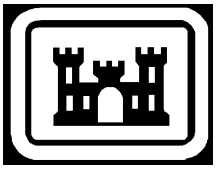


U.S. Army Corps
of Engineers
Los Angeles District

RIO DE FLAG
FLAGSTAFF, ARIZONA

FEASIBILITY REPORT AND
FINAL ENVIRONMENTAL IMPACT STATEMENT

SEPTEMBER 2000

U.S. ARMY CORPS OF ENGINEERS
LOS ANGELES DISTRICT
PLANNING DIVISION, PLAN FORMULATION BRANCH
P.O. BOX 532711
LOS ANGELES, CALIFORNIA 90053-2325

EXECUTIVE SUMMARY

The U.S. Army Corps of Engineers has conducted a four-year effort, including an open public involvement and participation process, to identify the flooding problems in the City of Flagstaff and develop an acceptable solution to minimize the impacts a large flood would have on the City. Several alternative solutions were developed and analyzed in accordance with Corps of Engineers feasibility criteria, including technical feasibility, economic justification, environmental compliance, and public supportability.

The economic, social, environmental, and regional impacts and damages from a large flood event would be severe and devastating to the community. The consequences of a major flood would be at such a level that it would take the community many years to recover and rebuild. Approximately 1,500 existing structures, worth about $395,000,000 exist in the 500-year floodplain. Over one-half of the City's population of 60,000 people would be directly affected and impacted from a large flood. Structural damage would occur throughout a major portion of the City, including historic properties, the Burlington Northern & Santa Fe Railroad and its primary east-west operations, and public infrastructure and services. Transportation problems would make a large portion of the City and the Continental area inaccessible for a few days, impacting several thousand people. A significant portion of Northern Arizona University is within the floodplain, and during severe flood events the University would incur closing and other disruptions and physical damage to facilities and historic buildings on campus. Numerous residential, commercial, downtown business & tourism, and industrial properties are at risk.

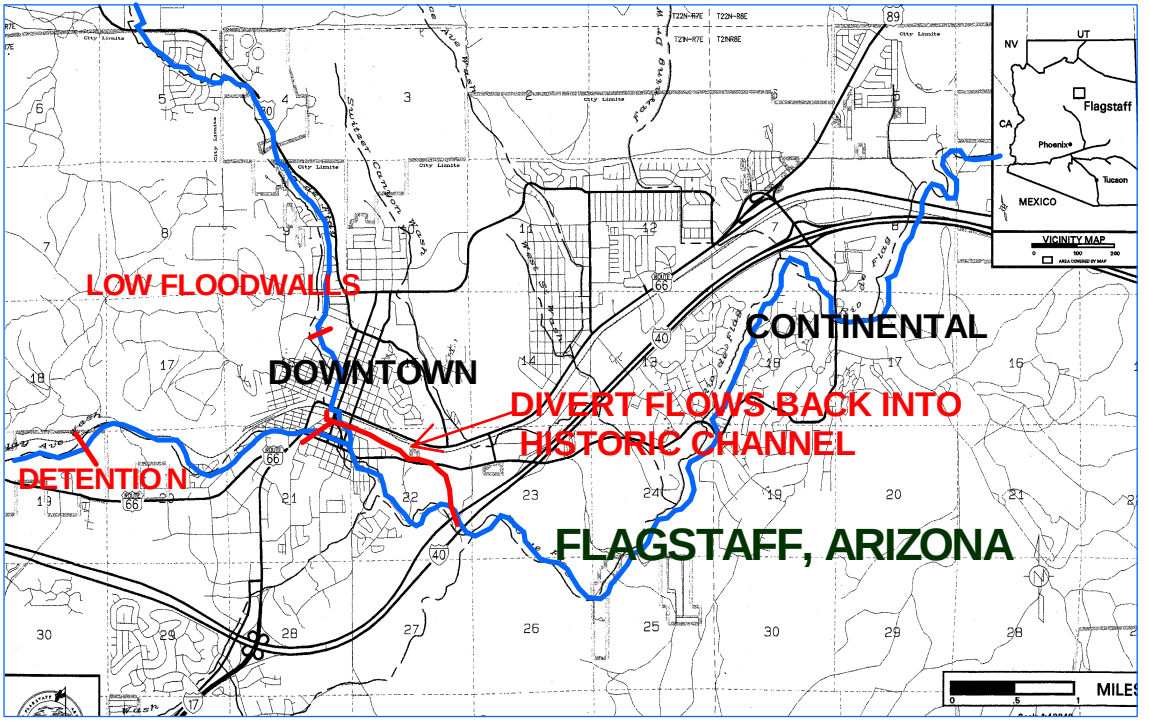
The last major floods occurred in the late 1930s, at a time when the town was much less populated and developed. Approximately 100 years of growth since the late 1800s has produced a densely urbanized and developed environment within those floodplains that will be impacted when large flood events occur again. This report identifies the opportunity to prevent the problem from occurring before that happens.

This report identifies a flood control solution that is estimated to cost approximately $24,072,000, which will be cost shared by the Federal government in an amount of approximately $15,576,000. Implementation of this plan will essentially prevent the approximate $93,000,000 worth of economic damage that would occur from a single large flood. The annualized benefit to cost ratio of the Recommended Plan is 1.33 (October 1999 price levels). The plan provides economic benefits in a regional approach that includes the Continental area downstream. Additional benefits from the plan include protection of historic resources, environmentally friendly flood control features, recreation, and long term regional and social benefits.

The Recommended Plan consists of flood control features to provide flood protection along the Rio de Flag and Clay Avenue Wash. The Plan consists of a detention structure along Clay Avenue Wash to reduce floodflows by approximately 90%, and channel improvements downstream of the detention structure to convey these reduced flows. Along the Rio de Flag, low floodwalls would be required at Thorpe Park to direct flows downstream, and a series of channel improvement

downstream of Thorpe Park would convey floodflows through the downtown area. The Clay Avenue Wash channel improvements meet up with the Rio de Flag channel improvements in a confluence area just south of City Hall. A diversion channel would be constructed alongside the railroad to divert flows away from the south side of town and Northern Arizona University. The floodflows would be diverted back into the historic Rio de Flag channel, through a series of improvements designed to restore the flow capacity of the historic channel. A schematic of the plan follows.

The Recommended Plan is satisfactory to the public, is cost efficient, and complies with United States law including appropriate Environmental requirements. The Corps of Engineers is seeking an exemption to CWA Section 404(r) and has coordinated with appropriate resource agencies. The proposed project meets all Corps of Engineers criteria.


LOW FLOODWALLS
DOWNTOWN
CONTINENTAL
DIVERT FLOWS BACK INTO
HISTORIC CHANNEL
DETENTION
FLAGSTAFF, ARIZONA
NV
UT
CA
Flagstaff
Phoenix
Tucson
MEXICO
VICINITY MAP
MILES

[This page left intentionally blank.]

Table of Contents (continued)

Page

RIO DE FLAG
FLAGSTAFF, ARIZONA
FEASIBILITY STUDY

Table of Contents

Page

Table of Contents (continued)

Table of Contents (continued)

Page

Table of Contents (continued)

Table of Contents (continued)

