL RESOURCES

Historical resources for the greater Phoenix area were also inventoried for the U.S. Army Corps of Engineers during 1976. A baseline inventory of historical resources was developed by the State Historic Preservation Office of the State Parks Board. The inventory's purpose was to enable the Corps of Engineers to take architecturally, culturally, and/or historically "sensitive areas" under consideration in planning future project locations.

The focus of this regional overview is the period from 1865 to 1930. During the Hispanic Period (1539-1821) and the Mexican Period (1821-1848), explorers may have passed through the Salt River Valley, but no known associated locations or trails have been identified. From 1848, when the land within the study area became part of the United States, until 1865, no Anglo American activities occurred which have left tangible recordable traces. Regional history ends at 1930 because historical resources are generally required to be at least 50 years old to be included in the National Register of Historic Places.

A "sensitivity" map was prepared for historical resources, and, like the archaeological resources sensitivity map, was based on existing records, with the exception of eight areas which were field investigated. These eight areas, none of which lie in the Agua Fria River study area, were determined to be of a more immediate

CULTURAL RESOURCES

concern in terms of their historical importance or because of proposed future impact to the area.

With the exception of an area between Van Buren Street and Buckeye Road that has been field investigated, the Agua Fria River area was evaluated based on a records search. The entire study area was rated as having a low sensitivity. In the event that a flood control project is proposed, areas subject to disturbance would require a field survey and mitigation would be necessary if significant resources were discovered.

MAN-MADE ENVIRONMENT

PUBLIC UTILITIES

Electricity and natural gas are provided to the study area by Arizona Public Service or Salt River Project, depending upon the particular location. Several transmission line corridors traverse the Agua Fria River at various points. In addition, some electric transmission line corridor links parallel the river, many of which are located within the floodplain. Water distribution for purposes other than irrigation is provided by several certified companies. Several different methods of sewage disposal are exercised by the various communities adjacent to the Agua Fria River, from individual septic tanks to sewage treatment plants. Three methods of solid waste disposal are used throughout the study area, sanitary landfills, landfills, and dumps. The City of Glendale operates a sanitary landfill in the general area, which is used by several other communities. Telephone service is provided to the study area by Mountain Bell.

TRANSPORTATION

Transportation is a vital part in the overall regional and community development process. Two state highways and numerous county roads provide access to and from the Agua Fria area.

The two state highways that pass through the area are essentially east-west routes. Grand Avenue (which serves as U.S. Highway Routes 60 and 89, or State Highway 93) passes through the communities of Peoria, Sun City, Youngtown, El

MAN-MADE ENVIRONMENT

Mirage, and Surprise. It is a wide, paved two-lane highway, except in Sun City where it is four lanes. State Route 85 is the other state highway, dissecting the southern part of the study area. This highway passes through or next to the communities of Cashion, Avondale, and Goodyear. It is also a wide, two-lane road except in Avondale where it is four lanes.

County maintained roads provide most of the direct access to land surrounding the Agua Fria area, with the following exceptions:

- 1) roads within municipalities that are maintained by their respective governments;
- 2) roads that have been dedicated for public use but are unacceptable because they do not meet county road construction standards;
- 3) private roads, such as irrigation canal maintenance roads.

Most of the principal county roads are located on the section lines established by the U.S. Geological Survey. Section line roads continually change from collectors to arterials or major roads depending on the nature and extent of development in the surrounding area.

When the Agua Fria River is dry, it can be crossed at several points: Jomax Road, Rose Garden Lane, State Route 74 (Carefree Highway), Bell Road, Grand Avenue, Olive Avenue, Northern Avenue, Glendale Avenue, Camelback Avenue, Indian School Road, McDowell Road, Van Buren Street, State Route 85, and Lower Buckeye Road. All of these river crossings currently exist as dip crossings except for State Route 74, Bell Road, Grand Avenue, Glendale Avenue, and State Route 85, where there are bridges. The Bell Road and Indian School Road bridges were damaged beyond use by flooding in February of 1980. The Bell Road bridge was reopened in Summer 1981 and plans are being prepared to replace the Indian School Road bridge.

MAN-MADE ENVIRONMENT

Probably the most influential transportation factor to affect urban development in the Agua Fria area will be the continuation of Interstate 10 from its present ending point at Dysart Road east to central Phoenix. Freeway construction tends to stimulate urban development as well as stimulate the local economy by presenting commercial and industrial opportunities near the freeway. Other freeway construction has proven that freeways have a dramatic short-term effect on the timing of development and may alter the long-range pattern of development.

Phoenix Sky Harbor International Airport provides the only scheduled air service for the greater Phoenix area. The only general aviation facility in the Agua Fria area is Phoenix-Litchfield Municipal Airport, owned and operated by the City of Phoenix. Fram Field and a couple of crop dusting facilities are privately-owned airfields in the area. Local passenger and freight service by bus is provided along the two state highways that traverse the study area. The Santa Fe Railroad passes through the northern part of the study area and the Southern Pacific Transportation Company through the southern end, both providing freight service to the study area. The City of Glendale has proposed a new municipal airport south of Glendale Avenue at the confluence of the Agua Fria River and the New River.

AIR QUALITY

Air pollutants causing some concern within the greater Phoenix area are carbon monoxide, ozone, and particulates. The Agua Fria River passes through the Maricopa County Urban Planning Area, which has been designated a nonattainment area for carbon monoxide, ozone, and total suspended particulates. These three pollutants have exceeded the maximum allowable level as established in the National Ambient Air Quality Standards defined by the U.S. Environmental

MAN-MADE ENVIRONMENT

Protection Agency. Since the Agua Fria River is located within the non-attainment area, current and future development must abide by any rules and regulations designed to aid in eventual attainment. Nonattainment plans have been completed which reveal that carbon monoxide and ozone violations are limited primarily to central Phoenix, while particulate levels are in violation throughout the Maricopa County Urban Planning Area.

Maricopa County Environmental Health Services does not restrict development of indirect pollutant sources. Most types of construction will result in an increase of particulates in the affected area, but upon completion of construction, particulate levels are likely to decrease. Maricopa County Environmental Health Services Department requires that all developers control fugitive dust levels.

NOISE

The Agua Fria area is comprised of predominantly agricultural and open lands with the exception of Sun City/Youngtown and Avondale. Two predominant sound sources exist in the general area: motor vehicle traffic and air traffic in connection with Luke Air Force Base and the Phoenix-Litchfield Municipal Airport. Point sources for noise in the study area include aircraft, all roads crossing the river, the two railroad crossings, and the several sand and gravel operations along the river.

During lulls in traffic and aircraft operations, wind and wildlife produce significant background noise. Typical day-night sound levels for open lands range from 15 to 45 dB, depending upon the proximity of environmental noise sources to areas of human activity. See Table 9.

TABLE 9
DAY-NIGHT SOUND LEVELS FOR MAJOR LAND USES

Land use	Day-night sound Levels in dB
Urban residential near to highway	75 - 85
Urban residential hi-rise	65 - 85
Urban shopping center	55 - 70
High density single family urban residential	50 - 65
Suburban residential	35 - 60
Suburban residential at city outskirts	45 - 60
Small town residential	40 - 55
Farm	30 - 45

HOUSING

Since 1960, the number of households in Maricopa County has been increasing at a faster rate than the population due to a steady decrease in the average number of persons in each household. This trend toward smaller households places additional stress on housing supply, over and above that due to population increases. As in many places throughout the United States, particularly in the rapidly developing Southwest, the cost of construction and increasing interest rates have combined to reduce new housing construction over the past four years.

In 1979, housing in the Phoenix metropolitan area consisted of 63 percent single-family dwellings, 20 percent multi-family units, 7 percent townhouses and condominiums, and 10 percent mobile homes. Assuming conditions continue to be favorable to the construction of multiple-family dwellings, their total number and their fraction of total housing both will likely continue to increase. Large parcels of land on the periphery of the urbanized area, such as the Agua Fria River area, will continue to attract such development. Table 10 illustrates the number of housing units by community for the study area.

COMMUNITY FACILITIES

As urbanization continues to expand in West Central Maricopa County, the availability of community facilities has also been increasing, but construction of such facilities usually lags behind urban growth. One apparent shortage of community facilities is in the area of parks and recreation.

TABLE 10
 NUMBER OF HOUSING UNITS WITHIN SELECTED COMMUNITIES

Community	Number of housing units	Community	Number of housing units
Avondale	2,742	Phoenix	299,156
Cashion*	736	Sun City*	25,410
El Mirage	1,125	Sun City West*	3,322
Glendale	35,388	Surprise	950
Litchfield Park*	1,273	Youngtown	1,445
Peoria	4,684	Luke Air Force Base*	876

*Figures for these unincorporated communities were available only as preliminary 1980 census estimates.

Source: U.S. Census Bureau.

FLOOD CONTROL ALTERNATIVES

INTRODUCTION

The flood control projects proposed here for the Agua Fria River are the result of extensive hydrological and environmental investigations, as well as discussions with local and regional governmental agency representatives. If any or all of the recommended projects are to be considered for implementation, however, additional investigations will need to be undertaken to develop detailed structural designs, project costs, and also to document significant probable environmental consequences of the proposed projects. The term "floodplain" as used here refers to the established 100-year floodplain. The term "hydrology developed by the U.S. Army Corps of Engineers, Los Angeles," refers to projected 100-year flows developed in 1980 and listed in Table 6.

Part of the Central Arizona Water Control Study (CAWCS) is a review of the potential for locating a larger dam (New Waddell Dam) below the existing dam as one of several alternatives to Orme Dam. The proposed New Waddell Dam would not allow for flood control.

Although a formal environmental assessment is not required at this stage in the implementation of alternative flood control measures, it may be eventually, depending on the sources of funding that are sought. Even if federal assistance is not solicited, some federal and state environmental regulatory requirements will have to be fulfilled in implementing the projects. In anticipation of this possibility, an evaluation of potential environmental consequences is presented for each of the proposed projects.

Impact categories for each project include: biological resources, cultural resources, land uses, transportation, air quality, and socioeconomic resources.

The environmental evaluations are presented by reach for each project, and include a description of the affected environment, an assessment of both short term construction-related impacts and long term operation-related impacts. Mitigation strategies are also proposed for reducing the severity of any adverse impacts, and the feasibility of implementing these strategies is evaluated.

The Agua Fria River passes through many varied types of terrain, from mountain foothills through natural desert to highly developed residential communities. Levees constructed along the Agua Fria River must prevent piping and scour, please the eye, and discourage localized vandalism that would compromise their structural integrity. Constructing the levees of soil cement and native material would economically fulfill all of the above requirements. Side slope selection for levee construction is based on structural requirements of the native material, environmental considerations of wildlife movement, and maintenance requirements. These considerations, plus the results of a cost comparison for all levees, led to the choice of a 4:1 side slope. Specific soil information could later call for alteration of this slope and the selected design for any alternative project. In all of the estimated costs for the proposed flood control project elements, the item "Channel Excavation" includes in its unit price the total cost of excavation, embankment, compaction and fine grading and all labor, materials and equipment to complete the levee construction.

LAKE PLEASANT

ALTERNATIVE MAPS INDEX

INDEX MAP LEGEND

••••• Map Plate Numbers

----- Reach Boundary

ALTERNATE MAP PLATES LEGEND

◆ Levees

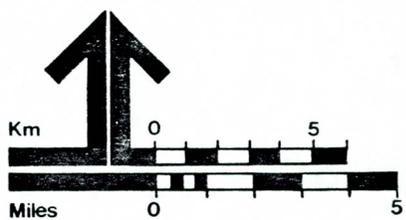
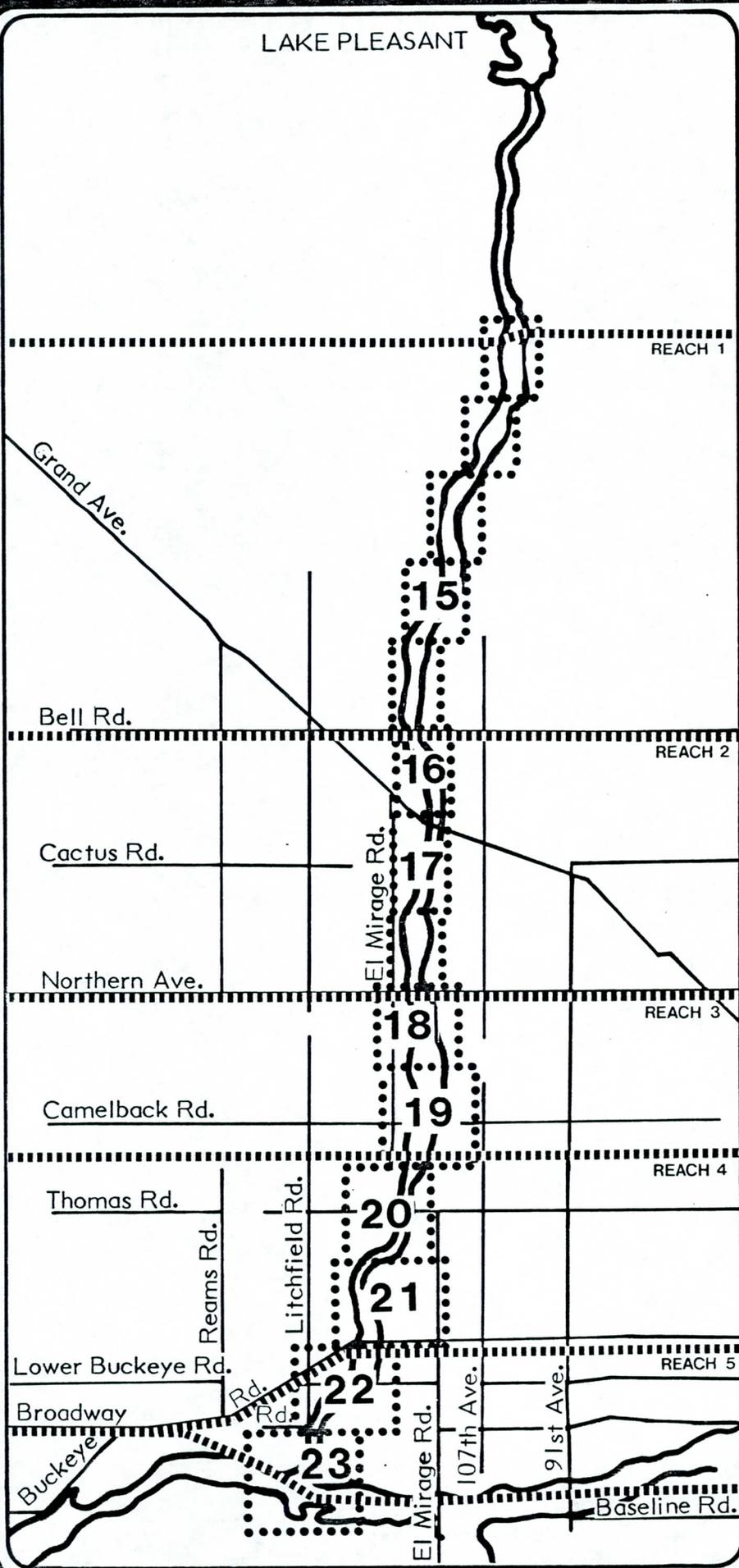
◆ Levees w/ Revetment Blanket

Prime Openspace

■ Proposed Development

••••• Prime Habitat Undisturbed

(see index map legend for other map designations)



Agua Fria River Study
Maricopa County, Arizona

Willdan Associates • 1981

REACH I: BEARDSLEY CANAL FLUME TO BELL ROAD

REACH DESCRIPTION

Reach I begins at the Beardsley Canal Flume, the northern boundary of this study, and ends at the Bell Road Bridge approximately 10.2 miles to the south. Bell Road marks the southern boundary of Reach I.

This reach of the river comprises a well defined channel ranging from 1200 feet to 4400 feet in width. The area is sparsely populated, with only two subdivisions, Hatfield Acres and Rose Garden Lanes, located within the floodplain. The floodplain covers approximately 4000 acres of land, of which about 310 acres are in active agricultural production. Major characteristics which could influence future flooding and damages are described below for each of eight consecutive segments from north to south along Reach I.

I. Beardsley Canal Flume

The Beardsley canal flume forms a link in the flow of irrigation water from Lake Pleasant to the Beardsley district. The flume measures about 970 feet in length, stands approximately 15 feet above the river bottom, and includes seven piers located in the floodplain. A hydraulic analysis of the flume performed for this study using a HEC-2 backwater analysis program and hydrology developed by the U.S. Army Corps of Engineers, Los Angeles, revealed no significant obstruction of the Agua Fria's flow attributable to this structure. No changes in the flume or in the river at this part of the reach are required.

2. Beardsley Canal Flume to Hatfield Acres

This section of the reach contains approximately 2650 acres, with about 160 acres in active agricultural production and the rest in the natural desert state. The Del Webb Corporation has proposed recreational facilities for this area to include riding trails, a gun club, and picnic grounds for use by nearby Sun City residents.

3. Calderwood Butte

A major topographic feature of this section is Calderwood Butte, located approximately 6.2 miles north of Bell Road. Here, the Agua Fria River makes a transition through mountainous terrain and into the valley. The area above Calderwood Butte has been classified as a culturally sensitive area (see environmental assessment section). Based upon initial hydraulic calculations, this area appears to be a suitable location for a water detention facility. In order to properly estimate the costs of this facility, more detailed information and investigation beyond the scope of this study would be necessary, an effort that certainly seems warranted. Additional information required would include at least the following:

1. Geology investigation (specific for proposed site);
2. Soils investigation (specific for proposed site);
3. Location of borrow areas for core work;
4. Complete environmental and cultural impacts investigation;

5. Investigation of use of state, BLM and private land for flowage easements and approximate costs;
6. Location of a water source for use during construction;
7. Development of typical sections based on detailed soils and geological investigations;
8. Additional hydraulic computations from the Corps of Engineers for design and sizing of this dam, outlet structure and emergency spillway.

Based on early preliminary data and computations, it is estimated that this project, including land rights, site investigations, engineering and construction, will cost from \$45 to \$55 million. This project would reduce peak flow in the Agua Fria River below the proposed dam from 120,000 cubic feet per second to 25,000 to 30,000 cubic feet per second. This reduction in flow substantially reduces the need for further downstream improvements on the Agua Fria. It should be noted that proposed alternative uses of this area would be open space only; water storage is not considered a feasible use.

4. Hatfield Acres

Hatfield Acres is a subdivision located approximately 5.4 miles north of Bell Road consisting of 32 parcels, 21 of which are currently occupied. Because Hatfield Acres suffered significant damage during both the 1978 and 1980 floods, the State of Arizona Emergency Services Agency is currently negotiating with the residents of Hatfield Acres for relocation to higher ground. For the purposes of this report, it is assumed that Hatfield Acres

will be removed from the floodplain and will no longer be affected by future flooding.

5. **Rose Garden Lane Subdivision**

Rose Garden Lane Subdivision lies about 2.25 miles north of Bell Road. The defined low water channel at Rose Garden Lane is approximately 800 feet wide and 3 feet deep. Based on hydrology developed by the U.S. Army Corps of Engineers, preliminary computations indicate that Rose Garden Lane would be inundated by 12 feet of water moving at 5.5 feet per second during a 100-year flood.

6. **Sun City West Water Reclamation Plant**

The Sun City West Water Reclamation Plant was constructed in 1980-81. With a current capacity of 2.2 million gallons per day and expansion capabilities to 6.4 million gallons per day, this plant will ultimately serve approximately 24,000 residences and businesses in Sun City West. Top-of-berm elevation for lagoons is 1210.00 feet. Finished floor elevation of the administration building is 1222.00 feet.

When constructed, this plant was located outside the established 100-year floodplain and sustained insignificant damage in the 1980 floods. Based upon hydrology developed by the U.S. Army Corps of Engineers, Los Angeles, preliminary computations indicate that future flooding will inundate this plant with 1 to 2 feet of water moving at 2.6 feet per second during a 100-year storm.