Page

LIST OF TABLES

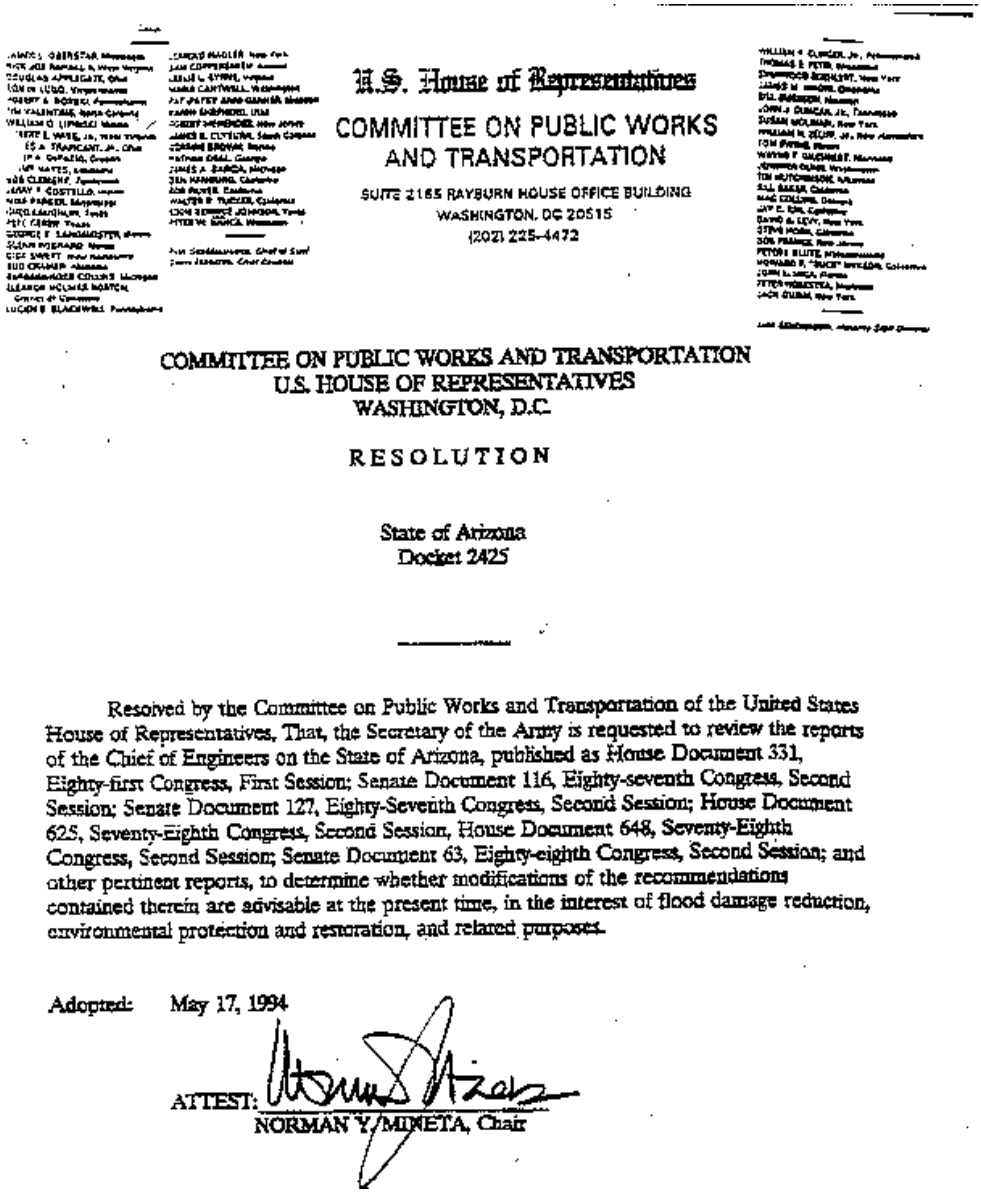
LIST OF FIGURES

Table of Contents (continued)

TECHNICAL APPENDICES

CHAPTER I
STUDY AUTHORITY

This study has been conducted under the authority given in House Resolution 2425, dated 17 May 1994. This report is an interim response under the authority. This report presents the findings of a feasibility study of Rio de Flag, Flagstaff, Arizona. A location map is presented in **Figure 1.1.**



U.S. House of Representatives

COMMITTEE ON PUBLIC WORKS AND TRANSPORTATION

SUITE 2165 RAYBURN HOUSE OFFICE BUILDING
WASHINGTON, DC 20515
(202) 225-4472

COMMITTEE ON PUBLIC WORKS AND TRANSPORTATION
U.S. HOUSE OF REPRESENTATIVES
WASHINGTON, D.C.

RESOLUTION

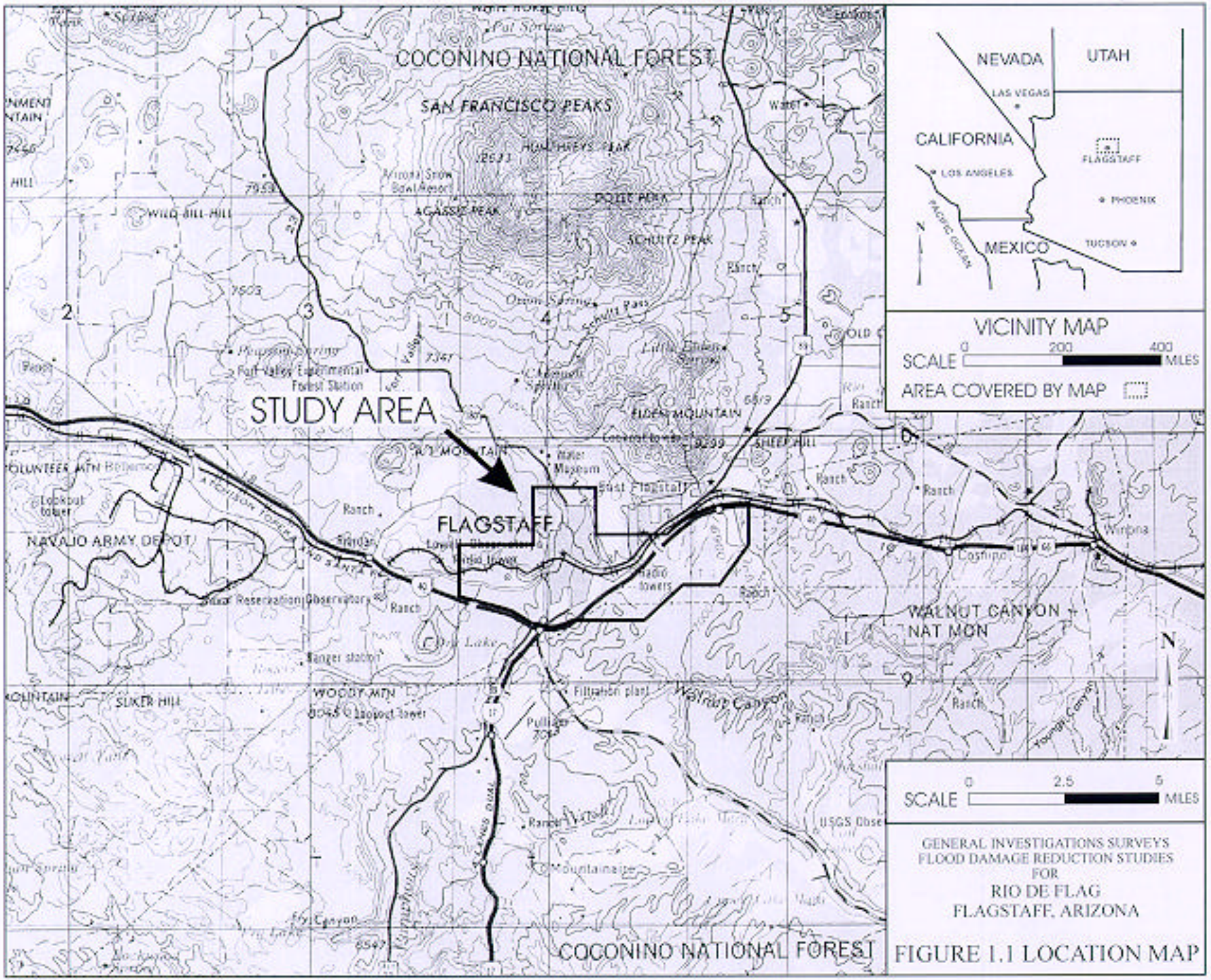
State of Arizona
Docket 2425

Resolved by the Committee on Public Works and Transportation of the United States House of Representatives, That, the Secretary of the Army is requested to review the reports of the Chief of Engineers on the State of Arizona, published as House Document 331, Eighty-first Congress, First Session; Senate Document 116, Eighty-seventh Congress, Second Session; Senate Document 127, Eighty-Seventh Congress, Second Session; House Document 625, Seventy-Eighth Congress, Second Session, House Document 648, Seventy-Eighth Congress, Second Session; Senate Document 63, Eighty-eighth Congress, Second Session; and other pertinent reports, to determine whether modifications of the recommendations contained therein are advisable at the present time, in the interest of flood damage reduction, environmental protection and restoration, and related purposes.

Adopted: May 17, 1994

ATTEST:

NORMAN Y. MINETA, Chair


COCONINO NATIONAL FOREST
SAN FRANCISCO PEAKS
HUMPHREYS PEAK
AGASSIZ PEAK
FREMONT PEAK
SCHULTZ PEAK
WILD BILL HILL
Fort Valley Experimental Forest Station
STUDY AREA
FLAGSTAFF
NAVAJO army DEPOT
WOODY MTN
SLIDER HILL
Mountainaire
COCONINO NATIONAL FOREST
WALNUT CANYON NAT MON
NEVADA
UTAH
LAS VEGAS
CALIFORNIA
LOS ANGELES
FLAGSTAFF
PHOENIX
TUCSON
MEXICO
PACIFIC OCEAN
VICINITY MAP
SCALE 0 200 400 MILES
AREA COVERED BY MAP
SCALE 0 2.5 5 MILES
N
GENERAL INVESTIGATIONS SURVEYS
FLOOD DAMAGE REDUCTION STUDIES
FOR
RIO DE FLAG
FLAGSTAFF, ARIZONA
FIGURE 1.1 LOCATION MAP

SOURCE: USGS

CHAPTER II

STUDY PURPOSE, STUDY SCOPE, AND STUDY AREA

A. Study Purpose

The Rio de Flag, Arizona, Feasibility Study and Environmental Impact Statement (EIS) are being conducted by the U.S. Army Corps of Engineers, Los Angeles District (Corps) and the City of Flagstaff. The specific purpose of this study is to define flooding and related problems in the watershed area of Rio de Flag and its tributaries in the City of Flagstaff and Coconino County, Arizona, and to investigate the feasibility of providing solutions to these problems.

This report will describe the base year conditions in the project area and the future without-project condition. The without-project condition is the same as the "no action" alternative and describes what is expected to happen in the absence of Federal action.

Alternative plans are being developed to provide for improving flood control, environmental, and water resources. This report is intended to be a complete decision document that presents the results of both the reconnaissance and feasibility phases of the General Investigation effort. This feasibility report is intended to accomplish the following tasks:

- Present the study results and findings, including those developed in the reconnaissance phase, so that readers can reach the same conclusions regarding the report recommendations independently;

- Indicate compliance with applicable statutes, executive orders, and policies; and

- Establish a sound and documented basis for decisions makers at all levels to judge the recommended solution(s).

B. Study Scope

The scope of this study consists of identifying problems and needs associated with flooding and related water resource concerns, formulating alternative measures to prevent future flood damages and maximize National Economic Development benefits, and identifying the opportunity and the role for Corps' participation in flood control and related water resources planning.

C. Study and Report Process

The Los Angeles District of the Corps of Engineers completed the first phase of the General Investigations study in May of 1997. The results and conclusions of the first phase were presented in the Rio de Flag, Flagstaff, Arizona Reconnaissance Report. The reconnaissance report established Federal interest in proceeding to a second, feasibility phase of the General Investigation Study to investigate the opportunities for providing flood protection in Flagstaff, Arizona.

D. Study Area

Rio de Flag is a tributary of San Francisco Wash, which in turn flows into the Little Colorado River. The stream originates on the southwestern slopes of San Francisco Mountain near Flagstaff, Arizona. The total drainage area of the watershed is approximately 116 square miles. Rio de Flag has numerous tributaries, with major contributing flows coming from Clay Avenue Wash drainage area to the west and Sinclair Wash drainage area to the southwest.

The study area was defined in coordination with the City of Flagstaff, with input from the Flood Control District of Coconino County and the State of Arizona. The City of Flagstaff identified Rio de Flag and Clay Avenue Wash as the primary drainages contributing to flooding of major damage centers and problem areas to be evaluated during the feasibility study. Located generally within the City of Flagstaff and Coconino County, Arizona, the study area for flood damages is approximately 15 square miles, and encompasses Rio de Flag upstream from the city limits to the Route 66 crossing just downstream of the Continental Estates housing development. A study area map is shown at **Figure 2.1.**

The City of Flagstaff is located in southern Coconino County, in north-central Arizona, approximately 150 miles north of Phoenix, and nearly centered between the east and west State boundaries along the historic Route 66 and Interstate 40 corridor. It is enclosed by Coconino National Forest, an area which contains a large number of natural scenic and recreation attractions. In addition, Flagstaff is the County seat of Coconino County which is itself the largest county in the State, and serves as a center for employment, culture, and trading for northern Arizona.

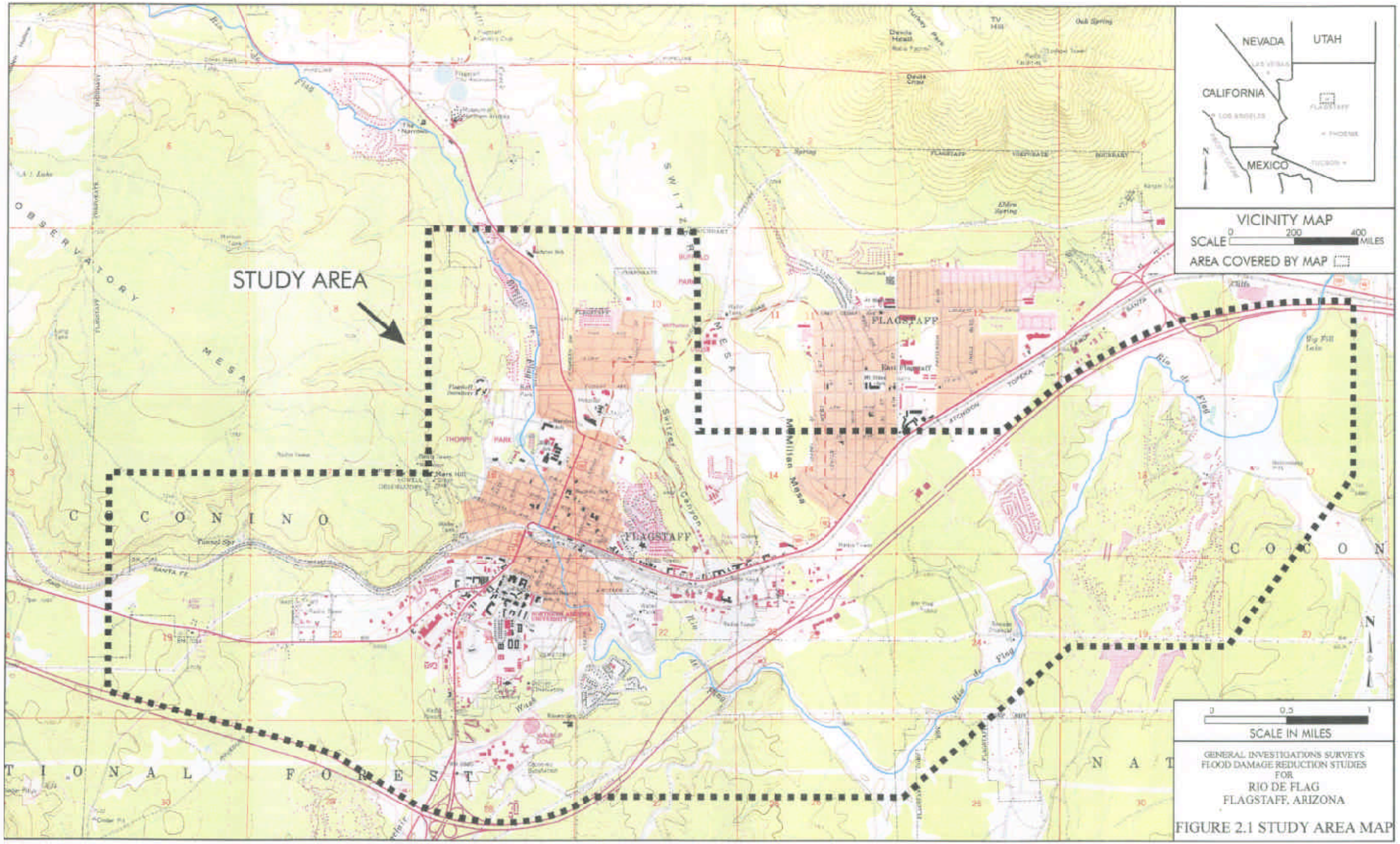


FIGURE 2.1 STUDY AREA MAP

SOURCE: USGS

With a total land area of 18,608 square miles, Coconino County is the second largest county in the United States. However, only 14 percent of this land (or about 2,600 square miles) is privately owned. Approximately 69 percent of county land represents either Indian or U.S. Forest Service land. The remaining 17 percent is owned by the State of Arizona and other public entities.

Of the 525 square miles that comprise the Greater Flagstaff Metropolitan Planning Organization area, 384 square miles are managed by the Coconino National Forest. To the north of the city are the San Francisco Peaks mountains and further to the north the Grand Canyon, and to the south is Walnut Canyon National Monument with prehistoric archaeological cliff dwellings.

Population

The regional area currently has a population exceeding 60,000. Flagstaff has experienced steady growth. U.S. Census statistics for the city show the population increasing from 5,080 in 1940 to 26,117 in 1970 and then to 45,857 for the 1990 census. The 1996 estimate by the Census Department is that Flagstaff has grown to 55,094 residents. Growth is expected to remain steady at an annual rate of approximately two percent.

Meteorology and Climate

The semi-arid climate of northern Arizona plays a significant role in the flow cycle of Rio de Flag. Flooding in Rio de Flag is related to snowmelt from the San Francisco Peaks in the winter and spring due to runoff (rain and/or snowmelt) and from single or multiple storm events such as intense summer thunderstorms and dissipating tropical cyclones.

The average annual precipitation for the Rio de Flag drainage area ranges from about 20 inches in Flagstaff to about 35 inches in the San Francisco Peaks, with a basin average of about 25 inches. Most of the winter precipitation falls as snow (approximately 85%). Additional significant precipitation may fall during the winter months, and during the "summer monsoon" period during July and August, when thunderstorms are widespread across Arizona.