7. McMicken Dam Outflow Structure

McMicken Dam was constructed by the U.S. Army Corps of Engineers in 1956 as a storm water detention facility for the Trilby Wash Basin. The outflow structure was designed to divert 4450 cubic feet per second peak flow to the Agua Fria River at its entrance to the river 0.5 miles north of Bell Road. This structure has not been operable since the dam was breached, and the flood control district of Maricopa County is currently looking into the possibility of reconstruction. If rebuilt, this facility will add to the Agua Fria's peak flows and will contribute approximately 4 percent of peak flows at the Bell Road Bridge and downstream. This outflow structure is included in another study, and no further consideration will here be given to possible alternatives. In preparing hydrology for the Agua Fria River, the U.S. Army Corps of Engineers assumed that this structure will be operable and contribute to peak flows of the Agua Fria, and the same assumption is made here.

8. Bell Road Bridge

Bell Road and its bridge mark the terminus of Reach I. The Bell Road Bridge was washed out during the 1980 flood, and a temporary low water crossing was constructed immediately thereafter. The Maricopa County Highway Department has constructed a new permanent crossing at Bell Road. The latest hydrology for the Agua Fria River was not available during the design phase, so the County developed their own hydrology for the reconstruction design of the Bell Road Bridge. Their report indicates a peak flow for a 100-year storm of 102,400 cubic feet per second. Hydrology developed by the U.S. Army Corps of Engineers indicates peak flows of 115,000 cubic feet per second at Bell Road. Based upon HEC-2 computer runs conducted during

runs conducted during the course of this study, the reconstructed Bell Road Bridge will carry projected flow as "Class A low flow".

"Class A low flow" is one of the classifications used by the U.S. Army Corps of Engineers to describe flow conditions through bridge structures. The other classifications are; "Class B low flow," "Class C low flow," "pressure flow," "Weir flow" and "Combination flow." "Class A low flow" occurs when water flows under a bridge in such a way that the water surface is below the lowest part of the bridge and that the bridge does not restrict flow so as to cause backwater conditions.

ELEMENTS OF PROPOSED ALTERNATIVE PROJECTS FOR REACH I

- (a) Rose Garden Lane Subdivision, Purchase and Relocation. For this element, this subdivision would be relocated and the area returned to river flowage.

Estimated Costs

Element (a), Reach I, Agua Fria River

Item No.	Description	Estimated Quantity	Unit	Unit Cost	Amount
1	Relocate 13 families	13	Each	\$ 50,000*	\$ 650,000
2	Purchase 38 parcels and demolish structures	38	Each	20,000*	760,000
				TOTAL	\$1,410,000

*Relocation costs include administrative costs in assessment and negotiation with residents during the relocation process.

(b) Rose Garden Lane Subdivision, Protection. Element (b) would provide protection of Rose Garden Lane through construction of a levee around the subdivision and grading of the channel adjacent to the levee. The proposed levee would begin at Beardsley Road approximately 4000 feet west of 115th Avenue, thence northeasterly to 115th Avenue approximately 4600 feet, thence north along 115th Avenue approximately 2000 feet, thence northwesterly approximately 1800 feet to tie into the existing bank. The total length of this levee would be 7900 feet and the height above the river bottom about 12 feet. Complete or partial purchase of 15 parcels would be required in order to build this levee, which would protect 11 existing structures and 15 vacant parcels. A low water crossing at Rose Garden Lane would be required in conjunction with this project.

Estimated Costs

Element (b), Reach I, Agua Fria River

Item No.	Description	Estimated Quantity	Unit	Unit Cost	Amount
1	Mobilization		L.S.	\$	\$ 50,000
2	Clearing and grubbing	20	Acres	350.00	7,000
3	Channel excavation	225,000	C.Y.	2.50	562,500
4	Soil cement	64,400	C.Y.	30.00	1,932,000
5	Reinforced concrete culvert	1	Each	15,000	15,000
6	Hydromulch	158,000	S.F.	0.05	7,900
7	Roadway excavation	4,500	C.Y.	2.50	11,250
8	Rock riprap (roadway)	3,000	C.Y.	18.00	54,000
	TOTAL				\$ 2,639,650
	Land Rights Easement	27	Acres	2,000	\$ 54,000

FLOOD CONTROL ALTERNATIVES
REACH I

- (c) Sun City West Water Reclamation Plant, Protection. In order to protect the Sun City reclamation plant from inundation and associated physical and environmental damage, it is proposed that a levee be built around the treatment plant property. The levee would be about 12 feet high and would begin at Beardsley Road approximately 1400 feet east of 115th Avenue, thence northwesterly approximately 1000 feet, thence north approximately 1000 feet, thence east approximately 1700 feet; for a total length of nearly 4000 feet. This element includes the construction of protective levees only and does not include any channel work other than controlled excavation to obtain materials to construct the levees. Permanent and temporary easements for construction of the levees would have to be acquired.

Estimated Costs

Element (c), Reach I, Agua Fria River

Item No.	Description	Estimated Quantity	Unit	Unit Cost	Amount
1	Mobilization		L.S.	\$	\$ 30,000
2	Clearing and grubbing	10	Acres	350.00	3,500
3	Channel excavation	112,000	C.Y.	2.50	280,000
4	Soil cement	30,500	C.Y.	30.00	915,000
5	Reinforced concrete culvert	1	Each	8,000.00	8,000
6	Hydromulch	79,000	S.F.	0.05	3,950
		TOTAL			\$ 1,240,450
	Land Rights Easement	13	Acres	2,000	\$ 26,000

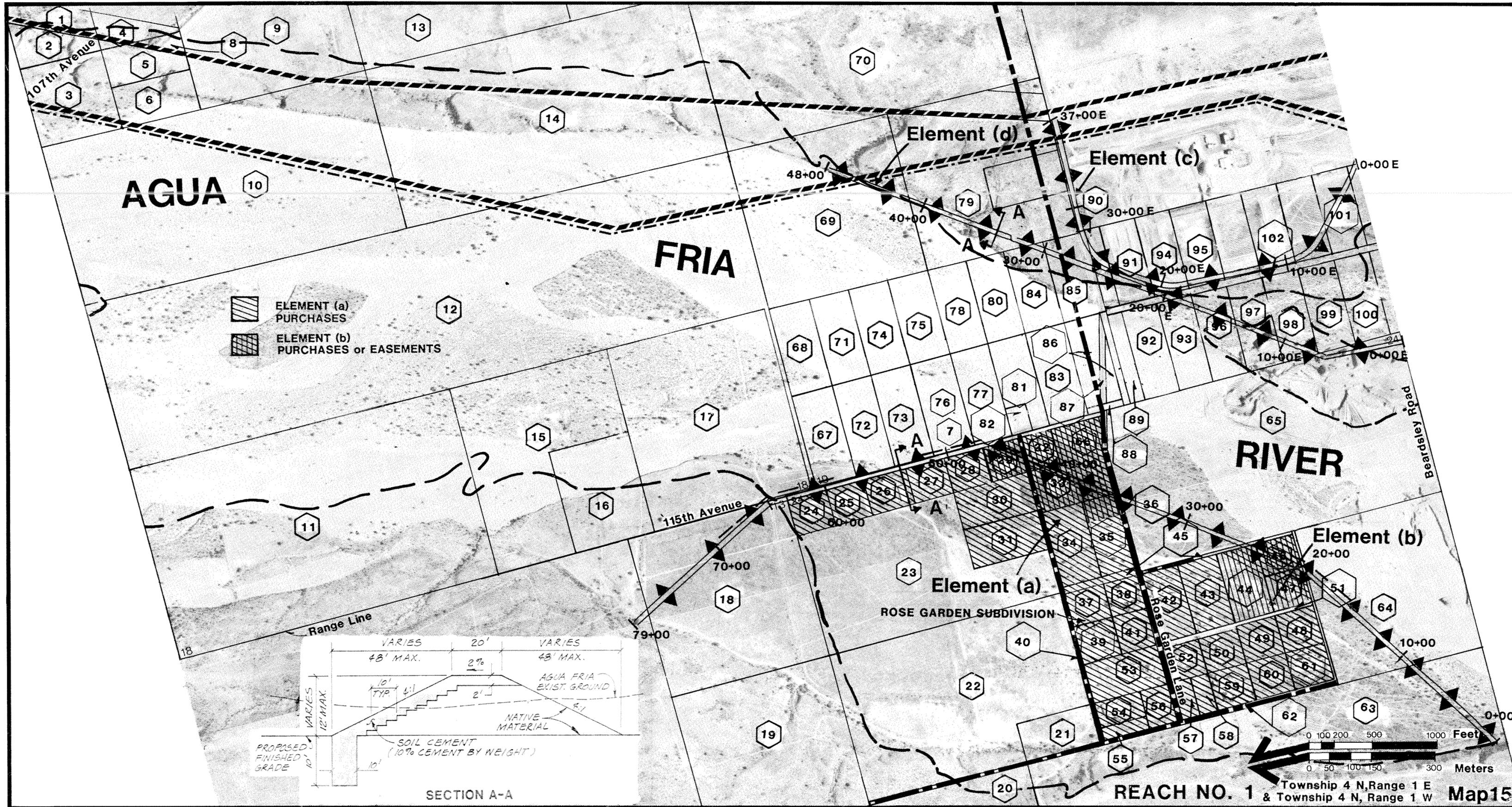
FLOOD CONTROL ALTERNATIVES
REACH I

- (d) Sun City West Water Reclamation Plant, Joint Protection. To protect the Sun City treatment plant in association with Element (b) (Rose Garden Lane Subdivision, Protection), it is proposed to construct a levee and associated channel cleanout. The levee would begin at Beardsley Road at 115th Avenue; thence northeasterly approximately 4800 feet to a point approximately 2400 feet east of 115th Avenue. The height of the levee above the river bottom would be approximately 12 feet. This element includes only that channel excavation required to construct the levee. Permanent and temporary easements for construction at the levees would have to be acquired.

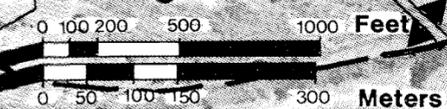
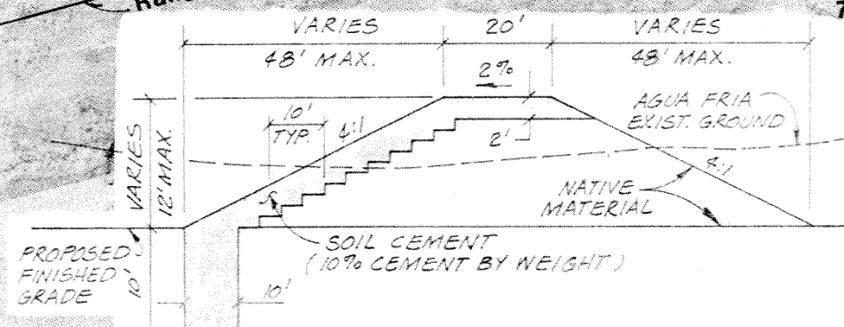
Estimated Costs

Element (d), Reach I, Agua Fria River

Item No.	Description	Estimated Quantity	Unit	Unit Cost	Amount
1	Mobilization		L.S.	\$	\$ 40,000
2	Clearing and grubbing	14	Acres	350.00	4,900
3	Channel excavation	150,000	C.Y.	2.50	375,000
4	Soil cement	39,000	C.Y.	30.00	1,170,000
5	Reinforced concrete culvert	1	Each	8,000.00	8,000
6	Hydromulch	94,000	S.F.	0.05	4,700
7	Roadway excavation	4,500	C.Y.	2.50	11,250
8	Rock rip rap (roadway)	3,000	C.Y.	18.00	54,000
	TOTAL				\$ 1,667,850
	Land Rights Easements	17	Acres	2,000	\$ 34,000



 ELEMENT (a) PURCHASES
 ELEMENT (b) PURCHASES or EASEMENTS



REACH NO. 1 Township 4 N, Range 1 E & Township 4 N, Range 1 W **Map 15**

PROPOSED ALTERNATIVE PROJECTS FOR REACH I

Alternative Project 1, Reach I, Agua Fria River

This project would combine the following elements:

- (a) Rose Garden Lane Subdivision, Purchase and Relocation
- (c) Sun City West Water Reclamation Plant, Protection by levee construction

Estimated construction cost for this alternative is \$2,650,450.

Alternative Project 2, Reach I, Agua Fria River

This project would combine the following elements:

- (b) Rose Garden Lane Subdivision, Protection by levee construction
- (d) Sun City West Water Reclamation Plant, Joint Protection by levee construction

Estimated construction cost for this alternative is \$4,307,500.

ENVIRONMENTAL IMPACTS FOR REACH I

Elements of Alternative Projects

Four elements of construction have been proposed for Reach I to protect Rose Garden Lane Subdivision and the Sun City West Water Reclamation Plant. They are summarized below:

- (a) Relocate Rose Garden Lane Subdivision out of the floodplain.
- (b) Construct a levee along the west bank to provide protection for most of the Rose Garden Lane Subdivision. The proposed levee would be 12 feet high and 7900 feet long.
- (c) Construct a levee around the Sun City West Water Reclamation Plant only, to provide protection on the north, west, and south sides of the plant.
- (d) Construct a levee along the east bank of the river from Beardsley Road and 115th Avenue northeasterly approximately 1200 feet north of the treatment plant to approximately 800 feet south of it. Total length would be approximately 4,800 feet; height would be 12 feet.

All elements would require clean-out of the riverbed along the levee sites. Levees would be constructed using the clean-out materials, and the soil and bank stabilization for the levees would be done with soil cement.

Affected Environment

The most sensitive features of the project area are man-made and inhabited. The water reclamation plant has been noted. Rose Garden Lane Subdivision, a small unincorporated community of single-family and mobile homes, extends from the banks of the channel to the west and between the area immediately to the north of Rose Garden Lane to Beardsley Road. All of the homes lie within the 100-year floodplain. If a relocation opportunity is not presented to this community, protection should be provided via levee construction. If an opportunity to relocate is provided and turned down by the community, then the subdivision should be allowed to remain, but without flood protection and at residents' own risk.

Agricultural fields are now being prepared along the Agua Fria's east bank, from Beardsley Road to approximately one mile north of Bell Road. The site lies approximately 50 to 75 yards on either side of a 230 kv transmission line corridor. No levee work is proposed for this site.

Transportation access to the proposed project area is provided by Beardsley Road and by Rose Garden Lane, both of which connect the Rose Garden Lane Subdivision with Lake Pleasant Road. Both roads are dirt and gravel in the project vicinity, but are well traveled and maintained.

Vegetation and wildlife habitats within the area of the proposed projects are sparse. Construction, human habitation, extraction activities, and previous flooding have removed most vegetation except for scattered shrubs and bushes. No protected plant species live within the immediate project sites.

A cultural resources survey has never been conducted along this reach of the Agua Fria. Any cultural sites that may have existed are likely to have been disturbed by previous human activities and by flooding. Because of the prevalence of cultural resources to the north of this area, however, an archaeological survey may need to be conducted prior to levee construction, and construction monitoring would be recommended as well.

Except for the water reclamation plant, the Rose Garden Lane Subdivision, the agricultural site, and the extraction operation, all land is in open space. The agricultural site now being prepared is within the Surprise, Arizona planning area.

Short Term Impacts

No serious environmental impacts have been identified in connection with the construction of any of the proposed alternative levees, although biological and cultural resources may be affected. Construction-related short term impacts would include the following:

1. Primary impacts during the construction phase will be from noise and dust. All project activities, including channelization, hauling of fill, and levee construction will cause fugitive dust that will be present throughout the construction period.
2. Most of the fill material will be obtained from the channelization and clean-out effort. If another borrow site is necessary, the impacts to that site will need to be evaluated separately. The use of another borrow site will also increase the use of haul roads.

3. No new haul roads will be required for the transportation of equipment or materials. Project activities will cause no damage to existing roads. Traffic along all affected roads is negligible at present and no traffic problems should occur. If construction activities temporarily block one road leading to the Rose Garden Lane Subdivision or the treatment plant, the other road will provide adequate access.
4. If only Alternative Project 1 is selected, the Rose Garden Lane Subdivision will not be protected from potential flooding. At present, no efforts are being made to relocate residents of that community. If the opportunity for relocation is presented to the Rose Garden Lane Subdivision, any residents who remain will do so at their own risk.
5. If Alternative Project 2 is selected, protection would be provided for the entire community. The levee of Alternative Project 2, however, would interrupt both Rose Garden Lane and Beardsley Road at the river. In such a case, and if the community is to remain, low-flow roads would have to be cut through the levees on both sides. This procedure would not increase project duration or construction-related impacts.
6. No significant impacts to vegetation, wildlife, historic or prehistoric cultural resources are anticipated from construction activities.

Mitigation Measures for Short Term Impacts

Mitigation measures are recommended for the control of noise and dust. Watering down of dirt roads should be used as necessary for dust control. Operations should

be confined to daylight hours to lessen the nuisance impact of noise. A cultural resources survey should be conducted prior to construction of any of the alternatives, and, depending on the survey findings, construction monitoring may be recommended to insure that any resources present in the immediate area are protected.

Long Term Impacts

No significant long term adverse impacts are anticipated. Limited annual maintenance will be required on all of the proposed levees. In case of flooding, the levees will not obstruct flow or direct it to new areas, but will confine the water within the defined banks.

ENVIRONMENTAL IMPACTS FOR REACH I: CALDERWOOD BUTTE DAM

Introduction

The scope of this report does not provide for the analysis of a dam at Calderwood Butte to the extent that it could be included in the report as a construction element or alternative project. However, the general assessment of the social and environmental impacts for such a project is within the scope of this report and is presented here to aid in the determination of the need for further study of the economic justification for a dam at this location.

Of the possible projects that have been studied for the Agua Fria River, the most significant is the construction of a detention dam in the vicinity of Calderwood Butte. This earthen embankment dam would span approximately three-quarters of a mile and would be on the order of 40 to 50 feet high. During a 100-year storm backwater could reach upstream to Beardsley Flume with the high water mark possibly reaching the 1350-foot elevation. This pool could contain approximately 64,000 acre-feet of water and could drain in less than seven days.

Affected Environment

The affected environment for this area could encompass approximately 2500 acres of undisturbed southwestern desert scrub, characterized by a creosote bush/paloverde community. Vegetation types include creosote bush, bursage, saguaro, cholla, and other cacti. Riparian vegetation includes mesquite, sycamore, cottonwood, and paloverde. Compared with the rest of the Agua Fria River study area,

this area is abundant in wildlife. Wildlife occurring along Reach I includes rabbits, skunks, coyote, deer, rodents, bats, and more than 300 species of birds, amphibians, and reptiles. In terms of cultural resources, the Calderwood Butte area has been rated as highly sensitive by the Office of Cultural Resources Management at Arizona State University. This rating is based entirely on known archaeological resources provided by secondary data sources. A cultural resources survey will need to be conducted prior to any dam construction.

Primary access to the Calderwood Butte area is by way of Jomax Road, which leads to the area from Lake Pleasant Road. Jomax Road is paved up to the river's east bank, continuing west across the river as a graded dirt road. Several jeep trails wind through the area as well. The predominant land use is vacant land, with agricultural fields along the west side of the river comprising the only other land use category for this area. A 69 kv transmission line follows the graded dirt road along the west side of the river. An abandoned recreation site, previously operated by the Del Webb corporation until recent floodwaters destroyed the area, is located adjacent to Calderwood Butte.

Short Term Impacts

No significant environmental impacts have been identified with the construction of Calderwood Butte Dam, although biological and cultural resources will be affected. Construction-related short term impacts would include the following:

1. Depending on the source(s) of borrow material, Jomax Road may be used as a haul road. Jomax Road crosses the river a few hundred feet below the proposed dam site and thus will not have to be relocated during construction.

Approximately 2.5 million cubic yards of dirt fill will have to be used to complete the dam, which will be available within two miles of the proposed dam site. This would require approximately 210,000 truckloads (12-yard haul trucks) of fill material. Local traffic is minimal and would be affected very little, if at all, by the haul truck traffic.

2. There is a possibility that new haul roads will have to be developed, again depending on the source(s) of borrow material. Road development would disturb existing biological resources to some degree.
3. Cultural resources may also be affected by construction activities. The lack of a cultural resources survey for this area, combined with the undetermined specifics of the construction project, make it difficult to assess the level of impact on cultural resources at this time.
4. Throughout the construction process, fugitive dust will be caused by the various construction-related activities.

Mitigation Measures for Short Term Impacts

Some mitigation techniques that might be employed during construction would include:

1. Keep new haul road development to a minimum, in terms of both length and width. Try to avoid the destruction of wildlife habitat, especially riparian habitat.

2. Protect any cultural resources that might be disturbed during construction with physical barriers.
3. Water down all dirt roads to keep fugitive dust to a minimum.

Long Term Impacts

Long term impacts that can be attributed to the construction of Calderwood Butte Dam include the following:

1. Backwater could inundate approximately 2500 acres of undisturbed natural vegetation on an episodic basis. This vegetation, much of which is riparian, provides habitat for wildlife. Although the duration of inundations will be brief, many species of plants will be affected while some species will be able to survive. Any saguaros that could potentially be inundated will have to be relocated as required by the Arizona Commission of Agriculture and Horticulture. No endangered species of vegetation or wildlife are known to occur in the area; however, the peregrine falcon (listed on the Federal endangered species list) has been known to migrate to this area on an occasional basis.
2. Several archaeological sites will be inundated by the backwater. As the detention pool drains, flow rates are not likely to cause significant damage, except to dislocate scattered surface deposits. This will not present any significant adverse impacts to the sites below the surface. In fact, during the time that the sites are inundated, these sites will be protected from any man-related disturbance.

3. In terms of transportation, a beneficial impact will occur, with Jomax Road proposed for relocation to the top of the dam, providing permanent access across the Agua Fria.
4. Several hundred acres of agricultural land along the west side of the river will be inundated by backwater. This federally leased land will be designated as a flowage easement that could continue to be farmed at the lessee's risk.

Because this dam will be a detention dam rather than a retention facility, water-based recreation will not be a potential land use for the area. A 69 kv transmission line located near the proposed high water mark will be able to endure brief periods of inundation.

Mitigation Measures for Long Term Impacts

1. Any new haul roads that have to be developed should be returned to natural desert in an effort to cover up construction-related disturbance.
2. As previously discussed, saguaro cacti should be transplanted to higher ground.

REACH 2: BELL ROAD TO NORTHERN AVENUE

REACH DESCRIPTION

Reach 2 begins at Bell Road and extends approximately 6.2 miles south to Northern Avenue. This reach flows through portions of urban metropolitan Phoenix and affects portions of Maricopa County (Sun City), Peoria, El Mirage, Youngtown and Surprise. The area contained in the established 100-year floodplain is 2604 acres, of which about 100 acres are residential or commercial developments, 16 acres are in active agricultural production, and the balance is native undisturbed land.

Major features of the reach that could influence flooding are presented below for three consecutive segments from north to south.

I. Bell Road to Grand Avenue

This section of the reach traverses largely undeveloped land, and the floodplain itself is mostly undeveloped. Sun City and Youngtown border the east bank, and undeveloped portions of El Mirage lie on the west bank. Parcel 17 (Map 16) contains a major-league spring-season practice field. Parcels 25 and 31 (Map 16) contain a large operating sand and gravel operation, and an abandoned sand and gravel operation is located on Parcels 17 and 18 (Map 16).

The sand and gravel operation located on Parcels 25 and 31 (Map 16) lies approximately 2000 feet north of the Grand Avenue Bridge and the Atchison Topeka & Santa Fe (AT & SF) Railroad Bridge. Hydrology developed by the

Corps of Engineers and a preliminary HEC-2 computer backwater analysis show that this operation is causing an obstruction in the river resulting in water depths of 25 feet above the natural bottom at the stockpiles. The influence of this obstruction extends upstream to a point about 2000 feet south of Bell Road, but does not extend downstream. Under present conditions, based on the hydrology and computer analysis referenced above, the Grand Avenue and the AT & SF railroad bridges have flowage capacities of 88,000 cubic feet per second and projected weir flow of 16,000 cubic feet per second over the bridges or roadway. This volume of weir flow would most likely require closing of the crossings.

2. Grand Avenue to Peoria Avenue

This section of the reach flows through heavily developed sections of Youngtown and El Mirage. Approximately 350 parcels along the west bank in El Mirage would be affected by flood waters.

The El Mirage sanitary landfill is located about 1200 feet south of the Grand Avenue Bridge and in the center of the Agua Fria waterway, and stands 15 to 20 feet above the channel floor and measures approximately 400 feet wide and 1000 feet long. The net effect of the landfill is to obstruct and restrict flow from the Grand Avenue Bridge, diverting water into the east bank of the river causing scour and erosion. Erosion of the cover over the landfill during heavy flows exposes portions of the refuse, creating a potential health hazard.

The east bank along this section of the Agua Fria is a well defined bank approximately 20 feet high. Intense commercial and residential development

has taken place along the top of this bank. Because of erosion and scour caused by the El Mirage sanitary landfill and high velocities through the Grand Avenue Bridge, this bank is eroding, endangering a public road, a man-made lake, and several commercial and residential developments.

3. Peoria Avenue to Northern Avenue

The land surrounding this section of Reach 2 is undeveloped and contains no major features of influence on past or future flooding.

ELEMENTS OF PROPOSED ALTERNATIVE PROJECTS FOR REACH 2

- (a) Grand Avenue Bridge, Protection. To improve entrance conditions to the Grand Avenue Bridge, it is proposed that a levee be constructed from the west abutment of the AT & SF Railroad Bridge to a point approximately 3000 feet north and west of said abutment.

Estimated Costs
Element (a), Reach 2, Agua Fria River

Item No.	Description	Estimated Quantity	Unit	Unit Cost	Amount
1	Mobilization		L.S.	\$	\$ 80,000
2	Clearing and grubbing	25	Acres	350.00	8,750
3	Channel Excavation	160,400	C.Y.	2.50	401,000
4	Soil cement	101,200	C.Y.	30.00	3,036,000
5	Hydromulch	400,000	S.F.	.05	20,000
	TOTAL				\$ 3,545,750
	Land Rights Easement	23	Acres	2,000	\$ 46,000

- (b) Sand and Gravel Operation North of Grand Avenue, Relocation. This operation, located 2000 feet north of Grand Avenue, is causing backwater north of its location, and is recommended for relocation. The net effect of removing this operation would be to channelize flow to the Grand Avenue bridges, thereby increasing their capacities.

Estimated Costs
Element (b), Reach 2, Agua Fria River

Item No.	Description	Estimated Quantity	Unit	Unit Cost	Amount
I	Removal of sand and gravel operation and cleanout of river bed		L.S.	\$400,000	
		TOTAL			\$ 400,000
	Land Rights Fee		50 Acres	6,000	\$ 300,000

(c) East Bank North of Grand Avenue Bridge, Stabilization. The east bank has existing bank velocities of 1.4 feet per second to 8.4 feet per second and potential improved section velocities of 5.7 feet per second to 11.3 feet per second. It is proposed that the east bank be stabilized from the east abutment of the A.T. & S.F. Railroad Bridge to a point 1200 feet north and east. Cost estimates for this element are based on the use of soil cement and natural materials for backfill. Alternative possibilities are:

- o Concrete or steel bin retaining walls,
- o Reinforced concrete retaining wall,
- o Revetment or gabion baskets,
- o Gunite or shotcrete,
- o Cellular retaining wall.

Estimated Cost
Element (c), Reach 2, Agua Fria River

Item No.	Description	Estimated Quantity	Unit	Unit Cost	Amount
1	Mobilization		L.S.	\$	\$ 9,000
2	Clearing and grubbing	3	Acres	350.00	1,050
3	Soil cement bank stabilization	9,800	C.Y.	30.00	294,000
	TOTAL				\$ 304,050.00
	Land Rights Easement	5	Acres	2,000	\$ 10,000

- (d) Grand Avenue and AT & SF Railroad Bridges, Protection. In order to increase capacity and lower water surface elevation to protect these bridges from inundation, it is proposed that the channel bottom from 500 feet upstream to 200 feet downstream be lined with concrete. It is further proposed that a filter fabric and revetment blanket be placed over the side slopes and channel bottom 600 feet upstream and downstream of the concrete lining.

Estimated Cost
Element (d), Reach 2, Agua Fria River

Item No.	Description	Estimated Quantity	Unit	Unit Cost	Amount
1	Mobilization		L.S.	\$	\$ 80,000
2	Clearing and grubbing	35	Acres	350.00	12,250
3	Channel excavation	130,000	C.Y.	2.50	325,000
4	Concrete lining	10,500	C.Y.	70.00	735,000
5	Filter fabric	120,000	S.Y.	1.00	120,000
6	Revetment blanket	120,000	S.Y.	22.00	2,640,000
	TOTAL				\$ 3,912,250
	Land Rights Fee	35	Acres	6,000	\$ 210,000

- (e) East Bank South of Grand Avenue Bridge, Stabilization. In order to protect existing city streets, commercial developments, residential areas and a man-made lake built along the east bank from erosion and scour, it is proposed to stabilize this bank from a point 800 feet south of Grand Avenue to a point approximately 9000 feet south. Soil cement bank stabilization is used for cost comparison; possible alternative designs are listed in Element (c) for this reach.

Estimated Costs
Element (e), Reach 2, Agua Fria River

Item No.	Description	Estimated Quantity	Unit	Unit Cost	Amount
1	Mobilization		L.S.	\$	\$ 80,000
2	Clearing and grubbing	18	Acres	350.00	6,300
3	Soil cement bank stabilization	93,000	C.Y.	30.00	2,790,000
	TOTAL				\$ 2,876,300
	Land Rights Easement	24	Acres	2,000	\$ 48,000

- (f) El Mirage Landfill, Relocation. To clear the river and to protect downstream areas from possible contamination, it is proposed that the El Mirage landfill be relocated to a site outside the floodplain to an existing landfill.

Estimated Costs

Element (f), Reach 2, Agua Fria River

Item No.	Description	Estimated Quantity	Unit	Unit Cost	Amount
1	Mobilization		L.S.	\$	\$ 30,000
2	Excavation and export	270,000	C.Y.	7.00	1,890,000
	TOTAL				\$ 1,920,000
	Land Rights Fee	40	Acres	6,000	\$ 240,000

- (g) Town of El Mirage, Protection. A major portion of the residential area lying south of Grand Avenue and west of the El Mirage landfill is susceptible to flooding with water depths of 13.11 feet to 15.28 feet and velocities of 5.6 feet per second. To protect this area, it is proposed that a levee be built beginning at the west abutment of the Grand Avenue Bridge and extending southwesterly to Alabama Avenue and thence west along Alabama Avenue approximately 3000 feet.

Estimated Costs
Element (g), Reach 2, Agua Fria River

Item No.	Description	Estimated Quantity	Unit	Unit Cost	Amount
1	Mobilization		L.S.	\$	\$ 50,000
2	Clearing and grubbing	30.00	Acres	350.00	10,500
3	Channel Excavation	17,000	C.Y.	2.50	42,500
4	Soil cement	65,500	C.Y.	30.00	1,965,000
5	Reinforced concrete culvert	1	Each	10,000.00	10,000
6	Hydromulch	400,000	S.F.	0.05	20,000
	TOTAL				\$ 2,098,000
	Land Rights Easement	24	Acres	2,000	\$ 48,000
	Land Rights Fee	55	Acres	6,000	\$ 330,000

- (h) Town of El Mirage, Protection. A diversion ditch is proposed to be constructed from the existing box culvert under Grand Avenue to a point in the levee. A concrete pipe outlet into the Agua Fria River would then be constructed.

Estimated Costs
Element (h), Reach 2, Agua Fria River

Item No.	Description	Estimated Quantity	Unit	Unit Cost	Amount
1	Clearing and grubbing	2	Acres	\$ 400.00	\$ 800
2	Ditch excavation	1,200	C.Y.	3.00	3,600
3	Reinforced concrete culvert with flap gate	2	Each	10,000.00	20,000
4	Hydromulch	82,000	S.F.	.05	4,100
		TOTAL			\$ 28,500
	Land Rights Easement	2	Acres	2,000	\$ 4,000

FLOOD CONTROL ALTERNATIVES
REACH 2

- (i) Town of El Mirage, Protection. This element would duplicate Element (g), except the proposed levee would terminate its southwesterly traverse on the north line of Parcel 282 (Map 17) and then run west for approximately 3000 feet.

Estimated Costs
Element (i), Reach 2, Agua Fria River

Item No.	Description	Estimated Quantity	Unit	Unit Cost	Amount
1	Mobilization		L.S.	\$	\$ 50,000
2	Clearing and grubbing	15	Acres	350.00	5,250
3	Channel Excavation	110,000	C.Y.	2.50	275,000
4	Soil cement	42,000	C.Y.	30.00	1,260,000
5	Reinforced concrete culvert	1	Each	10,000.00	10,000
6	Hydromulch	250,000	S.F.	0.05	12,500
		TOTAL			\$ 1,612,750
	Land Rights Easement	18	Acres	2,000	\$ 36,000

PROPOSED ALTERNATIVE PROJECTS FOR REACH 2

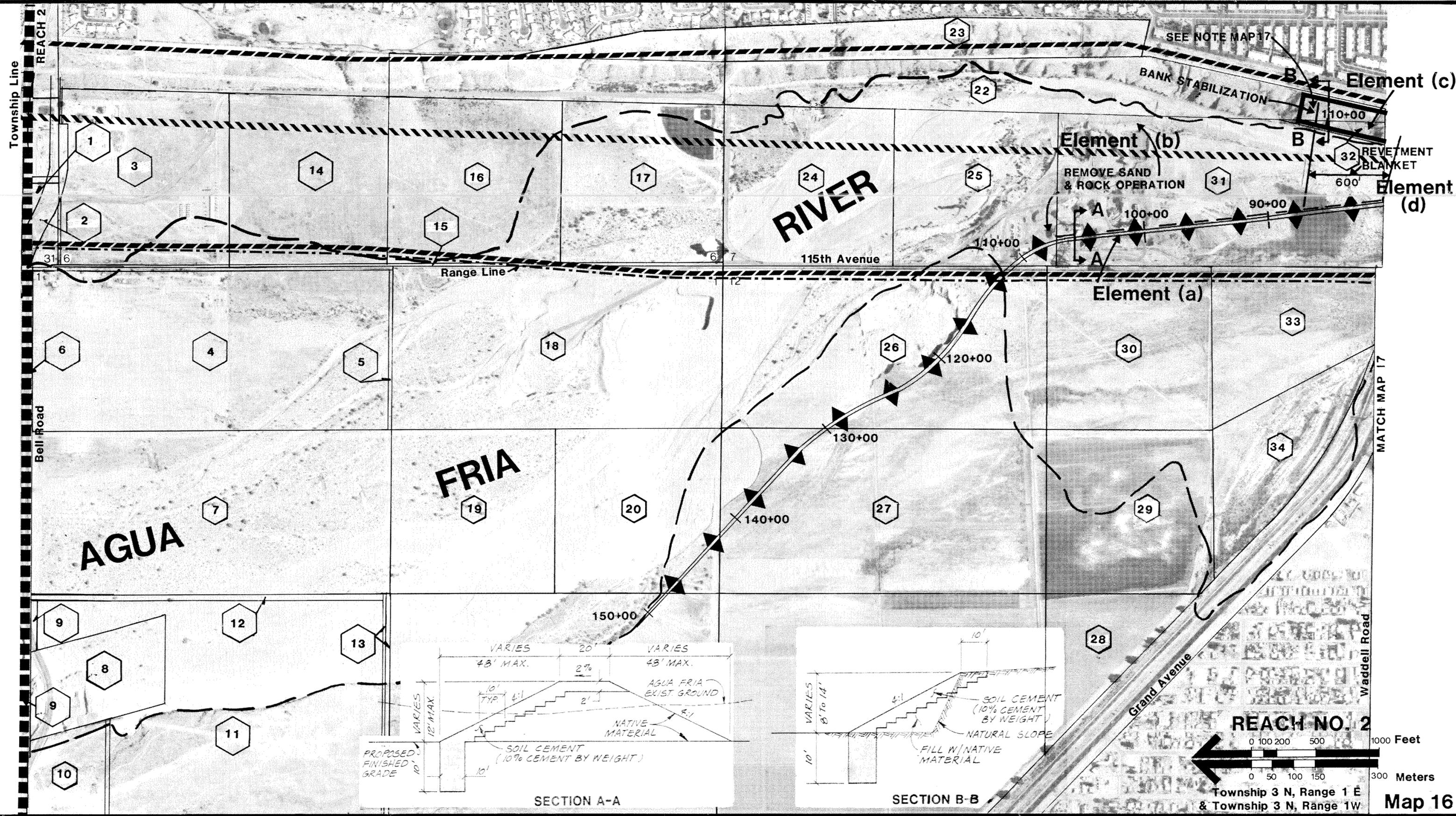
Alternative Project 1, Reach 2, Agua Fria River

This project would combine the following elements:

- (a) Levee construction, west bank, to protect Grand Avenue Bridge
- (c) Bank stabilization, east bank north of A.T. & S.F. Railroad Bridge
- (d) Installation of concrete lining and revetment blanket in bridge area
- (e) Bank stabilization, east bank south of Grand Avenue Bridge
- (f) El Mirage landfill relocation
- (g) Levee construction, west bank at El Mirage
- (h) Diversion ditch construction

Estimated construction cost for this alternative is \$14,684,850.

Estimated landrights cost for this alternative is \$936,000.