Annual temperature extremes in the Flagstaff area can typically range from 0° to 90° F. The yearly average high and low temperatures are 61° F and 30° F, respectively. The prevailing winds are from the southwest with an average speed of 8 to 9 miles per hour.

Existing Land Use

The floodplain of Rio de Flag is intensely developed through most of the city center. Land use in the area consists of residential dwellings, recreation areas, schools, light industry, railroad and utility easements, and retail business structures. Residential, commercial, and industrial development are extensive within the floodplain of Rio de Flag throughout most of the city. Portions of the campus of Northern Arizona University lie within the 100-year floodplain. The downtown area, and south side areas, which contain numerous registered historic structures, are almost entirely within the floodplain. Some historic residential and business buildings in the city center are over a hundred years old. Recreation facilities include parks, the Continental Country Club golf course, ball fields, picnic areas, a fishing pond, and bike/jogging trails.

Nearly half of the 100-year floodplain along Rio de Flag is zoned as residential areas. Areas zoned as commercial account for nearly a quarter of the 100-year floodplain.

CHAPTER III

PRIOR STUDIES, REPORTS & EXISTING PROJECTS

A. Prior Studies or Reports

Several prior studies and reports provided valuable reference information and were utilized for this feasibility study:

City of Flagstaff, *Country Club Drive Flood Limits - Feb. 19-21, 1993 Map*, 1996

Federal Emergency Management Agency, *Flood Insurance Study*, Sept. 1995

City of Flagstaff, *Rio de Flag Alternative Flood Study*, Sept. 1994

Rio de Flag Alternative Flood Control Study, URS Consultants, July 13, 1991

City of Flagstaff Alternative Flood Control Study, August 14, 1991

Rio de Flag Alternative Flood Control Study, City of Flagstaff, September, 26, 1991

URS Consultants Inc., *Alternative Flood Control Study for the Rio de Flag*, Sept. 1990

U.S. Geological Survey, *Flood Hydrology near Flagstaff, AZ*, June 1988

Arizona Department of Water Resources, *Pre-Reconnaissance Flood Control Study of Rio de Flag Wash*, Feb. 1988

Arizona Department of Water Resources, *City of Flagstaff - Rio de Flag Project (Back-Up Analysis)*, Sept. 1988

Arizona Department of Water Resources, *Water Resources of Southern Coconino County, AZ*, 1986

Arizona Engineering Company, *Runoff in the City of Flagstaff: Drainage system for Various Return Period and Storm Duration*, Feb. 1979

National Oceanic and Atmospheric Administration, *Climate of Flagstaff, Arizona*, Aug. 1974

Water Resources Associates Inc., *Flood Hydrology and Solutions to Flood hazard Problems - Continental Country Club Project*, May 1974

National Weather Service, *Precipitation-Frequency Atlas of Western U.S. Volume VIII - Arizona*, 1973

U.S. Army Corps of Engineers, *Rio de Flag, Flagstaff, Arizona, Reconnaissance Report*, May 1997

U.S. Army Corps of Engineers, *Rio de Flag and Sinclair Wash*, April 1978

U.S. Army Engineer District, Los Angeles, 1975, Floodplain information: Rio de Flag and Sinclair Wash, vicinity of Flagstaff, Coconino County, Arizona: U.S. Army Corps of Engineers, Los Angeles District (prepared for the City of Flagstaff, AZ), 36 pp.

U.S. Army Corps of Engineers, *Rio de Flag and Sinclair Wash: Floodplain Information*, Sept. 1975

U.S. Army Corps of Engineers, *Runoff from Snowmelt*, EM 1110-2-1406, Jan. 1960

Additional references specifically relating to Hydrology, Hydraulics, Geotechnical, Economics, Environmental work are listed in those appendices.

B. Existing Projects

There are no Federal water resource projects within the study area.

C. Master Planning

Flagstaff is a designated Metropolitan Planning Organization (MPO). Coconino County has an indirect role in infrastructure master planning. **Figure 3.1** shows the Flagstaff Metropolitan Planning Organization boundaries.

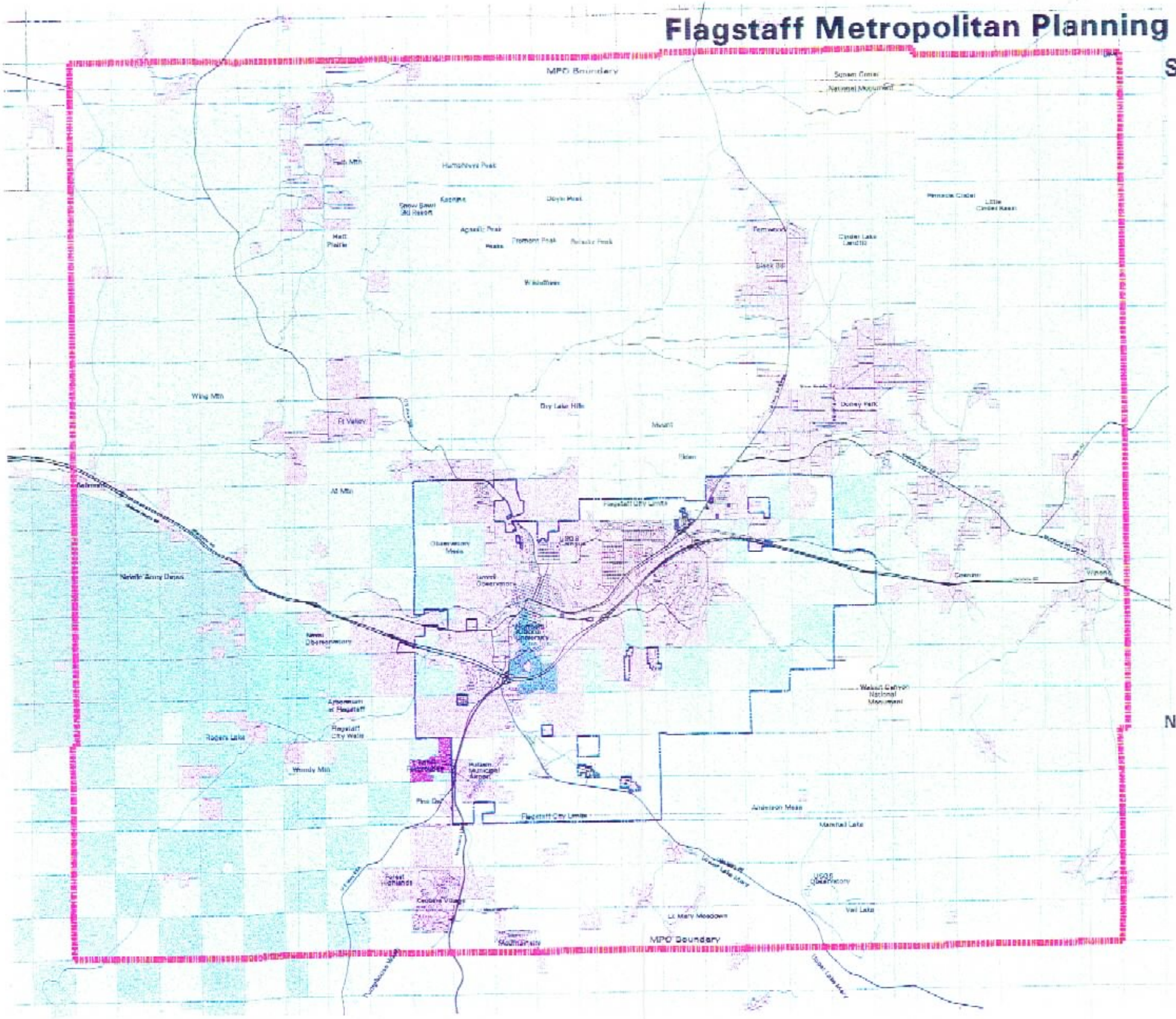
Flagstaff 2020 Program

Flagstaff is in the process of implementing a long range planning program called "Flagstaff 2020." The following is an excerpt from the program description:

> "As the 21st century rapidly approaches, Greater Flagstaff stands on the threshold of a new era of growth and change that presents both significant challenges and important

Flagstaff Metropolitan Planning Organization

September 9, 1996



LEGEND

- Coconino National Forest
- Adjacent National Forest
- State Land
- Military Land
- National Park Land
- Private Land
- Coconino County Land
- Northern Arizona University
- Major Roads
- Minor Roads

City of Flagstaff
Planning Division
September 1996
Data Source:
ALRIS GIS spring 1996 Land Data
Coconino County Planning
City of Flagstaff Planning
City of Flagstaff GIS

FIGURE 3.1

new opportunities. Emerging national trends such as rapid population growth, an aging and diversifying population, dramatic scientific and technological advances, a restructuring global economy, changing careers and workplaces, and shifting values and lifestyles will all have a major impact on the face of Flagstaff. A host of state, regional and local trends will also affect the future of our community.