Township Line

REACH 2

SEE NOTE MAP 17

BANK STABILIZATION

Element (c)

Element (b)

REMOVE SAND & ROCK OPERATION

Element (d)

REVETMENT BLANKET

RIVER

115th Avenue

Range Line

Element (a)

AGUA

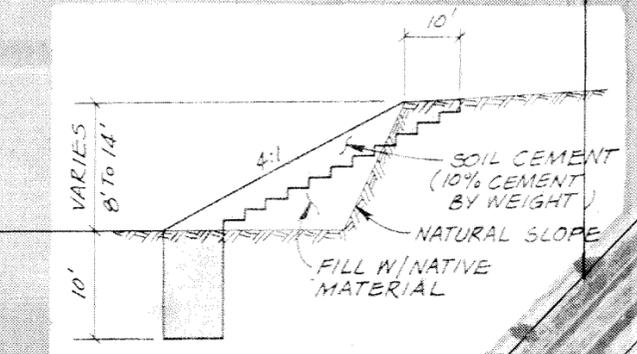
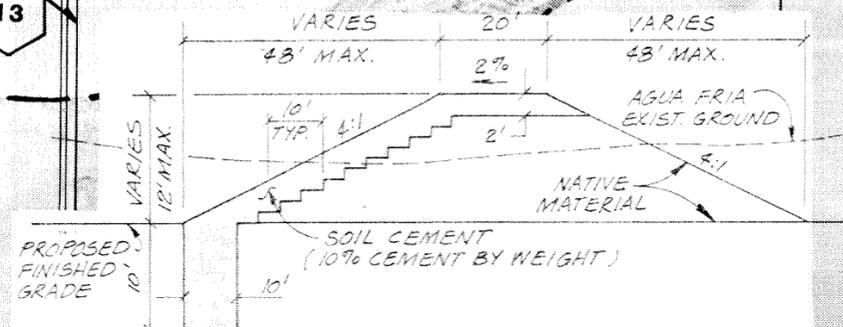
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MATCH MAP 17

Bell Road

Waddell Road

Grand Avenue



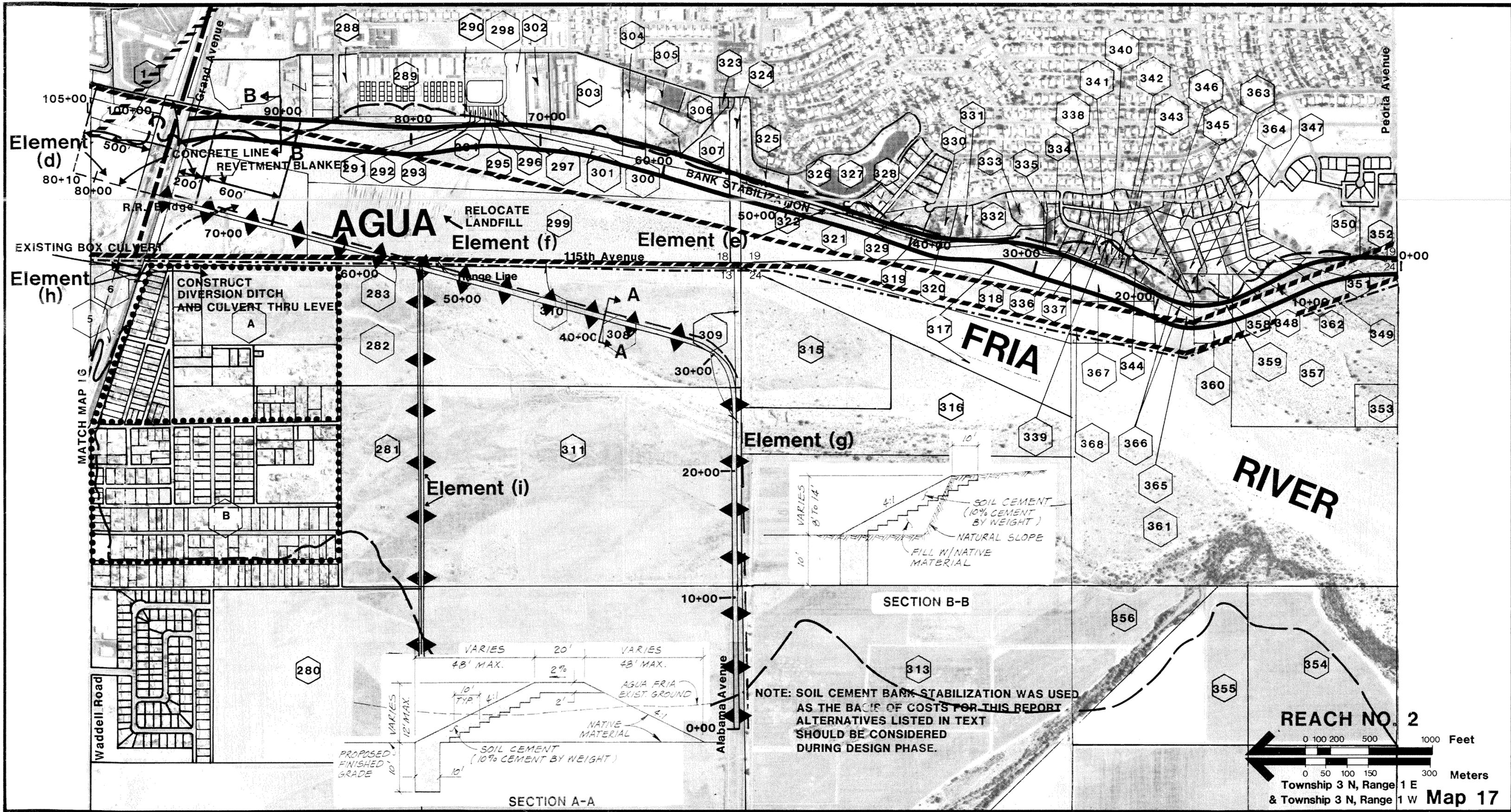
REACH NO. 2

0 100 200 500 1000 Feet

0 50 100 150 300 Meters

Township 3 N, Range 1 E
& Township 3 N, Range 1 W

Map 16



Element (d)

Element (h)

Element (f)

Element (e)

Element (g)

Element (i)

SECTION B-B

SECTION A-A

REACH NO. 2

0 100 200 500 1000 Feet

0 50 100 150 300 Meters

Township 3 N, Range 1 E & Township 3 N, Range 1 W **Map 17**

Alternative Project 2, Reach 2, Agua Fria River

This project would combine the following elements:

- (a) Levee construction, west bank, to protect Grand Avenue Bridge
- (b) Relocation of sand and gravel operation
- (c) Bank stabilization, east bank north of A.T. & S.F. Railroad Bridge
- (d) Installation of concrete lining and revetment blanket in bridge area
- (e) Bank stabilization, east bank south of Grand Avenue Bridge
- (f) El Mirage landfill relocation
- (h) Diversion ditch construction
- (i) Alternate levee construction, west bank at El Mirage

Estimated construction cost for this alternative is \$14,599,600.

Estimated landrights cost for this alternative is \$894,000.

Alternative Project 3, Reach 2, Agua Fria River

This project would combine the following elements:

- (a) Levee construction, west bank, to protect Grand Avenue Bridge
- (d) Installation of concrete lining and revetment blanket in bridge area
- (f) El Mirage landfill relocation
- (h) Diversion ditch construction
- (i) Alternate levee construction, west bank at El Mirage

Estimated construction cost for this alternative is \$11,019,250.

Estimated landrights cost for this alternative is \$536,000.

ENVIRONMENTAL IMPACTS FOR REACH 2

Flood control investigations along Reach 2 have focused primarily on facilitating a smooth flow of water through the Grand Avenue Bridge area. In addition, flood protection for Youngtown (bank stabilization) and for El Mirage (levee construction) have been proposed.

The Agua Fria River narrows sharply approximately 4000 feet north of the Grand Avenue Bridge and the AT & SF Railroad Bridge. The river channel remains constricted until approximately 3000 feet below the bridges. The El Mirage Landfill, located immediately below the bridges, is the primary cause for this constriction, a condition which threatens the structural integrity of the bridges. To remedy this problem, relocation is recommended for the El Mirage Landfill. A possible new location would be to the southwest, where the river is much wider. As an added benefit, the new landfill site would be protected by the levee proposed to protect the city of El Mirage.

Elements of Alternative Projects

Nine elements of construction have been proposed for Reach 2, and are summarized below:

- (a) Construct a levee from the west abutment of the AT & SF Railroad Bridge to a point 3000 feet north and west.
- (b) Relocate the sand and gravel operation north of the AT & SF Railroad Bridge.

- (c) Stabilize the east bank from the east abutment of the AT & SF Railroad Bridge to a point 1200 feet north and east.
- (d) Install concrete lining and revetment blanket in the vicinity of the AT & SF Railroad Bridge and the Grand Avenue Bridge.
- (e) Stabilize the east bank from Grand Avenue south to Peoria Avenue.
- (f) Relocate the El Mirage Landfill.
- (g) Construct a levee from the west abutment of the Grand Avenue Bridge south to Alabama and west along Alabama Avenue.
- (h) Construct a diversion ditch from the existing box culvert under Grand Avenue east through the proposed levee.
- (i) Construct alternate levee, west bank at El Mirage.

Affected Environment

Reach 2 passes through both rural and urban areas. Sun City and Youngtown, for the most part, border the east bank of the Agua Fria along this reach. The cities of Surprise and El Mirage are located on the west side of the river, in the area of Grand Avenue. Vegetation along this reach is relatively sparse, especially in the area of the Grand Avenue Bridge where development prevails. Wildlife is also extremely limited in this area.

Residential development dominates the east side of the river, while agricultural and open space are predominant along the west side. Two sand and gravel extraction sites are located within this reach, one between Northern and Olive Avenues and the other about one-half mile north of the Grand Avenue Bridge. The latter site has been recommended for relocation; the former has not. Immediately south of the Grand Avenue Bridge, the El Mirage Landfill has also been recommended for relocation.

The following roads provide access across the river: Bell Road, Grand Avenue, Olive Avenue, and Northern Avenue. A road providing access to Arizona Sand and Rock also crosses the river approximately one-half mile north of the extraction site. Access to the river bottom is available from both ends of the Grand Avenue Bridge; therefore, no new access should have to be developed for the projects proposed along this reach.

A cultural resources survey has never been conducted along this reach of the Agua Fria. There is a moderate likelihood that historic or prehistoric cultural resources are located in the vicinity of the proposed project locations. Any sites that may have existed, however, are likely to have been disturbed by previous human activities and by flooding. An archaeological survey may need to be conducted prior to any flood control development projects, and construction monitoring would be recommended as well.

Short Term Impacts

No serious environmental impacts have been identified with the construction of any of the proposed projects. Construction related short term impacts would include:

1. Local air quality will be adversely affected with the addition of fugitive dust to the atmosphere. All project activities, including channelization, hauling of fill material, and levee construction, will add fugitive dust to the air.
2. Noise from the various construction activities will increase daytime sound levels, which may provide an inconvenience to the surrounding residences and businesses.
3. Most of the needed fill material will be obtained from channelization and clean-out. Should a borrow site be necessary, the impacts to that site will need to be evaluated separately. A new borrow site would likely require new access (within the 100-year floodplain) and additional hauling.
4. No new haul roads are anticipated at this time, and project activities will cause no damage to existing roads. Traffic on Grand Avenue will not be affected, as the great majority of work to be accomplished will occur in the river bottom.
5. No significant impacts to vegetation, wildlife, historic or prehistoric cultural resources are anticipated from construction activities.

Mitigation Measures for Short Term Impacts

Mitigation measures are recommended for the control of noise and dust. Dirt roads should be watered down as necessary to control fugitive dust. Construction activities should be limited to daylight hours to lessen the impacts of noise. A cultural resources survey should be conducted prior to any construction, and,

depending on survey results, construction monitoring may be recommended to insure that any resources present in the immediate area are protected.

Long Term Impacts

No significant long term impacts are expected from the proposed projects. Limited annual maintenance will be necessary on all of the projects. Proposed bank stabilization along the east bank may present an impact to wildlife depending on the method selected. Any bank stabilization effort that would limit wildlife access due to its steepness present an adverse impact. Channelization may partially impede terrestrial wildlife movements.

REACH 3: NORTHERN AVENUE TO INDIAN SCHOOL ROAD

REACH DESCRIPTION

Reach 3 begins at Northern Avenue and extends south approximately 5 miles to Indian School Road.

The channel through this reach is well defined along the west bank, but not along the east bank. The floodplain measures approximately 6000 to 8000 feet in width and covers approximately 4000 acres, of which about 610 acres are in active agricultural production. The major factors that could influence flooding and damages are described below for six sections running from north to south along the reach.

1. Northern Avenue

The northern limit of the reach, Northern Avenue is a low water crossing which, during a 100-year event, will flow approximately 3750 feet wide and 5 feet deep. No structure is planned at this crossing.

2. Northern Avenue to Glendale Avenue

The floodplain spans approximately 6300 feet through this section of the reach, which contains one sand and gravel operation located about 1400 feet north of Glendale Avenue. Anticipating improvements to the Glendale Avenue Bridge, it appears that to prevent erosion downstream of the sand and gravel operation, Parcel 19 (Map 18) should be returned to its natural condition.

3. **Glendale Avenue**

Based on hydrology developed by the U.S. Army Corps of Engineers and a HEC-2 computer backwater analysis completed during the course of this study, the present top width of 570 feet at the Glendale Avenue Bridge is insufficient to carry projected 100-year flows without inundation of the bridge.

4. **Glendale Avenue to Camelback Road**

This section of the reach contains the confluence of the New River with the Agua Fria. The floodplain here measures approximately 8000 feet in width. Proposed developments in this area include an airport and an associated industrial park (Maps 18 and 19). The City of Glendale is planning the new airport facility north and east of the confluence of the Agua Fria River and New River. The facility is located east of 115th Avenue and south of Glendale Avenue. Approximately 50 percent of the proposed site is located in the 100-year floodplain. In order to protect this facility it will be necessary to build flood control levees along the Agua Fria River and New River.

5. **Camelback Road Bridge**

A major river crossing is planned for this road, with associated approaches and channalization. No plans are currently available. It is assumed here that this bridge will be designed to carry 100-year flows calculated by the U.S. Army Corps of Engineers with no associated increase in backwater depths.

6. **Camelback Road to Indian School Road**

The floodplain in this section of the reach varies in width between 1500 and 3400 feet, and the river inundates approximately 320 acres of agricultural land.

ELEMENTS OF PROPOSED ALTERNATIVE PROJECTS FOR REACH 3

- (a) Glendale Avenue Bridge, West Bank Protection. To increase the capacity of the Glendale Avenue Bridge enough to produce "Class A low flow," it is proposed that in addition to elements b and c, a levee be constructed beginning at a point 900 feet south of the west abutment of the bridge to a point 1100 feet north of the west abutment.

Estimated Costs

Element (a), Reach 3, Agua Fria River

Item No.	Description	Estimated Quantity	Unit	Unit Cost	Amount
1	Mobilization		L.S.	\$	\$ 2,500
2	Clearing and grubbing	4	Acres	350.00	1,400
3	Channel excavation	20,000	C.Y.	2.50	50,000
		TOTAL			\$ 53,900
	Land Rights Fee	5	Acres	6,000	\$ 30,000

- (b) Glendale Avenue Bridge, East Bank Protection. To funnel flow from a very wide floodplain through the Glendale Avenue Bridge, it is proposed that in conjunction with elements a and c, a levee be constructed along the east bank. It would begin at a point approximately 1800 feet south and east of the east abutment, run north to the east abutment, thence northeasterly approximately 1100 feet, and thence southeasterly approximately 1100 feet to the north embankment of Glendale Avenue. The total length of the levee would be about 4000 feet.

Estimated Costs

Element (b), Reach 3, Agua Fria River

Item No.	Description	Estimated Quantity	Unit	Unit Cost	Amount
1	Mobilization		L.S.	\$	\$ 10,000
2	Clearing and grubbing	15	Acres	350.00	5,250
3	Channel excavation	121,000	C.Y.	2.50	302,500
		TOTAL			\$ 317,750
	Land Rights Fee	5	Acres	6,000	\$ 30,000
	Land Rights Easement	5	Acres	2,000	\$ 10,000

- (c) Channel Improvements. In conjunction with elements a and b, it is proposed that the channel 500 feet upstream and 200 feet downstream of the Glendale Avenue Bridge be completely concrete lined, including the side slopes proposed in elements (a) and (b) above. A revetment blanket and filter fabric are to be placed 600 feet upstream and downstream of the concrete lining, across the entire channel width including the side slopes of the levees proposed in elements (a) and (b). To prevent possible erosion, it is proposed that the sand and gravel operations in Parcel 19, Map 9 be eliminated, and the parcel graded to return the river to a natural bottom.

Estimated Costs
Element (c), Reach 3, Agua Fria River

Item No.	Description	Estimated Quantity	Unit	Unit Cost	Amount
1	Mobilization		L.S.	\$	\$ 80,000
2	Clearing and grubbing	40	Acres	350.00	14,000
3	Channel Excavation	63,000	C.Y.	2.50	157,500
4	Filter fabric	133,000	S.Y.	1.00	133,000
5	A.B.C. filter material	62,000	S.Y.	6.00	372,000
6	Concrete lining	10,500	C.Y.	100.00	1,050,000
7	Revetment blanket	133,000	S.Y.	22.00	2,926,000
8	Purchase Parcel 19	40	Acres	10,000	400,000
		TOTAL			\$ 5,132,500
	Land Rights Fee	120	Acres	6,000	\$ 720,000

REACH 3

107th Avenue

PROPOSED GLENDALE AIRPORT

PROPOSED INDUSTRIAL PARK

Northern Avenue

Glendale Avenue

115th Avenue

Range Line

Township Line

AGUA

RIVER

FRIA

Element (c)

REMOVE SAND AND ROCK OPERATION RESTORE RIVER TO NATURAL CONDITION

Element (d)

Element (c)

Element (b)

PROPOSED BRIDGE LENGTHENING

Element (a)

EXISTING BRIDGE

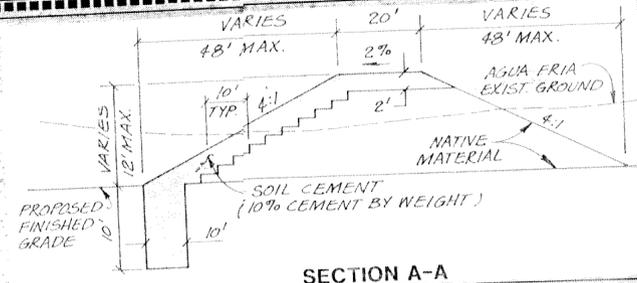
REVETMENT BLANKET
600'
500'
CONCRETE LINING

SEE NOTE

PROPOSED BRIDGE APPROACH

El Mirage Road

REACH NO. 3



NOTE:
ELEMENT (d) LENGTHEN BRIDGE TO 1400', RECONSTRUCT APPROACH, AND CHANNEL CLEANOUT

0 100 200 500 1000 Feet

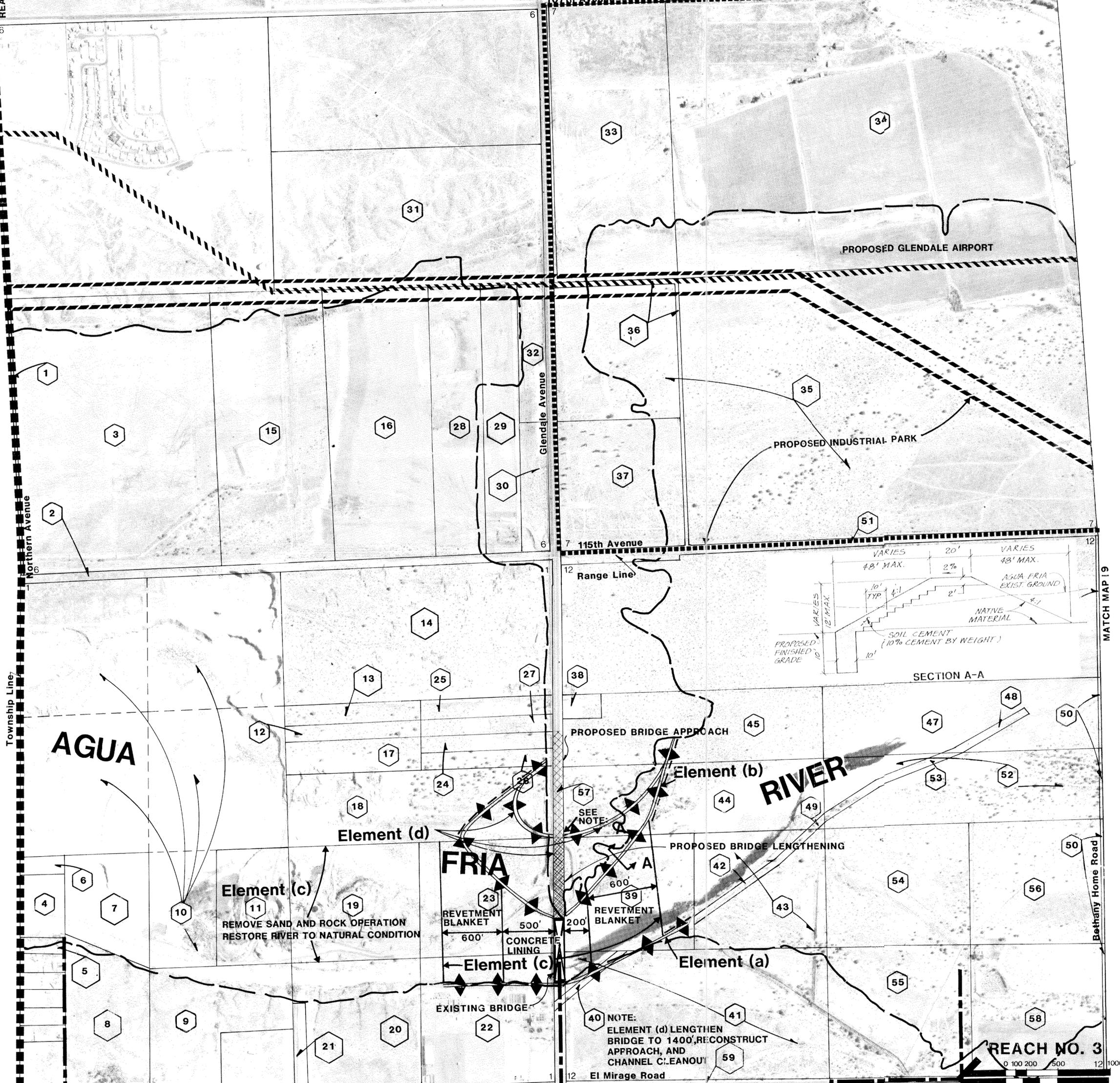
0 50 100 150 300 Meters

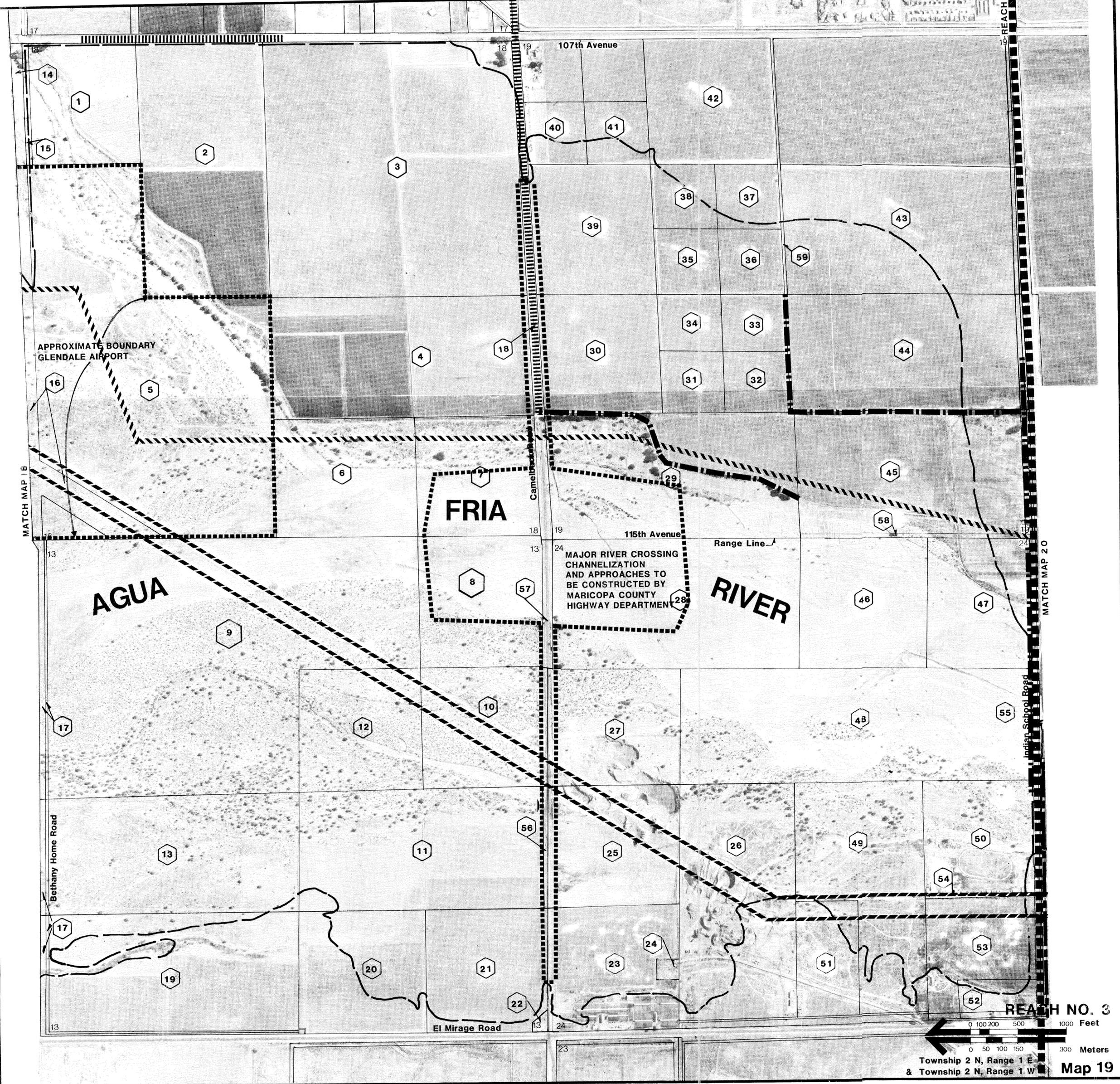
Township 2 N, Range 1 E & Township 2 N, Range 1 W

Map 18

MATCH MAP 19

Bethany Home Road





APPROXIMATE BOUNDARY
GLENDALE AIRPORT

FRIA

RIVER

AGUA

MAJOR RIVER CROSSING
CHANNELIZATION
AND APPROACHES TO
BE CONSTRUCTED BY
MARICOPA COUNTY
HIGHWAY DEPARTMENT

REACH NO. 3

0 100 200 500 1000 Feet

0 50 100 150 300 Meters

Township 2 N, Range 1 E
& Township 2 N, Range 1 W

Map 19

MATCH MAP 18

MATCH MAP 20

REACH 3

Indian School Road

107th Avenue

115th Avenue

El Mirage Road

Bethany Home Road

Camelback

Range Line

- (d) Glendale Avenue Bridge, Protection. In order to increase the capacity of the Glendale Avenue bridge to produce class A low flow, it is proposed that the bridge be lengthened at Glendale Avenue and its intersection with the Agua Fria River. Situated east of the existing bridge, the proposed lengthening would result in a finished top length of 1400 feet and a width of 60 feet. This element includes a levee along the east bank from 900 feet north of the bridge to 1200 feet south, and the levee proposed in element (a), including channelization of the river in the immediate vicinity of the bridge.

Estimated Costs

Element (d), Reach 3, Agua Fria River

Item No.	Description	Estimated Quantity	Unit	Unit Cost	Amount
1	Mobilization	1	L.S.	47,500	\$ 47,500
2	Clear & Grub	96	Acres	350	33,600
3	Channel Excavation	219,000	C.Y.	2.50	547,500
4	Rock Rip Rap	4,700	C.Y.	15	70,500
5	Hydromulch	60,000	S.Y.	.05	3,000
6	Bridge Construction	50,400	S.F.	40.00	2,016,000
		TOTAL			\$ 2,718,100
	Land Rights Fee	100	Acres	6,000	\$ 600,000

PROPOSED ALTERNATIVE PROJECTS FOR REACH 3

Alternative Project 1, Reach 3, Agua Fria River

This project would combine the following elements:

- (a) Levee construction, west bank at Glendale Avenue Bridge
- (b) Levee construction, east bank at Glendale Avenue Bridge
- (c) Installation of concrete lined channel near Glendale Avenue Bridge

Estimated construction cost for this alternative is \$5,504,150.

Estimated landrights cost for this alternative is \$790,000.

Alternative Project 2, Reach 3, Agua Fria River

This project would combine the following elements:

- (a) Levee construction, west bank at Glendale Avenue Bridge
- (d) Lengthening of bridge plus levee construction along the east bank and channelization.

Estimated construction cost for this alternative is \$2,772,000.

Estimated landrights cost for this alternative is \$630,000.

ENVIRONMENTAL IMPACTS FOR REACH 3

Elements of Alternative Projects

Four elements of construction have been proposed for Reach 3. They are summarized below:

- (a) Construct a levee along the west bank at Glendale Avenue.
- (b) Construct a levee along the east bank at Glendale Avenue.
- (c) Concrete-line and otherwise improve the channel at the Glendale Avenue Bridge.
- (d) Lengthen the Glendale Avenue Bridge and build the levees proposed in Elements (a) and (b).

Affected Environment

Immediately north of Bethany Home Road and approaching the Agua Fria's confluence with the New River, the study area supports significant stands of riparian habitat. Sycamore and mesquite trees occur, with both birds and ground dwelling animals increasing in number and kind. This riparian environment continues along close to the banks of the Agua Fria throughout the remainder of the reach to Indian School Road. In the vicinity of Bethany Home Road on the west bank of the river, there is a wildlife habitat area designated as highly sensitive in the Environmental Impact Study for the New River and Phoenix City Streams Report conducted by the U.S. Army Corps of Engineers, who recommend that this

area be preserved. They also recommend that the remainder of the riparian habitat between Bethany Home Road and Indian School Road be given adequate consideration for preservation as an open-space buffer adjacent to vegetation. The Corps of Engineers' recommendations have been taken into consideration, where practical, in the development of the proposed projects.

At each of the major river crossings in the reach--Northern Avenue, Glendale Avenue, Camelback Road, and Indian School Road--are found man-made structures and activities including landfill operations, sand and gravel extraction sites, single-family homes and trailers, auto wrecking firms, and horse corrals. None of these extend into the river itself except for a large sand and gravel extraction operation between Northern and Glendale Avenues. Near the Glendale Avenue crossing, in the vicinity of El Mirage Road but outside the 100-year floodplain, there is a wastewater treatment facility for Luke Air Force Base.

The primary land use between the river crossings is vacant land. Agricultural lands are located close to the east bank of the Agua Fria below the confluence with the New River, between Camelback Road and Indian School Road.

A new Glendale Airport is proposed to be located north of the confluence of New River and the Agua Fria. The site chosen for the new airport facility is currently used for agricultural purposes along the west bank of New River where it drains into the Agua Fria. A pair of 230 kv transmission lines cross the reach immediately to the north of the New-River/Agua-Fria-River confluence.

A cultural resources survey has not been conducted along this reach of the Agua Fria River. There is a moderate likelihood that historic or prehistoric cultural resources are located in the vicinity of the proposed project locations, although any sites that may have existed have certainly been disturbed by various human activities. This area was rated moderately sensitive by the Office of Cultural Resources Management at Arizona State University. A cultural resource survey may need to be conducted prior to any construction.

Short Term Impacts

No serious environmental impacts have been identified with the construction activities proposed for Reach 3, although biological resources will be affected. Construction-related short term impacts would include the following:

1. Channelization and concrete lining at Glendale Avenue would produce some alteration of vegetation and wildlife habitats. Because of the sparseness of vegetation and wildlife at the construction site, no significant adverse impacts are anticipated. No rare or protected species of plants or animals have been identified in the vicinity.
2. Channelization and construction of the concrete lining will create noise and fugitive dust that will be present throughout the construction period.
3. No significant impacts to historic or prehistoric cultural resources are anticipated as a result of construction activities, based on existing information.

Mitigation Measures for Short Term Impacts

Although no endangered or protected species of plant or animal life have been identified at the proposed construction site, construction activities should be undertaken with a maximum regard for the preservation of vegetation and wildlife. A survey of the site proposed for the concrete lining may need to be conducted prior to the beginning of work, and, based on the survey, construction monitoring may be recommended to insure protection of vegetation and wildlife habitats.

Mitigation measures recommended for the control of noise and dust include confining operations to daylight hours to lessen the nuisance impact of noise, and watering of dirt roads to control fugitive dust.

A cultural resources survey of the site should be conducted prior to construction, and, depending on the results of the survey, construction monitoring may be recommended to ensure protection of historic and prehistoric resources.

Long Term Impacts

No significant long term adverse impacts are anticipated. Limited maintenance will be required. The concrete-lined channel may partially impede terrestrial wildlife movements.

REACH 4: INDIAN SCHOOL ROAD TO BUCKEYE ROAD

REACH DESCRIPTION

Reach 4 begins at Indian School Road and extends approximately 4.4 miles south to Buckeye Road.

This reach meanders through highly developed agricultural land, portions of urbanized Avondale, and vacant land. Encompassing four sand and gravel operations, four existing major river crossings and one freeway river crossing, Reach 4 contains 2750 acres of land within the 100-year floodplain, of which 1440 acres are in active agricultural production. Major factors that could influence flooding and damages are described below for each of eleven consecutive segments from north to south along the reach.

1. Indian School Road Bridge

Indian School Road Bridge had two spans washed out during the 1980 flood. It is assumed here that this bridge will be rebuilt at its original location. A HEC-2 computer backwater analysis was performed based upon hydrology developed by the U.S. Army Corps of Engineers, Los Angeles, and it indicates that potential flows will be "Class A low flow."

2. Indian School Road to Roosevelt Irrigation District Canal Flume

Two sand and gravel operations lie in this section, one on the west bank and one on the east bank. These operations have encroached on the river channel to the point that the flow through the Indian School Road Bridge is severely limited, causing appreciable backwater into Reach 3.

3. Roosevelt Irrigation District Canal Flume

This flume, constructed in 1928, is located approximately 2200 feet south of Indian School Road and is a major link in transporting irrigation water to the Roosevelt District. The flume is about 6000 feet long and stands an average 17 feet above the Agua Fria River. A hydraulic analysis of this structure using a HEC-2 backwater analysis program and hydrology developed by the U.S. Army Corps of Engineers, Los Angeles, puts flow through this structure into the "Class A low flow" category. No improvements to this structure are required.

4. Roosevelt Irrigation District Canal Flume to Thomas Road

This section of the reach contains portions of the sand and gravel operations mentioned above, and the floodplain contains approximately 140 acres of farmland in active production. Both sand and gravel operations and the farmlands are vulnerable to inundation, however, its sand and gravel operations probably contribute to the flooding hazard in the area.

5. Thomas Road

Thomas Road does not now cross the Agua Fria River, however, future urbanization and increased traffic may warrant a major river crossing or a low water crossing at this location. This section presents no past effects on flooding.

6. Thomas Road to McDowell Road

The established floodplain in this section of the reach contains approximately 600 acres, of which 480 acres are in active agricultural production. A "dog leg," created between 1930 and 1940 as the result of encroachment of

agricultural land from the west, causes slowing of the river's overbank flow and flooding of agricultural land lying west of the low-flow channel.

7. McDowell Road Bridge

The Maricopa County Highway Department is developing plans for a major river crossing at McDowell Road with associated channelization and approaches. The structure will be designed with sufficient capacity to carry 100-year flows in accordance with hydrology developed by the U.S. Army Corps of Engineers, Los Angeles. With no associated increases in backwater depths anticipated, this structure should not affect future flooding.

8. McDowell Road to Interstate 10

The "dog leg" mentioned in section 6 above significantly restricts flow through this section of the reach, causing backwater. The Arizona State Department of Transportation has purchased considerable acreage to date in this part of Reach 4 for embankment construction and flowage easements in conjunction with the completion of the Interstate 10 Bridges.

9. Interstate 10 Bridges

The two bridges for Interstate 10, one for east bound, one for west bound traffic measure 1502 feet at the top and stand about 22 feet above the main channel bed. Hydrologic analysis conducted in the course of this study and by the Arizona Department of Transportation indicates that these bridges will operate as "Class A low flow" and should not affect flooding after the approaches are constructed.

10. Interstate 10 Diversion Channel

This channel will be built along the north side of Interstate 10 from 27th Avenue to the Agua Fria River and will drain an area of approximately 45 square miles. Peak flows from the diversion channel are not expected to exceed 9300 cfs and will not affect peak flows on the river. Allowances for this inlet must be incorporated into the design of any Agua Fria levee or channelization work in this area.

11. Interstate 10 to Buckeye Road

From the Interstate 10 Bridges, the Agua Fria River flows through urbanized sections of Avondale on the west and highly developed agricultural land on the east. The floodplain in this section is about 5200 feet wide. A sand and gravel operation located immediately north of Van Buren Street affects upstream flooding only minimally. If this business were to expand to its property limit on the north, however, backscour to the Interstate 10 Bridges could occur, endangering their foundations.

Lying immediately south of the sand and gravel operation, Van Buren Street is a low water river crossing. Future development may warrant that this crossing be upgraded. Presently, Van Buren Street requires maintenance after each major flow in the Agua Fria River.

Another feature of this section of Reach 4 is an abandoned landfill owned by Maricopa County, located immediately north of Buckeye Road. The location and height of the landfill are such that the effects on flows and flooding along the Agua Fria at Buckeye Road are minimal. Erosion of the cover over this landfill could occur, however, with the resulting exposure and transport of refuse posing a potential health hazard.

ELEMENTS OF PROPOSED ALTERNATIVE PROJECTS FOR REACH 4

- (a) Indian School Road to the Roosevelt Irrigation District Canal Flume Protection. Encroachments of sand and gravel operations into the river have narrowed the channel to 400 feet in this area, causing backwater and possible backscour as far as the Indian School Road Bridge. It is proposed that levees be constructed on both sides of the river from the east and west abutments of the Indian School Road Bridge south approximately 2000 feet to points on either side of the Roosevelt Irrigation District Canal Flume. The two levees would stand approximately 10 feet above the channel bottom.

Estimated Costs

Element (a), Reach 4, Agua Fria River

Item No.	Description	Estimated Quantity	Unit	Unit Cost	Amount
1	Mobilization		L.S.	\$	\$ 40,000
2	Clearing and grubbing	12	Acres	350.00	4,200
3	Channel excavation	105,000	C.Y.	2.50	262,500
4	Soil cement	34,000	C.Y.	30.00	1,020,000
5	Reinforced concrete culvert	2	Each	8,000.00	16,000
6	Hydromulch	120,000	S.F.	0.05	6,000
7	R/W requirements	75	Acres	10,000.00	750,000
		TOTAL			\$ 2,098,700
	Land Rights Fee	15	Acres	6,000	\$ 90,000

(b) Indian School Road to Roosevelt Irrigation District Canal Flume, Protection.

In order to keep levee heights minimal yet protect the Indian School Road Bridge from potential backscour damage, it is proposed that in conjunction with Element (a), the river bottom be excavated and graded to form a channel with a 1600-foot bottom width from the Indian School Road Bridge to the Roosevelt Irrigation District Canal Flume.

Estimated Costs

Element (b), Reach 4, Agua Fria River

Item No.	Description	Estimated Quantity	Unit	Unit Cost	Amount
1	Mobilization		L.S.	\$	\$ 0*
2	Clearing and grubbing	55	Acres	350.00	19,250
3	Channel excavation	80,000	C.Y.	2.50	200,000**
		TOTAL			\$ 219,250
	Land Rights Fee	80	Acres	6,000	\$ 480,000

*Mobilization included in Element (a).

**Additional excavation required as part of Element (a).

- (c) Roosevelt Irrigation District Canal Flume to Thomas Road, Protection.
Levee construction, channel relocation, excavation, and grading are proposed to protect this segment of the reach. The channel relocation would move the river to a more favorable alignment to improve and protect proposed crossings downstream at McDowell Road and Interstate 10. This new channel would have a 1150 to 1600 foot wide bottom, 3:1 side slopes, and banks standing 13 feet above the river bottom, giving 3 feet of freeboard above projected 100-year flows.

Estimated Costs

Element (c), Reach 4, Agua Fria River

Item No.	Description	Estimated Quantity	Unit	Unit Cost	Amount
1	Mobilization		L.S.	\$	\$ 70,000
2	Clearing and grubbing	160	Acres	350.00	56,000
3	Channel excavation	1,300,000	C.Y.	2.50	3,250,000
4	Soil cement	89,000	C.Y.	30.00	2,670,000
5	Reinforced concrete culvert	2	Each	8,000.00	16,000
6	Hydromulch	188,000	S.F.	0.05	9,400
		TOTAL			\$ 6,071,400
	Land Rights Fee	100	Acres	6,000	\$ 600,000

- (d) Thomas Road to Interstate 10, Protection. It is proposed that this section of the river be relocated to eliminate the man-made "dogleg," improve flows, and protect proposed crossings and embankments at McDowell Road and Interstate 10. The proposed relocation would realign the river on a more direct path west of its present location. From Thomas Road to McDowell Road, the new channel would have a bottom width of 1150 feet, 3:1 side slopes, and banks and levees standing 13 feet above the proposed river bottom. From McDowell Road to Interstate 10, the channel bottom would gradually widen from 1150 to about 1500 feet.