How the people of Flagstaff choose to respond to these trends will strongly influence whether our future is one bright with the promise of new horizons - or dimmed by a plague of seemingly unmanageable problems. Without a shared vision to guide us in making such difficult choices, the future we most desire may not be the one we get. It is only if the people of Flagstaff take an active role in anticipating and planning for change, that a preferred future for our community will be realized. That's the reason for Flagstaff 2020.

Flagstaff 2020 is a long-range community planning - or 'visioning' - process by and for the people of Greater Flagstaff. Through this process, members of the community will come together to create a shared image of our preferred future. Once this ' realistically idealistic' image has been created, we will begin working to achieve our goals. Through visioning, we will articulate core community values, build greater consensus for future directions, and develop specific strategies for positive change in our community.

The Flagstaff 2020 visioning process is sponsored by a unique public-private partnership of leading government, business, education, community and environmental organizations and the general public. They include (in no particular order):

Northern Arizona University
City of Flagstaff
Flagstaff Chamber of Commerce
Coconino County
Grand Canyon Trust
Coconino Community College
Flagstaff Unified School District
Northern Arizona Home Builders
Friends of Flagstaff's Future
Citizens-at-large

Throughout the visioning process, particular attention will be focused on seven overarching 'target areas' of concern related to the future of our community. The target areas were developed with input from the 2020 Management Committee representing Flagstaff 2020's sponsoring organizations, a series of public meetings held throughout the community early in the process, and a scientific survey of the entire community. The seven target areas of concern are:

Managing Growth
Protecting the Environment
Fostering Human Development
Improving Housing & Livability
Promoting Health & Safely
Creating Economic Opportunity
Strengthening & Sustaining Community

Perhaps the key guiding principle of Flagstaff 2020 is to make the visioning process as participatory as possible. Already, hundreds of citizens have become involved in this

process through community welcome meetings, the community values survey, the newly-formed citizen Vision Task Force, and project volunteer committees and support activities.

Underlying all these activities and events is a common goal: to create the best possible future for our community. This goal will require the input, creativity and commitment of the entire community. With this involvement, realizing a shared vision for the future can become a reality. Without it, the future we get may not be the one we most desire."

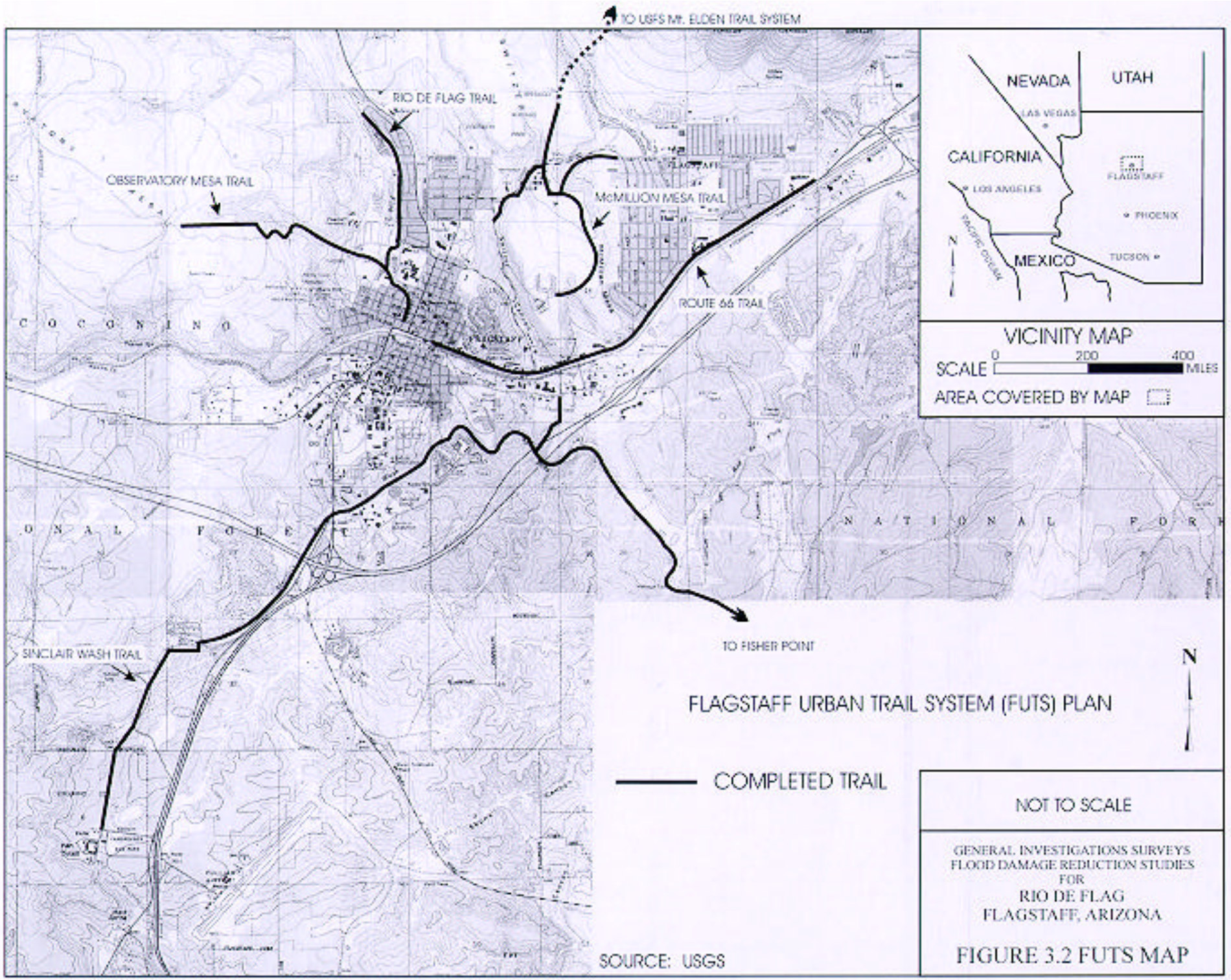
Flagstaff Urban Trails System Program (FUTS)

The City has developed a number of trail systems, including Rio de Flag, Observatory, Sinclair Wash, Bow and Arrow, Route 66, and McMillan Mesa Trail Systems. These interconnected trails and linear recreation areas extend throughout the City. They offer and provide for alternative means of transportation, informal exercise and recreation opportunities. Uses include bicycling, hiking, jogging, cross country skiing, educational activities, as well as pedestrian and bike commuting.

The following is an excerpt from the Flagstaff Urban Trails System program description:

"The Flagstaff Urban Trails System (FUTS) is being developed as a city-wide interconnecting network of non-motorized transportation corridors and linear recreation areas. **Figure 3.2** shows the FUTS trail map. Various off-street trails are proposed to interconnect employment areas, activity centers, neighborhoods, schools and parks throughout the city. FUTS offers and provides for an alternative means of transportation, informal exercise and recreational opportunities. Anticipated uses of such a system include: bicycling, hiking, jogging, cross-country skiing, educational activities, as well as pedestrian and bike commuting. FUTS promotes year-round full season opportunities for a diversity of uses.

Interconnection with the Arizona State Trail, Coconino National Forest trail system, and the Flagstaff Bikeways System creates an attractive regional recreational opportunity for visitors and residents alike. An extensive and easily accessible trail network would allow access to forest wilderness areas, canyons, cultural centers, national monuments, the Arboretum, the University, schools, residential and shopping areas, and downtown Flagstaff. The natural greenbelt setting in which the Flagstaff Urban Trails System is primarily located secures open space and greenbelt land use, promotes enjoying the



GENERAL INVESTIGATIONS SURVEYS
FLOOD DAMAGE REDUCTION STUDIES
FOR
RIO DE FLAG
FLAGSTAFF, ARIZONA

FIGURE 3.2 FUTS MAP

environment, and provides a diverse exposure to various native wildlife and plant life. The benefits are economic, social and environmental.

The City already owns or has easements for a considerable amount of land required to place the framework of a trails system. Acquisition of additional right-of-way to secure these trail routes is an essential, continuing effort for the FUTS program. Utilization of major drainage ways, utility easements, floodplains, scenic areas, high-slope areas, and developable land provides appropriate locations for the trails.

Approximately 20 miles of trail development are proposed through the FUTS program. It is anticipated that full improvement of the system will take several years. Priorities for future trail developments are flexible so as to respond to property acquisition and budget availability. Additional dedication of private easements and land acquisition will have to be negotiated to create a fully integrated system. Continuing public support is necessary if this program is to be fully implemented. Civic and neighborhood groups are encouraged to participate in the Adopt-A-Trail program for volunteer clean-up, maintenance, and minor improvements.