Estimated Costs
Element (d), Reach 4, Agua Fria River

Item No.	Description	Estimated Quantity	Unit	Unit Cost	Amount
1	Mobilization		L.S.	\$	\$ 140,000
2	Clearing and grubbing	320	Acres	350.00	112,000
3	Channel excavation	2,872,000	C.Y.	2.50	7,180,000
4	Soil cement	183,000	C.Y.	30.00	5,490,000
5	Reinforced concrete culvert	1	Each	8,000.00	8,000
6	Hydromulch	200,000	S.F.	0.05	10,000
		TOTAL			\$ 12,940,000
	Land Rights Fee	270	Acres	6,000	\$ 1,620,000

- (e) Interstate 10 to Buckeye Road, Protection. To protect approximately 600 acres of active agricultural land in the east floodplain, and approximately 80 acres of active agricultural land and 45 commercial and residential parcels in the west floodplain, it is proposed that this section be channelized. To keep right-of-way requirements and excavation costs to a minimum, the channel would have a bottom width of 1150 feet. Levees are proposed for both sides of the channel with heights 13 feet above the channel bottom and a curvilinear alignment. A 100-year flow would have velocities of 7 to 9 feet per second requiring slope protection for this element.

Estimated Costs
Element (e), Reach 4, Agua Fria River

Item No.	Description	Estimated Quantity	Unit	Unit Cost	Amount
1	Mobilization		L.S.	\$	\$ 140,000
2	Clearing and grubbing	230	Acres	350.00	80,500
3	Channel excavation	1,150,000	C.Y.	2.50	2,875,000
4	Soil cement	135,000	C.Y.	30.00	4,050,000
5	Reinforced concrete culvert	4	Each	5,000.00	20,000
6	Hydromulch	285,000	S.F.	0.05	14,250
		TOTAL			\$ 7,179,750
	Land Rights Fee	255	Acres	6,000	\$ 1,530,000

- (f) Interstate 10 to Buckeye Road, Local Protection. To protect urbanized portions of Avondale along the west bank of this section, it is proposed that a levee be constructed. The levee would stand 2 to 13 feet above natural ground and have 4:1 side slopes, and would start at Interstate 10 Bridge abutment and run south approximately 7000 feet to the abutment of Buckeye Road.

Estimated Costs

Element (f), Reach 4, Agua Fria River

Item No.	Description	Estimated Quantity	Unit	Unit Cost	Amount
1	Mobilization		L.S.	\$	\$ 60,000
2	Clearing and grubbing	18	Acres	350.00	6,300
3	Channel excavation	158,000	C.Y.	2.50	395,000
4	Soil cement	68,000	C.Y.	30.00	2,040,000
5	Reinforced concrete culvert	2	Each	5,000.00	10,000
6	Hydromulch	300,000	S.F.	0.05	15,000
		TOTAL			\$ 2,526,300
	Land Rights Easement	30	Acres	2,000	\$ 60,000

PROPOSED ALTERNATIVE PROJECTS FOR REACH 4

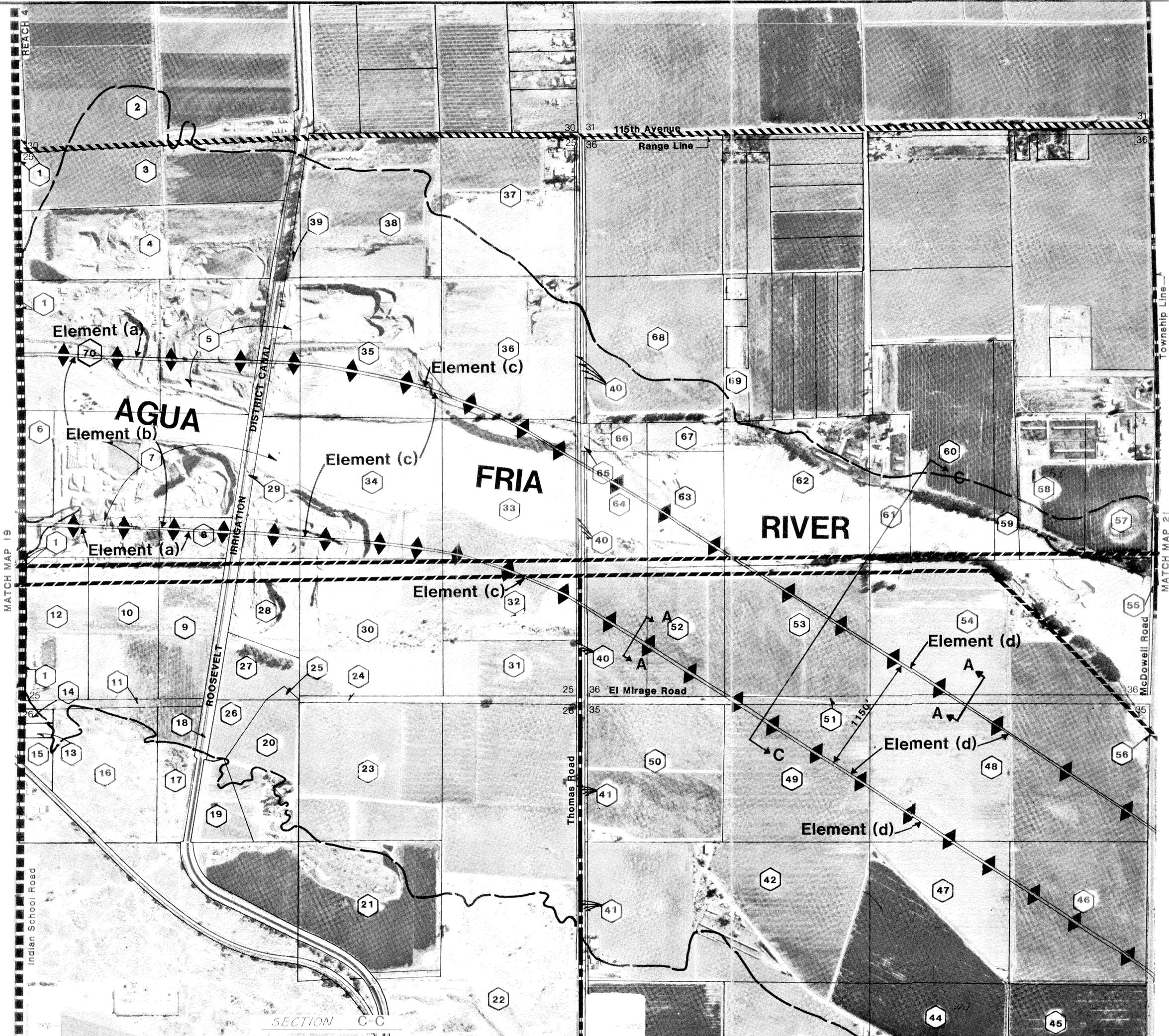
Alternative Project 1, Reach 4, Agua Fria River

This project would combine the following elements:

- (a) Levee construction, east and west banks, Indian School Road to the Roosevelt Irrigation District Canal Flume
- (b) Channel excavation and grading, Indian School Road to the Roosevelt Irrigation District Canal Flume
- (c) Channel relocation and levee construction from the Roosevelt Irrigation District Canal Flume to Thomas Road
- (d) Channel relocation and levee construction from Thomas Road to Interstate 10
- (e) Channelization and levee construction from Interstate 10 to Buckeye Road

Estimated construction cost for this alternative is \$28,509,100.

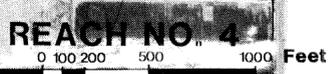
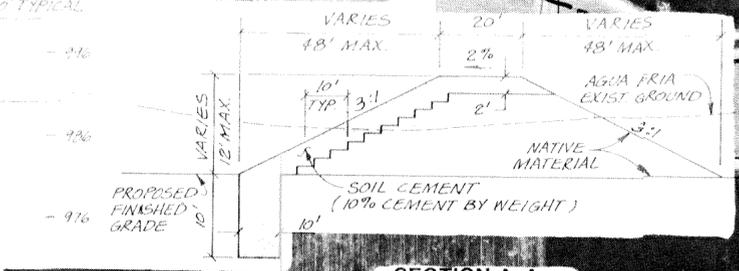
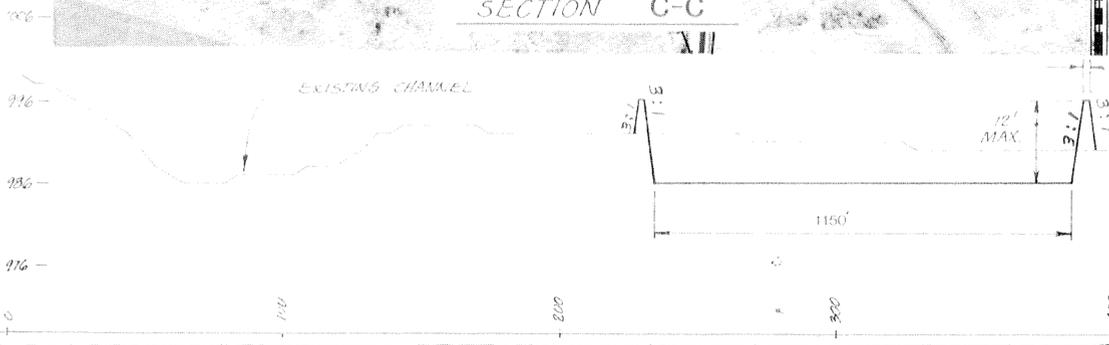
Estimated landrights cost for this alternative is \$4,320,000.



MATCH MAP 19

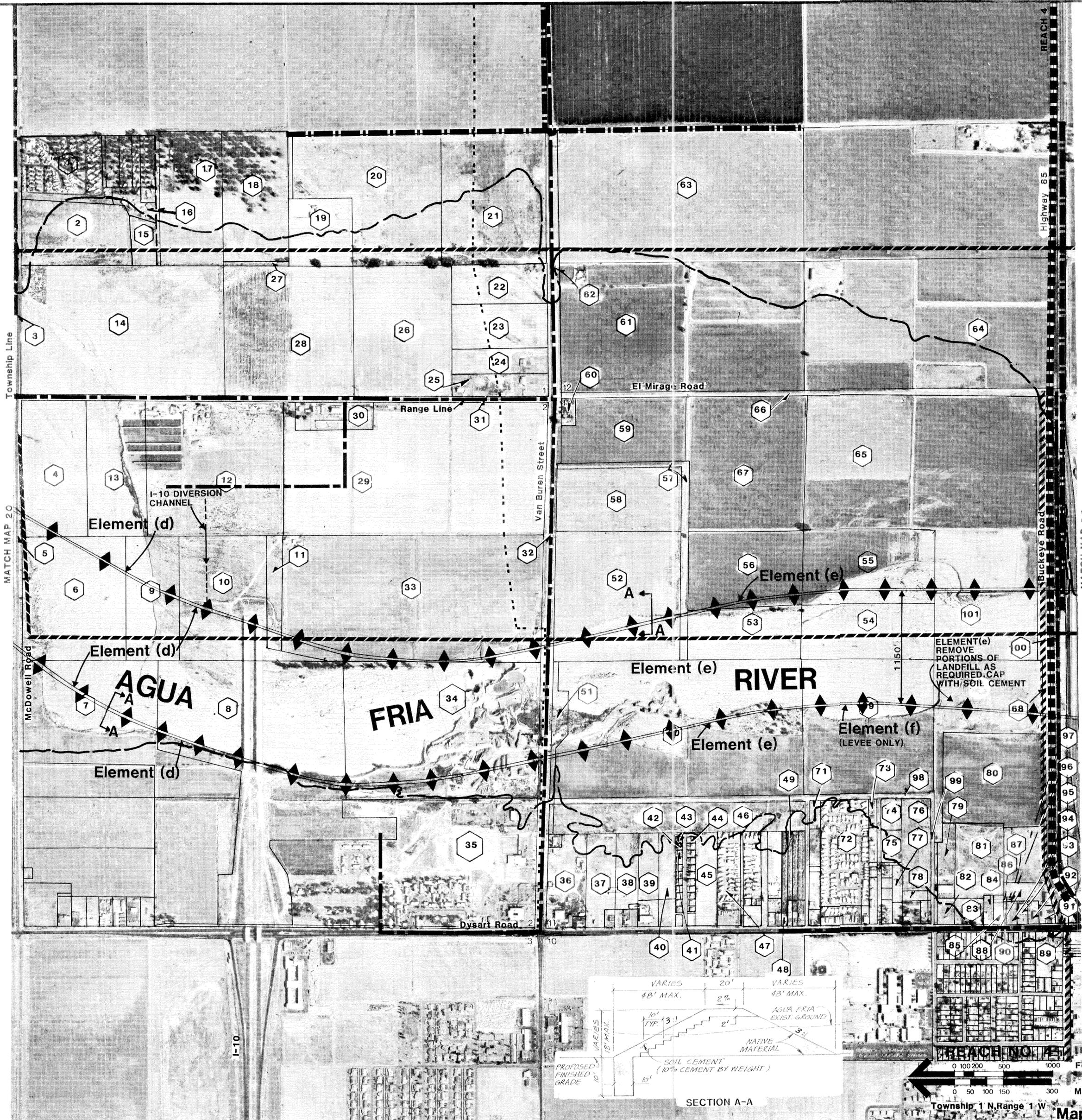
MATCH MAP 21

SECTION C-C



SECTION A-A

Township 2 N. Range 1 E. & Township 2 N. Range 1 W. Map 20



Township Line

MATCH MAP 20

McDowell Road

I-10

Element (d)

Element (d)

Element (d)

I-10 DIVERSION CHANNEL

AGUA FRIA

FRIA

Range Line

Van Buren Street

Dysart Road

El Mirage Road

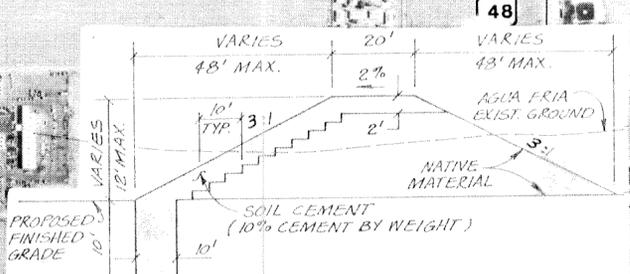
Element (e)

RIVER

Element (e)

Element (f)
(LEVEE ONLY)

ELEMENT (e)
REMOVE PORTIONS OF
LANDFILL AS
REQUIRED. CAP
WITH SOIL CEMENT



Township 1 N. Range 1 W. Map 21

REACH 4
Highway 85

Buckeye Road

MATCH MAP 22

Alternative Project 2, Reach 4, Agua Fria River

This project would combine the following elements:

- (a) Levee construction, east and west banks, Indian School Road to the Roosevelt Irrigation District Canal Flume
- (b) Channel excavation and grading, Indian School Road to the Roosevelt Irrigation District Canal Flume
- (c) Channel relocation and levee construction from the Roosevelt Irrigation District Canal Flume to Thomas Road
- (d) Channel relocation and levee construction from Thomas Road to Interstate 10
- (f) Levee construction, west bank (local protection only)

Estimated construction cost for this alternative is \$23,855,650.

Estimated landrights cost for this alternative is \$2,850,000.

ENVIRONMENTAL IMPACTS FOR REACH 4

Elements of Alternative Projects

Six elements of construction have been proposed for Reach 4. They are summarized below:

- (a) Construct levees on the east and west banks from Indian School Road to the Roosevelt Irrigation District Canal Flume.
- (b) Excavate and grade channel to 1600 feet in width.
- (c) Construct levees and relocate the channel from the Roosevelt Irrigation District Canal Flume to Thomas Road.
- (d) Construct levees and relocate the channel from Thomas Road to the Interstate 10 Bridges.
- (e) Construct levees and channelize river from the Interstate 10 to Buckeye Road.
- (f) Construct a levee along the west bank from Interstate 10 to Buckeye Road.

Affected Environment

Reach 4 of the Agua Fria River, which extends from Indian School Road to Buckeye Road, contains a variety of natural settings and human activities. Immediately downstream from the Indian School Bridge, large sand and gravel extraction operations extend into the river. The Roosevelt Irrigation District canal crosses the Agua Fria between Indian School Road and Thomas Road, carried over the riverbed in an elevated flume.

Beginning just north of Thomas Road and extending for the remainder of the reach, agricultural lands lie along both sides of the river and abut the river's banks. These are irrigated farmlands planted to a variety of crops, principally cotton and melons. Commercial packing and shipping operations are located along and close to the river between Thomas and McDowell Roads. Also from Thomas to McDowell, a thin fringe of riparian habitat lines both sides of the river. There are scattered riparian areas south of McDowell Road for the remainder of the reach.

Just north of Van Buren Street, a large sand and gravel extraction operation extends from bank to bank. A landfill, which is now closed, is located in the immediate vicinity as well.

Roadway access to Reach 4 is provided by river crossings at Indian School Road, McDowell Road, Van Buren Street, and Buckeye Road; in addition, there are a number of county and private roads that lead to the agricultural and commercial operations along the river.

No protected or endangered species of plant or animal life have been reported for Reach 4, but the area on both sides of the river, from Thomas Road to the I-10 overpass, was recommended by the U.S. Army Corps of Engineers' New River - Phoenix City Streams Study for preservation as an open-space buffer adjacent to vegetation. This includes both riparian habitat and land that is currently used for agricultural purposes.

A cultural resources survey has not been conducted along this reach of the Agua Fria River. The occurrence of historic or prehistoric resources is feasible, although any sites that may have existed have most likely been disturbed by various human activities and flooding. Reach 4 has been rated as moderately sensitive by the Office of Cultural Resources Management at Arizona State University, based on the overall density and quality of archaeological resources in the entire study area. A cultural resources survey will need to be conducted prior to any construction.

Paralleling the river throughout the reach within or adjacent to the floodplain are 230 kv transmission line corridors, which cross the riverbed both north and south of McDowell Road.

Short Term Impacts

No serious adverse environmental impacts have been identified in conjunction with the construction activities proposed for Reach 4. Biological and cultural resources may be affected, however. Construction related short term impacts would include the following:

1. Channelization and clean-out will cause noise and fugitive dust during the entire activity period.
2. If any sand and gravel operations are relocated, the relocation site should be environmentally acceptable.
3. No significant impacts to historic or prehistoric cultural resources are anticipated as a result of construction activities, based on existing information.
4. Transmission line towers standing in the path of the proposed channel would likely need to be modified to withstand projected flood flows.

Mitigation Measures for Short Term Impacts

1. All proposed activities should be undertaken with maximum attention to the protection of vegetation and wildlife. Particular care should be taken in the vicinity of the riparian environments. Monitoring of activities in this area should be recommended to ensure environmental protection.
2. All proposed activities should be undertaken with maximum regard for man-made facilities and activities. Particular attention should be devoted to the protection of wells, and other components of agricultural operations.
3. Fugitive dust should be controlled, as necessary, by watering down dirt roads. The nuisance factors of noise should be reduced by confining construction activities to daylight hours.

4. A cultural resources survey covering the reach may need to be conducted prior to the start of construction activities. Depending on survey results, construction monitoring may be recommended to insure protection of historic and prehistoric resources. When spoil disposal sites are identified, these areas should be surveyed to determine the potential for cultural resource impacts attributable to spoil disposal.