Proposed Plans include: the North Rio de Flag Trail to the Museum of Northern Arizona and the Cheshire neighborhood, the East Rio de Flag to Foxglenn Park, Sinclair Wash Trail to the Arboretum and Woody Mountain, the Bow and Arrow Wash Trail, the McMillan Mesa Trail to Buffalo Park, and numerous shorter connecting links, such as those to Lockett Valley, Walnut Canyon and the Arizona State Trail."

Other Water Resources Planning

The population of Flagstaff is projected to grow substantially and nearly double in size over the next 40 to 50 years. To meet the expected municipal water supply demands, the city is investigating additional sources of groundwater. In January 1995, Flagstaff contracted with the USGS to investigate possible sites for test drills. Currently, it receives water from the Inner Basin, Upper Lake Mary, Lake Mary Wellfield, and Woody Mountain Wellfield. The 1997 annual water usage was 2,675,000,000 gallons of water, which translates into a per capita use rate of 134 gallons a day.

CHAPTER IV

PROBLEMS AND OPPORTUNITIES

Problems and opportunities were identified, defined, and assessed through coordination with local and regional agencies, the public involvement process, site assessments, interpretation of prior studies and reports, and technical analyses. Specific problems and opportunities were identified based on an assessment of existing and expected future conditions within the study area.

A. Historical Conditions and Problem Development

A stripped ponderosa pine tree used as a westward trail marker made the Flagstaff area a destination point. The formation of the City of Flagstaff was first attempted in 1872. On Independence Day 1876 the pine tree marker was topped with a flag to celebrate the country's centennial. A settlement was started hoping for quick expansion from the railroad that was nearing; however, delays in the laying of the railroad caused this first settlement to be abandoned. Later a second settlement, near the banks of Rio de Flag, began to grow from the commerce produced by the herders and westbound travelers.

The naming of the settlement, which now had a post office (1881), was done by a group of citizens. Eventually the name Flagstaff was suggested and this name was adopted. A fire in 1882 destroyed the town, which was rebuilt only to be destroyed by fire again in 1884. Rebuilding the town again was done around the then new train depot.

Railroad construction was the jumping point at which Flagstaff became a major area of commerce and industry in Northern Arizona. Further expansion of the railroads west created a need for lumber, and Flagstaff was an ideal location and source. Lumber became a major industry and the impetus for the town to grow and prosper. Railroad and lumber's strong and continuous growth spurred additional growth and development of the town.

As the City of Flagstaff grew, development occurred generally expanding outward from the City center which was situated in close proximity to the train depot. Most of this development was in close proximity to the major streams in the area, within a topographic depression which was, and still is, subject to inundation from major flood events. The ongoing development and pressures

associated with land use resulted in a rerouting of the natural Rio de Flag channel and additional encroachment into the floodplains. As time passed, these areas became more densely populated and developed, and with only minor flooding and a more transient population occurring during those early years, people were unaware of the potential for major flooding of those areas which were growing. A historical growth map is presented on **Figure 4.1.**

Flooding History

The last major floods in Flagstaff occurred in the 1920s and late 1930s. Only minor floods (less than an estimated 25-year event) have since occurred. Significant development within the City's floodplains continued until the adoption of FEMA Flood Insurance in 1983. Since 1983, development within the floodplain has been required to elevate above the FEMA flood zone depth. Consequently, nearly 100 years of prior unregulated development and encroachment has left the channel very narrow and shallow throughout much of the city. Upstream and downstream of Flagstaff, the natural channel is very wide and deep, but within the City, homes and businesses back up to an encroached channel that is narrow and shallow. The channel's current alignment does not follow its original historic path through the city. The existing and estimated historic channel alignment is shown on **Figure 4.2.**

Residential, commercial, and industrial development are extensive along the floodplain of Rio de Flag throughout most of the city. Residential development varies from light to heavy along the tributaries' floodplains. The downtown area, and south side areas, which contain numerous registered historic structures, are almost entirely within the floodplain. Further downstream, the Continental Estates area is subject to flooding as well.

Flooding in Flagstaff is known to have occurred as early as 1888. Other reported floods have occurred in 1896, 1903, 1916, 1920, 1923, 1937, 1938, 1950, 1963, 1966, 1973, 1979, 1983, 1988, 1990, 1993, and 1995. The last major flood in terms of discharge was in 1938, and on a volume basis, 1993.

Damage Areas

Within the overall study area, there are two specific areas which suffer flood damages. These two areas are (1) the Downtown area, which consists of downtown, west portions of Flagstaff, and the south side of Flagstaff including Northern Arizona University, and (2) the Continental Estates area which is at the downstream limits of the study area. The feasibility study focuses on these two areas; other areas do not experience flood damage or already have channel improvements to convey tributary flows.

US ARMY ENGINEER DISTRICT

CORPS OF ENGINEERS

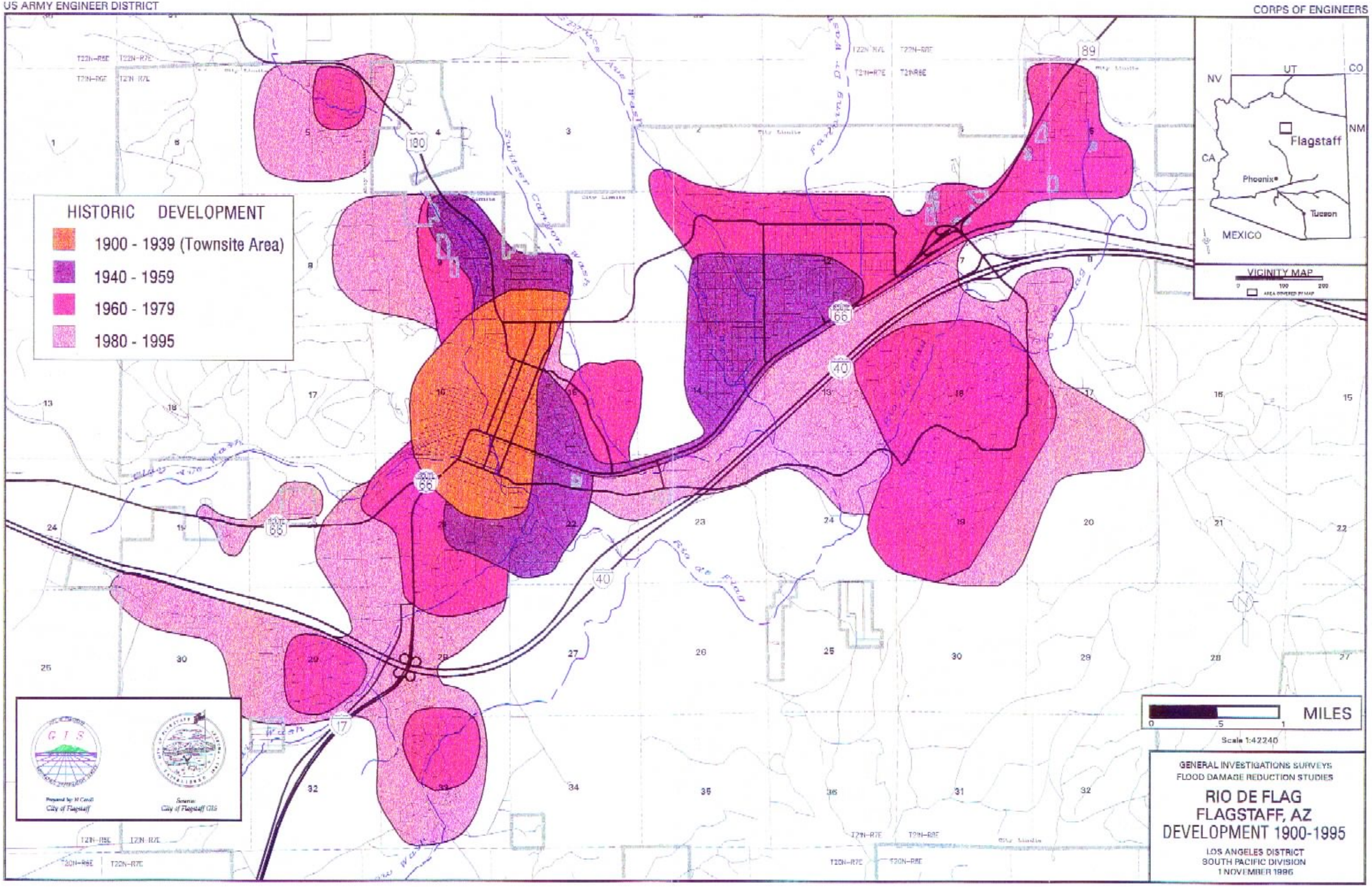


FIGURE 4.1

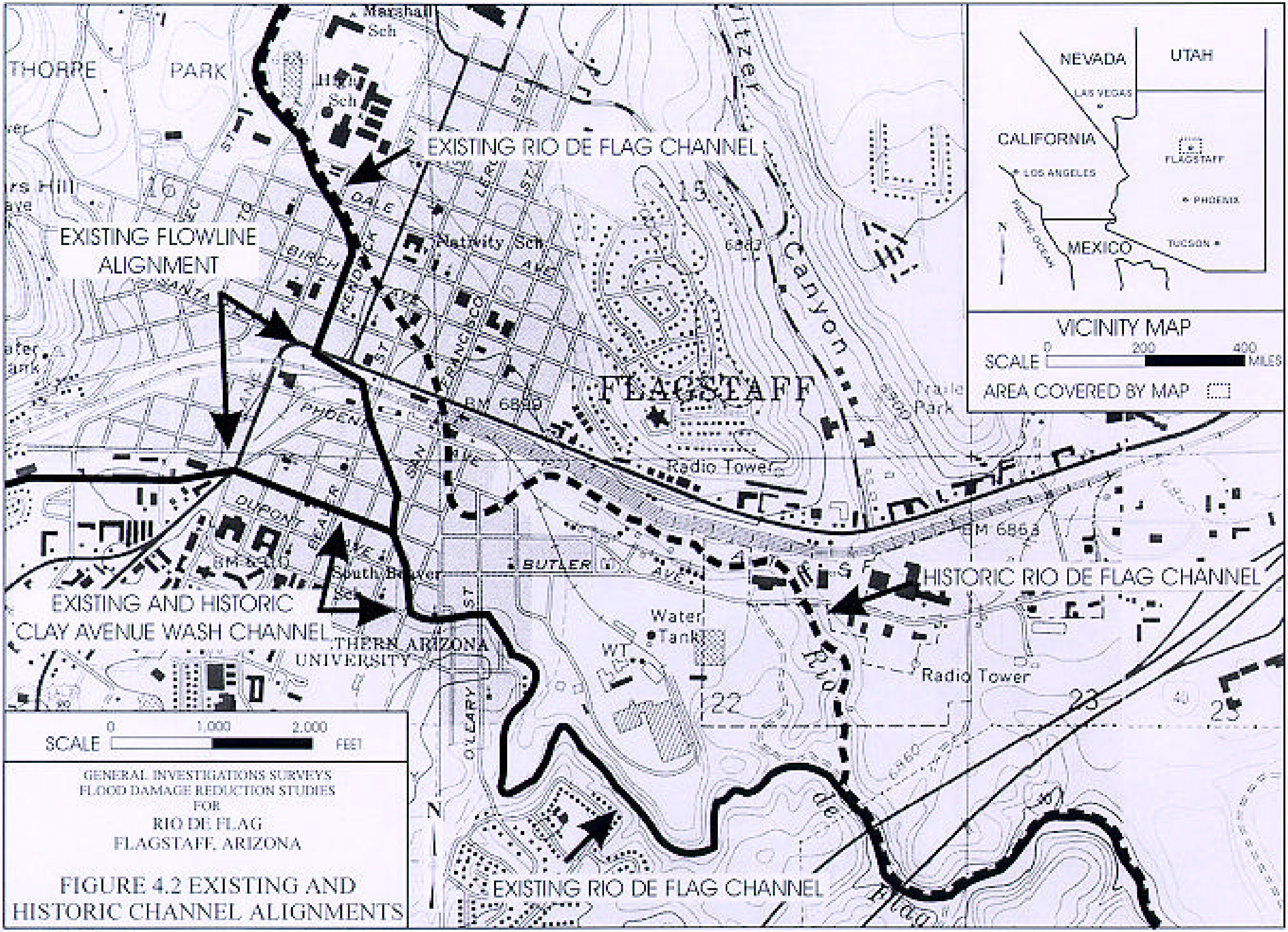


FIGURE 4.2 EXISTING AND HISTORIC CHANNEL ALIGNMENTS

SOURCE: USGS

Historic Damages

As shown on **Figure 4.1**, the City of Flagstaff has experienced significant growth in the past. It is known that flooding has occurred regularly; however, information regarding dollar damages from past flood events is sparse. The 1993 floods resulted in some FEMA claims, and the City has some minimal records from the 1995 floods related to clean up costs. Historic damages, especially in the town center, are known to have occurred, however, records of dollar estimates are non-existent prior to the 1993 FEMA claims. Anecdotal evidence of historic damages is available in the form of recollections of people in the area and old newspaper articles. The last large floods were in the 1920s and 1930s, prior to development of major sections of the town. These damages occurred when the City was smaller and less developed, and would not be meaningful or comparable to existing conditions which reflects recent extensive development both in terms of density and areal extent. Photographic evidence of flooding from recent minor events is provided on **Figure 4.3** through **Figure 4.5**.

The hydrologic, hydraulic, and economic modeling efforts are detailed in the respective appendices to this report. Specifically, the hydrologic modeling effort utilized available historic flooding information from USGS gauges, stage data from recent floods, surveyed high water marks from the 1993 flood event, and associated rainfall data. The existing and without project conditions reflect the results from a calibrated hydrologic model based upon previously observed stage-discharge and other extensive data, including runoff characteristics of the watershed. For a complete discussion of the historical data used in the modeling efforts conducted, please refer to the appropriate appendices.

In the absence of extensive data on historical dollar damages, a detailed and comprehensive effort was undertaken to accurately define the existing floodplain using detailed hydrologic and hydraulic modeling based upon current 2-foot contour interval topographic GIS mapping. Historical data, as discussed above, was utilized to calibrate the models to produce results that are consistent with what has been observed and recorded. The hydrologic and hydraulic modeling efforts result in outputs that are reasonable and defensible, and are generally consistent with previous modeling efforts including FEMA FIRMs. These outputs (discharge, stage, and frequency relationships) form the basis for input parameters for the economic modeling effort.

Structure and content damages were computed using the Corps' HEC-FDA Flood Damage Reduction Model, version 1.2. With available detailed GIS topographic information, first floor elevations of all structures in the floodplain were input along with 100% inventory regarding structure data, structure category, stream location, structure value, content value, and water surface elevations for each frequency of flooding. The Economic model uses standard depth-damage functions and uncertainty functions to produce annualized damage estimates based upon the hydrologic and hydraulic inputs to the model.

Historic damages, even if available, would not be meaningful to the study results due to the growth and development which has occurred in the City over the past 60 years. The last major recorded flood occurred in 1938, and produced water surface elevations comparable to those generated as a result of the hydraulic analysis for this study. However, since the town was much less populated and less densely developed, and the extent of the development at that time did not encompass the entire extent of the floodplain as it does now, estimates of those historic damages are not meaningful for economic justification. In a similar manner, due to the dynamics of growth and ongoing historical change, past estimates of historic dollar damages from other floods are not valid for economic comparison purposes.

Due to the detail of the analysis, extensive review, and the use of this methodology on a variety of Corps of Engineers studies nationwide in recent years, the results to the synthetic damage estimates are considered reasonable and are based upon current conditions.

The cost of a project to control the one percent flood is estimated to be $23,584,000. The annualized cost is $1,780,000, and the estimated annualized benefits under year 2000 conditions are $1,937,000. The benefit-cost ratio based upon existing conditions is 1.09. Additional details are in **Appendix F, Economics**, under Alternative Analysis - Final Array, *"Benefit/Cost Ratio Based Upon Existing Conditions."*

Residential Flooding

Channel in Center of Photo

Figure 4.3 1982 Flood Photos - Downtown Area

Two Hours After Peak

Four Hours After Peak

Figure 4.3 1982 Flood Photos - Downtown Area (cont.)

Channel Exceeding Capacity

Area to the Right - One Foot Depth in Homes

Figure 4.4 1993 Flood Photos - Downtown Area

Flows Breaking Out to the Right

Two Hours Prior to Peak

Figure 4.4 1993 Flood Photos - Downtown Area (cont.)

Continental Estates Area - Post Peak Photo

Figure 4.5 1993 Flood Photos - Continental Area

B. Base Year Conditions

Definition of Base Year Conditions

Base year conditions are defined as those conditions which are expected to exist within the study area in the earliest year that a flood control project could begin to accrue flood damage reduction benefits. A thorough assessment and evaluation was conducted for current conditions for this study. A complete discussion of those conditions is referenced in the associated appendices to this report. This section focuses specifically on the without-project conditions in a base year of 2003. The future without-project condition, discussed later in this report, is a projection of how the base year without-project conditions are expected to change over the 50-year study period to form the basis against which alternatives could be developed, evaluated, and compared.

Hydrology

The past history of flooding within the City of Flagstaff indicates that flooding may occur during any season of the year. Three types of storms produce precipitation in the area: (1) general winter storms, (2) general summer storms, and (3) local storms. Summer storms normally are high-intensity, short-duration local storms, but severe. General summer storms, usually associated with tropical cyclones, also occur. General winter storms cover large areas and are usually of long duration. Flooding has resulted from a variety of meteorological circumstances. Intense short-duration rainfall, heavy snowpack with ripe melting conditions, and generally severe rainfall on melting snow can also lead to flooding. Warm rain on snow during the winter with frozen ground conditions results in substantial runoff. Flooding can also result from a series of storms, which prime the basin for runoff.