Long Term Impacts

1. The new channel between Thomas and McDowell Roads will permanently remove approximately 200 acres of land from agricultural use.
2. Vegetation and wildlife habitat will be altered to some extent. Channelization will require the removal of some vegetation.
3. The purchase of land on either side of the channel will also affect agricultural lands. Obtaining flowage easements, however, will protect both natural and man-made environments in the event of flooding.
4. Relocating or limiting the sand and gravel operations will have no long term adverse effects.
5. There will be no long term effects to the area's transportation system.
6. Limited annual maintenance will be required, but should not pose any effects to the area.

Mitigation Measures for Long Term Impacts

Elements of projects for this reach should be designed to achieve maximum environmental protection. Development should occur in such a way so as not to totally disrupt terrestrial wildlife movements. No other mitigation efforts have been identified except for the monitoring of annual maintenance activities.

REACH 5: BUCKEYE ROAD TO THE GILA RIVER

REACH DESCRIPTION

Reach 5 begins at the Buckeye Road Bridge and extends approximately 3.4 miles south to the Gila River. The floodplain in the south half of this reach is heavily influenced by flows in the Gila River.

The established floodplain covers 2900 acres, which includes 1050 acres in active agricultural production, and 110 acres of urbanized area in the City of Avondale. The balance of the land is either riverbed or vacant. Major factors that could affect flooding are discussed below for three sections running north to south along the reach.

1. Buckeye Road Bridge and Southern Pacific Railroad Bridge

Buckeye Road Bridge is about 1150 feet long and stands approximately 12.5 feet above the riverbed. A hydraulic analysis of this structure conducted during the course of this study using hydrology developed by the U.S. Army Corps of Engineers, Los Angeles, puts this structure in the "Class A low flow" category. Therefore, no improvements to the bridge are proposed.

The Southern Pacific Railroad Bridge is located immediately north of and parallel to Buckeye Road. This bridge is approximately 1500 feet long, top width, and is constructed approximately 13 feet above the channel bottom. Based on a HEC 2 computer backwater analysis using hydrology developed by the Corps of Engineers, it was determined that this structure will also operate as "Class A Low Flow." No improvements are required at this structure.

2. **Buckeye Road to Lower Buckeye Road**

This section of the Reach 5 contains approximately 140 commercial and residential parcels and 30 acres of active agricultural land within the established floodplain. Based upon preliminary hydraulic calculations using the above-referenced hydrology, it appears that approximately 30 to 50 additional commercial tracts and residential units will be affected by 100 year level flows.

The City of Avondale proposes to improve Dysart Road from Buckeye Road to Lower Buckeye Road, all within the established floodplain.

Lower Buckeye Road is a low water crossing. Although it does not affect flooding, this road will sustain damages from floods with ten-year or less frequencies, and its maintenance therefore must be considered in any flood control measure.

3. **Lower Buckeye Road to the Confluence with the Gila River**

This section of the reach contains approximately 2350 acres in the established floodplain, of which 1050 acres are in active agricultural production. Approximately one-half of the land in this section is affected by flows in the Gila River.

The City of Avondale's sewage treatment facility is located immediately south of Lower Buckeye Road and west of the low-flow channel of the Agua Fria River. On the east side of the floodplain lie several individual farming operations with structures ranging from residential housing to agricultural storage barns. These structures are susceptible to flooding during any storm with a 10-year or less frequency.

ELEMENTS OF PROPOSED ALTERNATIVE PROJECTS FOR REACH 5

- (a) City of Avondale, Protection. To protect developed portions of the City of Avondale as well as its sewage treatment facility from future flooding, it is proposed that a levee be constructed from the west abutment of the Buckeye Road Bridge southwesterly to Dysart Road, thence south along Dysart Road to Lower Buckeye Road, thence southwesterly around the Avondale Sewage Treatment Plant, and terminate at a well established bank. The total length of this levee would be approximately 8600 feet.

Estimated Costs

Element (a), Reach 5, Agua Fria River

Item No.	Description	Estimated Quantity	Unit	Unit Cost	Amount
1	Mobilization		L.S.	\$	\$ 70,000
2	Clearing and grubbing	25	Acres	350.00	8,750
3	Import (embankment)	100,000	C.Y.	2.50	250,000
4	Soil cement	96,000	C.Y.	30.00	2,880,000
5	Reinforced concrete culvert	2	Each	5,000	10,000
6	Hydromulch	237,000	S.F.	0.05	11,850
7	Roadway excavation	4,000	C.Y.	2.50	10,000
8	Rip rap bank protection	8,000	C.Y.	7.00	56,000
		TOTAL			\$ 3,296,600
	Land Rights Easement	25	Acres	2,000	\$ 50,000

- (b) West Bank, Stabilization. To protect parcels on the west bank from further erosion and possible structural damage, it is proposed that the bank be stabilized from the termination of the levee proposed in Element (a) southwesterly along the existing bank to a point approximately 1400 feet north of Broadway Road. The total length of the bank stabilization would be approximately 3700 feet.

Estimated Costs

Element (b), Reach 5, Agua Fria River

Item No.	Description	Estimated Quantity	Unit	Unit Cost	Amount
1	Mobilization		L.S.	\$	\$ 20,000
2	Clearing and grubbing	4	Acres	350.00	1,400
3	Soil cement bank stabilization	31,500	C.Y.	30.00	945,000
		TOTAL			\$ 966,400
	Land Rights Easement	15	Acres	2,000	\$ 30,000

- (c) West Bank, Agricultural Land and Buckeye Irrigation District, Protection. To protect approximately 600 acres of agricultural land and the headworks of the Buckeye Irrigation District from damage during flooding, it is proposed that a levee be constructed from a point 1400 feet north of Broadway Road, thence southwesterly 7500 feet to Southern Avenue, thence west 4700 feet to Bullard Avenue, for a total length of about 12,200 feet. Construction of a box culvert and realignment of the Buckeye Irrigation District Canal through the levee will also be necessary. The construction of this element should be coordinated with the bridge crossing proposed for Bullard Avenue. Neither Broadway Road nor Southern Avenue cross the Agua Fria River, and no provision for their crossing is included in this study.

Estimated Costs

Element (c), Reach 5, Agua Fria River

Item No.	Description	Estimated Quantity	Unit	Unit Cost	Amount
1	Mobilization		L.S.	\$	\$ 70,000
2	Clearing and grubbing	45	Acres	350.00	15,750
3	Import (embankment)	242,500	C.Y.	2.00	485,000
4	Soil cement	104,000	C.Y.	30.00	3,120,000
5	Reinforced concrete culvert	2	Each	5,000	10,000
6	Reinforced concrete box culvert	1	Each	30,000	30,000
7	Ditch excavation	1,200	C.Y.	2.00	2,400
8	Hydromulch	476,000	S.F.	0.05	23,800
		TOTAL			\$ 3,756,950
	Land Rights Easement	35	Acres	2,000	\$ 70,000

- (d) East Floodplain, Development Protection. To protect four residential lots and one industrial operation located south and east of the Buckeye Road Bridge, it is proposed that a levee be constructed beginning at the southeast abutment of Buckeye Road Bridge, thence south approximately 1200 feet, thence east approximately 1200 feet to a point outside the floodplain.

Estimated Costs

Element (d), Reach 5, Agua Fria River

Item No.	Description	Estimated Quantity	Unit	Unit Cost	Amount
1	Mobilization		L.S.	\$	\$ 10,000
2	Clearing and grubbing	6	Acres	350.00	2,100
3	Import (embankment)	48,000	C.Y.	2.50	120,000
4	Soil cement	20,500	C.Y.	30.00	615,000
5	Reinforced concrete culvert	1	Each	5,000	5,000
6	Hydromulch	94,000	S.F.	0.05	4,700
		TOTAL			\$ 756,800
	Land Rights Easement	10	Acres	2,000	\$ 20,000

(e) East Floodplain, Subdivision Protection. To protect an existing subdivision with approximately 40 lots within the floodplain, it is proposed that a flood protection levee be constructed. The levee would begin at a point 1100 feet south of Lower Buckeye Road, then run north to a point approximately 800 feet north of Lower Buckeye Road, thence east approximately 1000 feet to a point outside the floodplain. In association with this levee, the existing low water crossing at Lower Buckeye Road should be constructed over the levee.

Estimated Costs

Element (e), Reach 5, Agua Fria River

Item No.	Description	Estimated Quantity	Unit	Unit Cost	Amount
1	Mobilization		L.S.	\$	\$ 20,000
2	Clearing and grubbing	8	Acre	350	2,800
3	Import (embankment)	63,000	C.Y.	2.50	157,500
4	Soil cement	25,000	C.Y.	30.00	750,000
5	Reinforced concrete culvert	1	Each	5,000	5,000
6	Roadway excavation	4,000	C.Y.	2.50	10,000
7	Rock rip rap	8,000	S.Y.	7.00	56,000
8	Hydromulch	140,000	S.F.	0.05	7,000
		TOTAL			\$ 1,008,300
	Land Rights Easement	10	Acres	2,000	\$ 20,000

- (f) East Floodplain, Development and Subdivision Protection. This element would combine the protection proposed in elements (d) and (e) above. Instead of turning the levees east to a point outside the floodplain, however, it is proposed here to connect these two projects to form a single levee.

Estimated Costs

Element (f), Reach 5, Agua Fria River

Item No.	Description	Estimated Quantity	Unit	Unit Cost	Amount
1	Mobilization		L.S.	\$	\$ 30,000
2	Clearing and grubbing	20	Acre	350	7,000
3	Import (embankment)	142,000	C.Y.	2.50	355,000
4	Soil cement	56,000	C.Y.	30.00	1,680,000
5	Reinforced concrete culvert	2	Each	5,000	10,000
6	Roadway excavation	4,000	C.Y.	2.50	10,000
7	Rock rip rap	8,000	S.Y.	7.00	56,000
8	Hydromulch	312,000	S.F.	0.05	15,600
		TOTAL			\$ 2,163,600
	Land Rights Easement	20	Acres	2,000	\$ 40,000

PROPOSED ALTERNATIVE PROJECTS FOR REACH 5

Alternative Project 1, Reach 5, Agua Fria River

This project would combine the following elements:

- (a) Levee construction, City of Avondale
- (d) East Floodplain, Development Protection
- (e) East Floodplain, Subdivision Protection

Estimated construction cost for this alternative is \$5,061,700.

Estimated landrights cost for this alternative is \$90,000.

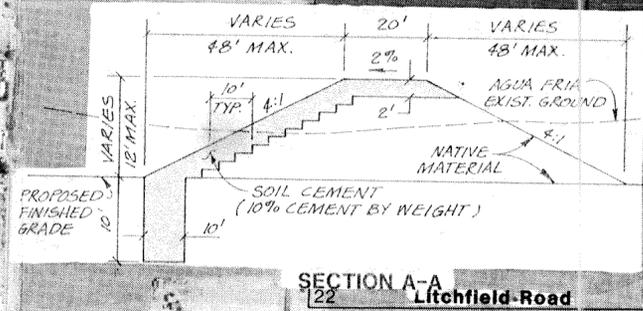
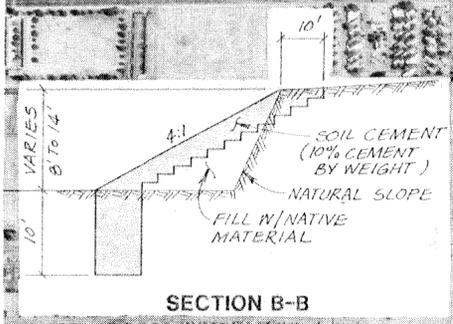
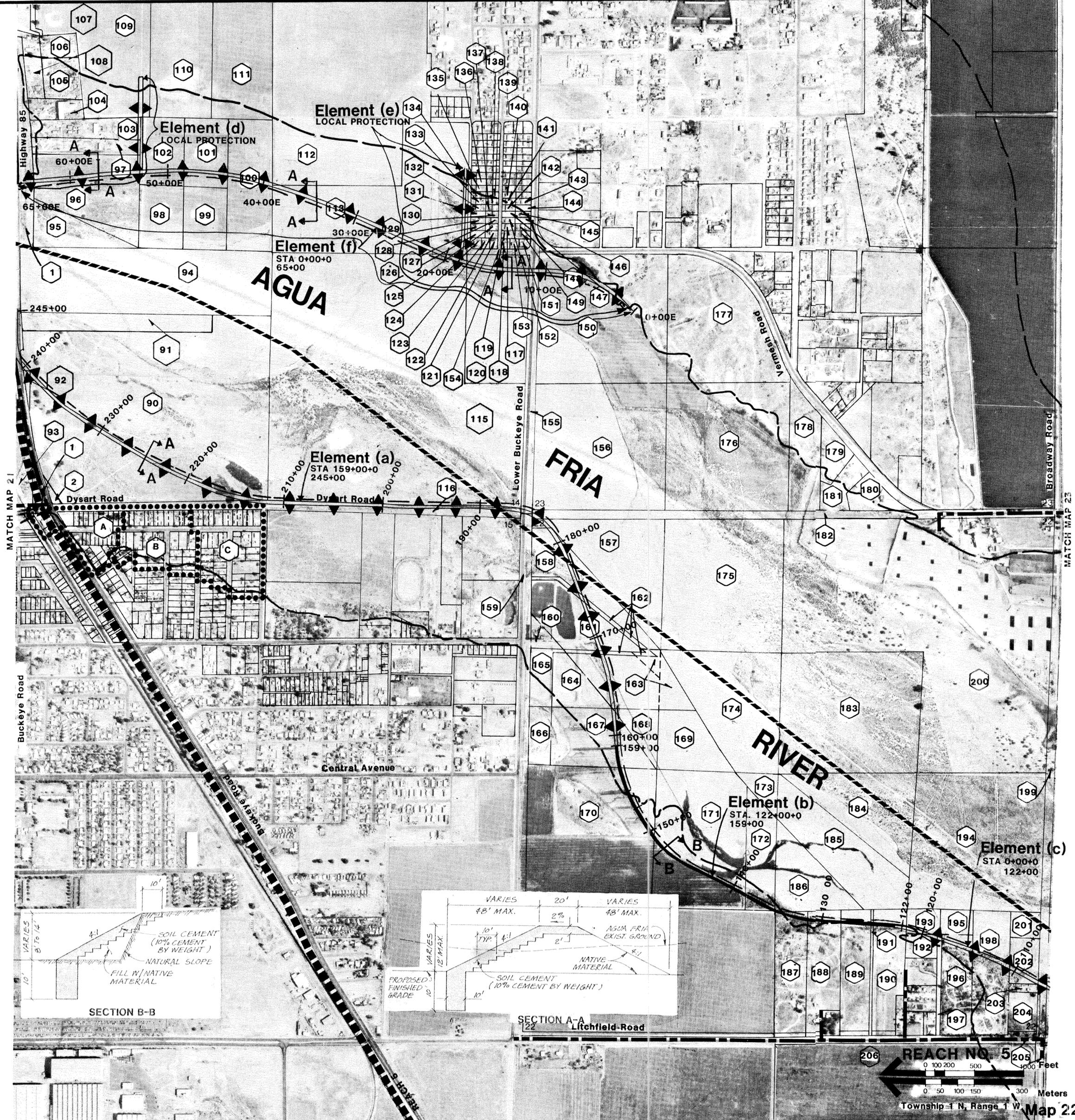
Alternative Project 2, Reach 5, Agua Fria River

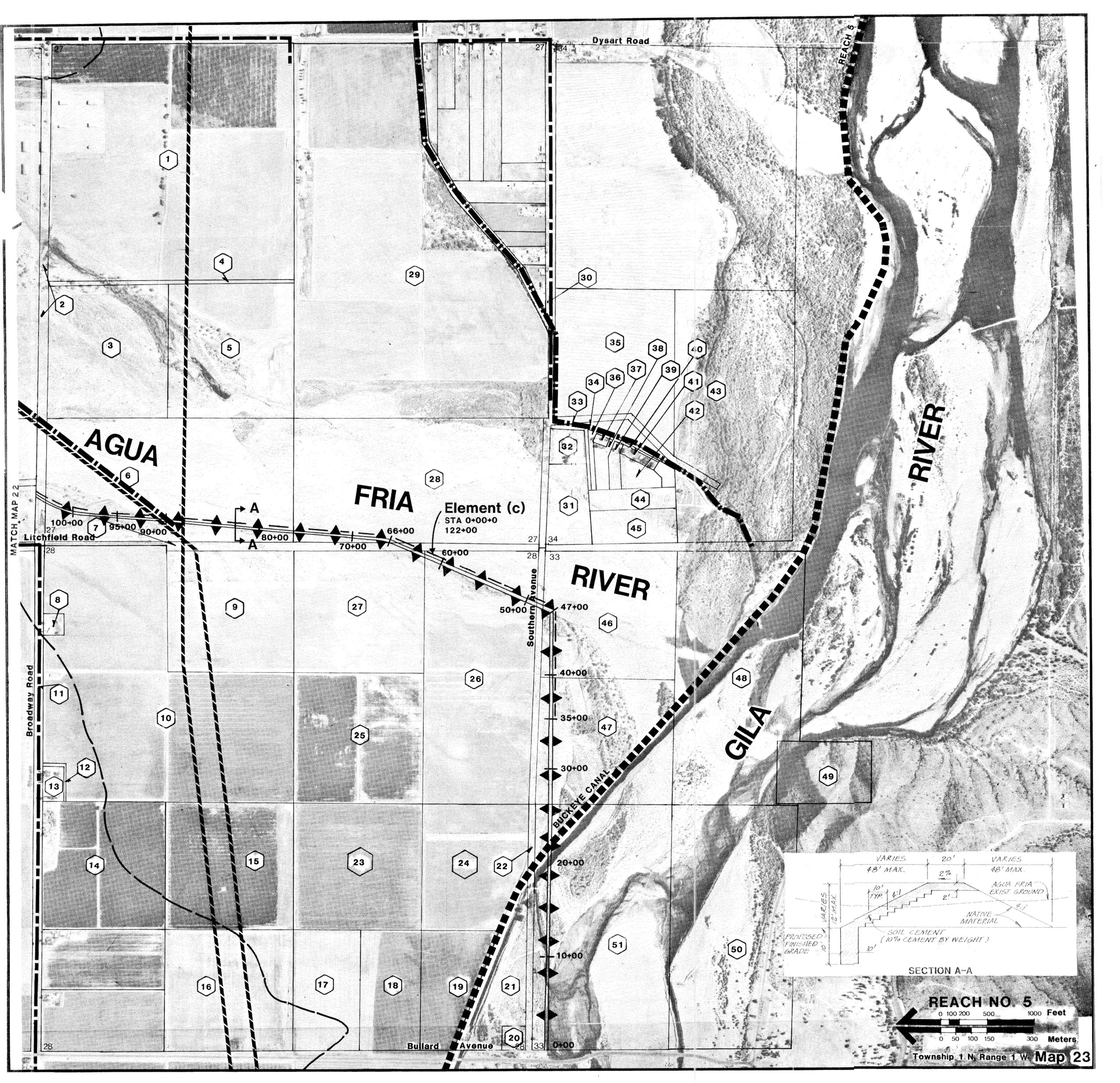
This project would combine the following elements:

- (a) Levee construction, City of Avondale
- (f) East Floodplain, Development and Subdivision Protection

Estimated construction cost for this alternative is \$5,460,200.

Estimated landrights cost for this alternative is \$90,000.





Dysart Road

REACH 5

AGUA

FRIA

Element (c)
STA 0+00+0
122+00

RIVER

RIVER

GILA

BUCKEYE CANAL

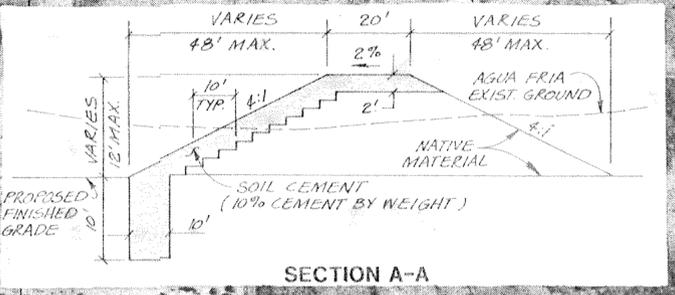
Southern Avenue

Broadway Road

Bullard Avenue

MATCH MAP 22

Litchfield Road



REACH NO. 5

0 100 200 500 1000 Feet

0 50 100 150 300 Meters

Township 1 N, Range 1 W, Map 23

Alternative Project 3, Reach 5, Agua Fria River

This project would combine the following elements:

- (a) Levee construction, City of Avondale
- (b) West Bank stabilization
- (c) West Bank, Agricultural Land and Buckeye Irrigation District,
Protection
- (f) East Floodplain, Development and Subdivision Protection

Estimated construction cost for this alternative is \$10,183,550.

Estimated landrights cost for this alternative is \$190,000.

ENVIRONMENTAL IMPACTS FOR REACH 5

Reach 5 of the Agua Fria River is that section of the river from Buckeye Road to its confluence with the Gila River. This reach contains human activities and open-space natural environments.

Elements of Alternative Projects

Six elements of construction have been proposed for Reach 5. They are summarized below:

- (a) Construct a levee from the west abutment of the Buckeye Road Bridge to a point southwest of the Avondale Sewage Treatment Plant.
- (b) Stabilize the west bank southwest of Element (a).
- (c) Construct a levee from Broadway Road southwest to Southern Avenue, thence west to Bullard Avenue.
- (d) Construct a local protection levee around residential lots and an industrial operation southeast of the Buckeye Road Bridge.
- (e) Construct a local protection levee around an existing subdivision on the east bank located approximately 4500 feet south of the Buckeye Road Bridge.

- (f) Construct a levee along the east bank from Buckeye Road to a point approximately 1100 feet south of Lower Buckeye Road combining the protection in element (d) and (e).

Affected Environment

Human activities are particularly concentrated in the upstream portion of the reach. There are residential developments and active agricultural land in and near the floodplain, particularly on the east bank near Lower Buckeye Road, and on the west bank between Lower Buckeye Road and Broadway Road. The Avondale Wastewater Treatment Plant is located along the west bank just downstream from Lower Buckeye Road. Agricultural lands lie along both sides of the river, some within the floodplain, for much of the reach. The Buckeye Irrigation District Canal crosses the Agua Fria at its confluence with the Gila River, and the headworks of the District are located in that vicinity.

Riparian environments increase as the Gila River confluence is approached. There are no reported endangered or protected plant or animal species, but a number of areas within the reach were designated by the recent Corps of Engineers' New River - Phoenix City Streams Study for protection as an open space buffer adjacent to vegetation. These areas are located along the west bank between Buckeye Road and Lower Buckeye Road, and close to the east bank from Lower Buckeye Road to south of Broadway Road. In addition, along the east bank from Lower Buckeye Road to Southern Avenue, buffers have been recommended for consideration for preservation as open-space area.

Transportation access to the area is provided by a number of county and private roads. Roads crossing the river include Buckeye Road (State Route 85) and Lower Buckeye Road. Litchfield and Dysart Roads approach the west bank of the river, but do not cross it. A 230 kv transmission line corridor parallels the river within the floodplain from Buckeye Road to approximately one-quarter mile south of Broadway Road, where it turns to the west. Another 230 kv line crosses the river in this same area.

A cultural resources survey has not been conducted along this reach of the Agua Fria River. The occurrence of historic or prehistoric resources is feasible, although any sites that may have existed have most likely been disturbed by various human activities. Based on the estimated overall density and quality of archaeological resources within the vicinity, the Office of Cultural Resources Management, Department of Anthropology, Arizona State University has rated the area as moderately sensitive.

Short Term Impacts

No significant adverse environmental impacts have been identified in conjunction with the construction activities proposed for Reach 5. Biological and cultural resources may be affected, however. Construction related short term impacts would include:

1. Fugitive dust and equipment noise will provide a disturbance to the local environment.
2. Wildlife may be disturbed during daytime construction activities.

3. No significant traffic problems will be created by construction activities because most construction traffic will occur in the riverbottom. No new haul roads will be required for the transport of equipment and materials. Levee construction along Southern Avenue may warrant the control of traffic along this street to promote safety.
4. No significant impacts to historic or prehistoric cultural resources are anticipated as a result of construction activities, based on existing information.

Mitigation Measures for Short Term Impacts

1. Proposed projects should be undertaken with maximum attention to the protection of vegetation and wildlife. Areas identified as having riparian habitat should be preserved. Construction monitoring should be recommended to insure environmental protection.
2. All construction activities should be accomplished with maximum regard for man-made facilities and activities. Particular attention should be devoted to the protection of wells, and other components of agricultural operations.
3. Fugitive dust should be controlled, as necessary, by watering down dirt roads. Noise impacts should be confined to daylight hours.
4. A cultural resources survey covering the reach should be conducted prior to the start of construction. Depending on survey results, construction

monitoring may be recommended to insure protection of historic and pre-historic resources.

5. During levee construction along Southern Avenue, suitable traffic control measures should be implemented to promote safety.

Long Term Impacts

No significant long term impacts are anticipated to occur as a result of the flood control projects proposed for Reach 5. Bank stabilization efforts should possibly incorporate an improvement that would still allow wildlife access to both sides of the river. In addition, levee development along Southern Avenue should not present an eyesore to passersby. Planting a ground cover on the dry side of the levee may be recommended to make the structure more visually attractive.

OPERATION AND MAINTENANCE COSTS
FOR ALTERNATIVE FLOOD CONTROL PROJECTS

The flood control alternative projects proposed in this study would operate automatically during flooding conditions and therefore would require no operational input other than periodic inspection and maintenance. Annual operation and maintenance costs are summarized in Table II with a general description of the key elements of an operation and maintenance program for flood control facilities is presented below.

PERIODIC INSPECTION

In order to maintain the integrity of the levees and of the channelization projects listed in the table, it is recommended that periodic inspections be conducted at three-month intervals and following any major flows in the Agua Fria River. These inspections would require an estimated maximum of five hours per month per proposed alternative, with a recommended crew consisting of two laborers and a pickup truck. A written report would be required stating findings and recommended repairs.

VEGETATION CONTROL

Most of the proposed alternatives include recommendations that vegetation be established by using hydromulch on the back side of all levees. Within the channel, natural vegetation will grow undisturbed. None of this vegetation is expected to affect flow in the channel, and should require no attention.

RODENT CONTROL

Levees located in non-urbanized areas, of which there would be many for most of the proposed alternative projects, will be vulnerable to the assaults of burrowing animals. Should perforations occur deep enough that water enters a levee embankment, subsequent seepage or piping could, if unchecked, lead to failure of the levee. Levees should be inspected for burrows during the periodic maintenance checks, and poison or traps should be placed at those times. Damage from burrowing should be reported and necessary repairs made. This procedure could be incorporated into the periodic inspections discussed above, with no significant increase in time.

LEVEE REPAIR

To maintain the structural integrity of the levees, periodic repairs will be required. A standard maintenance crew would consist of four laborers, two dump trucks, one front-end loader, one bulldozer and a pickup truck. The estimated cost for levee repairs is \$2,000 per year per mile.

SURVEY CROSS SECTIONS

During the project life, sediment will be transported by flood waters and deposited in areas where channelization is recommended. To monitor the rate of accumulation and the ability of the river to clear away this siltation, it is recommended that a three-man survey crew take cross sections for each of the alternative projects following major storms. The average anticipated time for this procedure would be three crew-days per year per alternative project.

FLOODPLAIN MANAGEMENT

Because many jurisdictions hold various levels of control over potential development of the Agua Fria River, no money has been specifically set aside in the operation and maintenance budget in Table II for floodplain management. To prevent additional flood damage, however, all future development, including the procedures of sand and gravel operations, should be closely monitored and controlled by those having jurisdiction.

TABLE II

ANNUAL OPERATION AND MAINTENANCE COSTS FOR ALTERNATIVE PROJECTS

Alternative Project No.	Reach No.	Annual Operation and Maintenance Costs						Total Costs
		Periodic Inspection	Vegetation Control	Rodent Control	Levee Repair	Survey Cross Section		
1	1	\$ 1,800	\$ 0	\$ 300	\$ 1,500	\$ 1,600	\$ 5,200	
2	1	1,800	0	300	5,000	1,600	8,700	
1	2	1,800	0	300	8,500	1,600	12,200	
2	2	1,800	0	300	6,500	1,600	10,200	
3	2	1,800	0	300	6,500	1,600	10,200	
1	3	1,800	0	300	1,200	1,600	1,900	
2	3	1,800	0	300	3,000	1,600	6,700	
1	4	1,800	0	300	17,000	1,600	20,700	
2	4	1,800	0	300	13,000	1,600	16,700	
1	5	1,800	0	300	5,000	1,600	8,700	
2	5	1,800	0	300	6,000	1,600	9,700	
3	5	1,800	0	300	12,000	1,600	15,700	

STORMS OF FREQUENCY LESS THAN 100 YEARS

During the course of this study a computer backwater analysis was run for storms with 10, 25, 50 and 100 year return periods. As a result of these computer runs several alternatives were considered for various levels of protection. These alternatives included low flow channels and flowage easements, low flow structures at Northern, Van Buren and Lower Buckeye Road, and selected local protection levees. Because of the quantity of water, 60,000 cfs at the Beardsley Canal Flume and 27,000 cfs at the confluence with the Gila River for a storm with a 10 year frequency, it was found that none of these alternatives were practical or economical when compared to the overall benefits of 100 year protection.

In analyzing possible low flow structures at Northern, Van Buren and Lower Buckeye Road, it was found that the cost of these structures to allow flow from a 10 year storm, would be prohibitive for the degree of flood protection provided. Transportation disruptions due to inundation of these crossings will be minimized by the existing Buckeye Road Bridge, the completion of Interstate 10 and proposed major river crossings at McDowell Road and Camelback Road.

POSSIBLE PROJECTS OUTSIDE THE STUDY AREA

The Agua Fria River starts northeast of Prescott and begins its course south paralleling Route 69 until it crosses Interstate 17 approximately 22 miles north of Black Canyon City. From Black Canyon City, the river continues southwesterly to Lake Pleasant. From Lake Pleasant to its origin at Prescott the Agua Fria River has 50 named tributaries contributing flow. Extensive hydrologic studies need to be completed to determine the extent that each of these tributaries contribute to peak flows. Two tributaries that appear to have possibilities of having substantial impact on downstream flows are Bumblebee Creek and Black Canyon Creek. Both are located north of Black Canyon City and west of Interstate 17. Another area that would have substantial impact on downstream flows is on the Agua Fria River immediately north of Lake Pleasant. A detention facility at any or all three of the above sites would control the rate of inflow into Lake Pleasant thereby reducing downstream flows. Other than detention facilities no other structural improvements north of Lake Pleasant would have a beneficial impact in the study area.

If the area between Lake Pleasant and Prescott should urbanize, local detention will be required to maintain peak flows at their current rate. If the increased flows from urbanization is not controlled higher volumes can be expected over the next 20 to 30 years causing higher peak flows than those now estimated.

ECONOMIC ANALYSIS

Under existing conditions, without flood protection, floods from the Agua Fria River will cause extensive direct damage to roads, bridges, private and public utilities, agriculture, commercial buildings, public facilities and housing. Indirect damages such as interruption of utilities service, loss of school and work time, and disruption of transportation and commerce will also result from flooding. Alternative projects have been proposed for each reach which provide protection to lands outside of the proposed channel widths from the 100-year storm. Presented below is a summary of the installation costs for each of the alternative projects.

TABLE NO. 12

SUMMARY OF PROJECT INSTALLATION COSTS* (100 year level of protection)

<u>Reach/ Alternative</u>	<u>Construction</u>	<u>Contingencies @ 5%</u>	<u>Land Rights</u>	<u>Engineering & Administration</u>	<u>Total Installation Costs</u>
1/1	\$2,650,450	\$ 132,522	\$ 26,000	\$ 185,000	\$ 2,993,972
1/2	4,307,500	215,375	1,462,000	300,000	6,284,875
2/1	14,684,850	734,242	936,000	960,000	17,315,092
2/2	14,599,600	729,980	894,000	960,000	17,183,580
2/3	11,019,250	550,962	536,000	710,000	12,816,212
3/1	5,504,150	275,208	790,000	385,000	6,954,358
3/2	2,772,000	138,600	630,000	194,000	3,734,600
4/1	28,509,100	1,425,455	4,320,000	1,996,000	36,250,555
4/2	23,855,650	1,192,782	2,850,000	1,670,000	29,568,432
5/1	5,061,700	253,085	90,000	354,000	5,758,785
5/2	5,460,200	273,010	90,000	382,000	6,205,210
5/3	10,183,550	509,178	190,000	712,000	11,594,728

*1981 Price Base

The economic analysis of flood control projects involves the determination of the dollar value of benefits to be achieved by the construction of the proposed projects. The benefits to be realized from flood control projects are the damages prevented or reduced by the projects and the benefits attributable to increases in land values (enhancement benefits) which result from the construction of the projects. The net damages prevented benefit is determined by computing the estimated dollar value of damages that would be incurred without flood protection and deducting from this figure the estimated dollar value of the damages that would be incurred with the proposed projects in place. The net enhancement benefits are determined by computing the value of land removed from the design year (100-year) floodplain, assuming the projects are in place, and deducting from this amount the value of the land without the projects. For the purposes of this report, the projects are designed to provide for protection from the 100-year flood with no residual damages occurring. Presented below are the estimated total cost of damages prevented by each alternative project (Damage Benefits) and the associated average annual damage benefits.

TABLE NO. 13

**DAMAGE BENEFITS
ESTIMATED TOTAL COST OF
PREVENTABLE DAMAGES BY FREQUENCY OF FLOOD OCCURRENCES
(1981 Price Base)**

Reach/ Alternative	Frequency, one occurrence in:				Average Annual
	100 years	50 years	25 years	10 years	
1/1	447,603	360,757	271,990	174,054	37,799
1/2	558,245	446,754	345,036	213,565	45,961
2/1	3,089,755	1,916,998	778,695	260,745	127,109
2/2	3,133,079	1,969,225	844,277	344,134	137,836
2/3	1,807,432	1,395,578	738,620	238,487	96,668
3/1	2,701,861	1,451,861	1,226,861	6,861	111,930
3/2	2,701,861	1,451,861	1,226,861	6,861	111,930
4/1	17,204,771	9,542,628	2,160,971	1,370,007	597,250
4/2	16,392,914	8,836,842	1,527,602	968,019	516,992
5/1	1,507,986	1,063,905	718,815	305,189	91,745
5/2	1,535,333	1,085,916	738,825	324,531	94,839
5/3	9,045,396	5,137,798	973,440	678,989	306,004

Since all of the alternative projects provide protection from the 100-year flood, all of the enhancement benefits occur upon completion date of the projects. Presented below are the total and average annual enhancement benefits associated with each alternative project.

TABLE NO. 14

ENHANCEMENT BENEFITS - 100-YEAR ANALYSIS
(1981 Price Base)

<u>Reach/ Alternative/ Project</u>	<u>Total Enhancement Benefits</u>	<u>Average Annual Enhancement Benefits</u>
1/1	\$ 660,000	20,889
1/2	4,770,000	150,970
2/1	45,210,300	1,430,906
2/2	53,436,700	1,691,272
2/3	30,145,800	954,115
3/1	66,700	2,111
3/2	29,000	918
4/1	25,717,700	813,965
4/2	14,957,700	473,411
5/1	1,481,000	46,874
5/2	2,706,000	85,645
5/3	11,852,000	375,116

A comparison of the average annual reduction in damages, and the enhancement benefits resulting from project construction to the average annual total project cost, adjusted for annual operation and maintenance expenditures is made to develop benefit cost ratios for the proposed alternatives. Benefit cost ratios have been developed using procedures and criteria established by the Arizona Department of Water Resources. This criteria includes three (3) percent amortization rate and a 100-year life of project.

The justification for constructing a particular project occurs when the benefit:cost ratio is equal to or greater than unity. The derivation of the benefit cost ratio for each of the alternative projects is summarized below.

TABLE NO. 15
BENEFIT: COST COMPARISON--100 YEAR ANALYSIS
(Average Annual)

<u>Reach/ Alternative Project</u>	<u>Project Installation Cost</u>	<u>O & M* Cost</u>	<u>Total Project Cost</u>	<u>Total Benefits</u>	<u>Benefit Cost Ratio</u>
1/1	\$ 94,759	\$ 5,200	\$ 99,959	\$ 58,688	0.59
1/2	198,916	8,700	207,616	196,931	0.95
2/1	548,023	12,200	560,223	1,558,015	2.78
2/2	543,860	10,200	554,060	1,829,108	3.30
2/3	405,633	10,200	415,833	1,050,783	2.53
3/1	220,105	1,900	222,005	114,041	0.51
3/2	117,251	6,700	123,951	112,848	0.91
4/1	1,147,330	20,700	1,168,030	1,411,215	1.21
4/2	935,841	16,700	952,541	990,403	1.04
5/1	182,266	8,700	190,966	138,619	0.73
5/2	196,395	9,700	206,095	180,479	0.88
5/3	366,973	15,700	382,673	681,120	1.78

* Refers to Table 11, Page 142

CONCLUSIONS AND RECOMMENDATIONS

The engineering and economic analysis of the twelve proposed alternative flood control projects indicates that benefit:cost ratios which are nearly or greater than unity might be realized through implementation of the following projects:

- Reach 1, Alternative 2
- Reach 2, Alternative 1, 2 and 3
- Reach 3, Alternative 2
- Reach 4, Alternative 1 and 2
- Reach 5, Alternative 2 and 3

It is recommended that these projects be studied further at the feasibility level to refine the engineering design and to further substantiate their economic justification for construction and their eligibility for funding assistance. Special attention should be given to the refinement of enhancement benefits and the crop damages to the Buckeye and Roosevelt Irrigation Districts.

Because of benefit:cost ratios considerably less than unity, the remainder of the proposed projects do not warrant further consideration. These projects are as follows:

- Reach 1, Alternative 1
- Reach 3, Alternative 1
- Reach 5, Alternative 1

GLOSSARY

- cfs Abbreviation for cubic feet per second. A unit of water flow, sometimes called "second-feet."
- Class A low flow Occurs when water flows under a bridge in such a way that the water surface is below the lowest part of the bridge and that the bridge does not restrict flow so as to cause backwater. The bridge routine uses the Yarnell equation for this class of flow to determine the change in water surface elevation through the bridge.
- flood An overflow or inundation that comes from a river or other body of water and causes or threatens damage.
- flood frequency When associated with a certain year (i.e., 5-year, 10-year, etc.) defines the average frequency that a flood of a certain maximum magnitude will occur at least once within the stated period of time. It is based on statistical analysis of streamflow records for the watershed, and of rainfall and runoff in the general region of the watershed.
- floodplain The relatively flat area or lowlands adjoining the channel of a river, a stream, or other watercourse that has been or may be inundated by floodwaters.
- levee An artificial embankment, usually of earth fill, built along the bank of a watercourse and designed to protect land from inundation or to confine streamflow to its channel.
- recurrence interval The average interval of time within which the given flood will be equaled or exceeded once.
- riprap A layer of large, durable, dense, specially selected and graded, broken rock fragments emplaced to prevent erosion by strong currents and thereby preserve the shape of a surface or slope.
- scour The powerful and concentrated clearing and digging action of flowing water, especially the downward erosion by stream water in sweeping away sediments during time of flood.
- sediment Fragmental material that originates from weathering of rocks and is transported by, suspended in, or deposited by water or air or is accumulated in beds by other natural forces.
- watershed An area or region in which the rainfall or snow melt drains to a particular watercourse or body of water.

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