The Corps of Engineers (COE) has been directly involved in flood studies in this vicinity since 1940 and most recently during the period from 1960 through the 1970s. Several additional studies have been undertaken by private consultants, the Arizona Department of Water Resources (ADWR), the United States Geological Survey (USGS), and the Federal Emergency Management Agency (FEMA) in the intervening period since the Corps of Engineers Floodplain Information report was published in 1974. The hydrology for the FEMA Flood Insurance Rate Maps has not been updated since 1983, and those maps are still in effect for the City of Flagstaff.

Discharge-frequency values for appropriate locations on Rio de Flag and Clay Avenue Wash have been developed to reflect the near term year 2003 base year conditions. The 2003

discharges are displayed in **Table 4.1**, the future discharges are discussed later in this report under "Future Without-Project Conditions".

Base Year (2003) Floodplain

The hydrologic modeling which has been performed for this feasibility study was utilized to delineate the floodplain for the purposes of economic analysis of expected damages within the study area. The floodplain was determined for a near term base year of 2003 and for future conditions in the year 2053. The Rio de Flag overflow analysis mapped the 2, 10, 25, 50, 100, and 500-year floodplains using the U.S. Army Corps of Engineers HEC-2 and HEC-RAS water-surface profile models. Base year (2003) overflow mapping is presented on **Figure 4.6** and **Figure 4.7.** Detailed overflow mapping at a large scale, along with flood profiles, are presented in the **Appendix B, Hydraulics**. Future floodplain overflow mapping is presented later in this chapter under Section C, "Future Without-Project Conditions."

The patterns and extent of development are significant within the study area because of the limited availability of developable land, and the small size of the watershed (116 square miles). Of those 116 square miles, there is an effective drainage area of approximately 85 square miles. Between 1995 and the base year (2003) approximately 9.4 square miles (sq.mi.) of the City of Flagstaff is anticipated being developed. Then, between the base year (2003) and the end of the project life (2053) an additional 9.84 sq.mi. of development is anticipated in upland surrounding areas which directly contribute to runoff; hence, by the year 2053 projected growth and development for the City of Flagstaff will encompass approximately 30 sq.mi. compared to the 1995 figure of about 11 sq.mi. An updated analysis of these projections is described below.

Year 2003 Base Year discharges are approximately 20 percent higher than 1995 discharges due to development which is known will occur up until the base year from building permits already applied for. The increase in developed area between existing conditions and base conditions is approximately ten square miles, which represents an approximate doubling of the effective impervious cover. This increase in effective impervious cover results in a general increase of 20 percent in peak discharges, which subsequently results in an approximate ten percent increase in estimated economic damages. As discussed previously, the project is justified based upon economic damages under existing conditions. **Table 4.2** summarizes the changes in basin development from 1974 to 1995 to 2003 to 2053, the year established as the end of the project lifespan. These projections are consistent with what has actually occurred as described below.

The 1973 City of Flagstaff Land Use Survey indicated that the developed area at that time within the City was approximately ten square miles. In August 2000, the City of Flagstaff and Planning Division and Geographic Information Systems Division performed a detailed spatial analysis of the existing developed area within the City of Flagstaff Urban Service Boundary (USB). The entire USB lies within the Rio de Flag and Clay Avenue Wash watersheds. This analysis indicates that there is currently 19.325 square miles of developed area and 11.22 square miles of developable area within the USB. The average rate of growth is approximately 325 acres per year and over one square mile of committed development will occur in 2001 alone. All lands between the USB and the Corporate City Limits will be preserved as open space per the Flagstaff Area Regional Land Use and Transportation Plan.

The City of Flagstaff continues to pursue an aggressive growth management policy as briefly described above that, in conjunction with established floodplain management practices (FEMA FIRM requirements in place since 1983), is reasonably expected to limit the development growth, and hence the associated runoff, down to those projections currently being utilized for this feasibility study.

As seen from the overflow figures, the floodplain encompasses several sections of Flagstaff. The upper limit of the floodplain originates in the northwest quadrant of the city and includes a large residential area north of Flagstaff High School and mixed residential and commercial development in the downtown area south of the high school and north of Highway 66. South of the highway, the overflow area extends downstream into the southwest quadrant of the city.

Table 4.1 Rio De Flag Base Condition (2003) Results: Peak Discharge Frequency and Stage Frequency Results

CP NO.	LOCATION	EFFECTIVE DA sq.mi.	500-YR	100-YR	50-YR	25-YR	10-YR	2-YR
			Discharges in ft³/s					
	RIO DE FLAG							
1	at Flagstaff (former gage site)	31.1	4830	1910	1400	925	451	90
2	at Santa Fe Avenue (Route 66)	33.9	2520	1510	1290	550	318	102
3	above confluence with Sinclair Wash	49.2	3560	2390	2100	1170	358	63
4	below confluence with Sinclair Wash	60.8	5370	3140	2570	1530	622	145
5	below confluence with Switzer Wash	76.1	8380	4040	3270	1760	526	124
6	above AT & SF Railroad embankment (Continental Lake)	85.3	8430	4120	3350	1860	531	154
	below AT & SF Railroad embankment (outlet from culverts)	85.3	94	85	82	71	32	7
	CONTINENTAL LAKE STAGE							
6	Maximum Water Surface Elevation, ft NGVD	85.3	6768.9	6764.8	6762.9	6758.4	6751.5	6748.4
6	Inflow to geologic drain	85.3	244	217	202	162	56	0

NOTES:

- Results include impacts of channel routing, breakouts from channel and overbank routing based upon hydraulic data provided by RS Engineers
  To include split flow leaving Rio de Flag in vicinity of (1) Thorpe Road, (2) West Cherry Avenue, and (3) Butler Avenue;
  Return flow (overbank) in the vicinity of (1) Bonito Street, (2) Route 66/Santa Fe Avenue, and (3) Rio de Flag via the Historic Channel, respectively.
- Clay Avenue Wash is presumed to enter Rio de Flag along a lateral front, which was quantified for modeling purposes as the vicinity of Butler Avenue.
- Results include impact of the detention basin on Sinclair Wash in vicinity of Palmer Road.
- Outflow based upon culverts being partially blocked. In the vicinity of Continental Lake a portion of stored water in the basin to the geologic drain.

Table 4.2 Basin Development - 1974, 1995, 2003, and 2053

Subarea		Percent Drainage Area (DA) Developed									
		1974		1995		2003		Changes, 2003 - 2053		2053	
Designation	Effective DA, sq.mi.	COF[1]	FPI % Eff. Imp. Cover	COF[1]	FPI % Eff. Imp. Cover[2]	COF[1]	FPI % Eff. Imp. Cover[2]	COF[3]	FPI % Eff. Imp. Cover[4]	COF[3]	FPI % Eff. Imp. Cover[4]
A	31.13	0	0	2	0/1	8	4	5	1.71	13	6
B	2.84	36	15	48	23	60	29	21.2	6.9	81	36
C	15.24	5	3	9	4	13	6	11.5	5	24.5	11
C1	14.19					9	4	12.3	5.1	21.3	9
C1-A	10.57					9	4	10.1	4.4	19.1	8
C1-B	0.64					2	1	18.3	8.7	20.3	10
C1-C	0.23					2	1	12.3	8.6	14.3	10
C1-D	2.75					10	5	19.2	6.8	29.2	12
C2	1.05					65	31	1.1	3.7	66.1	35
D	8.25	0	0	2	1	2	1	17.7	5.7	20.	7
E	3.35	25	2	48	23	66	32	17	12.3	83.	44
F	9.13	6	0	9	4	47	23	28.5	20.4	75.5	43
F1	0.49					100	48	10.6	8.1	100	48
F2	3.96					33	25	35.1	30.4	6.8.1	55
F3	4.68					53	25	24.7	13.3	77.7	38

Table 4.2 Basin Development - 1974, 1995, 2003, and 2053 (continued)

Subarea		Percent Drainage Area (DA) Developed									
		1974		1995		2003		Changes, 2003 - 2053		2053	
Designation	Effective DA, sq.mi.	COF[1]	FPI % Eff. Imp. Cover	COF[1]	FPI % Eff. Imp. Cover[2]	COF[1]	FPI % Eff. Imp. Cover[2]	COF[3]	FPI % Eff. Imp. Cover[4]	COF[3]	FPI % Eff. Imp. Cover[4]
G	6.16	15	25	20	10	51	24	2.2	1.4	53.2	25
H	9.23	16	2	40	19	46	22	12.3	4.3	58.3	26
S, sq. mi.	**85.33**	**5.57**	**2.68**	**10.88**	**5.16**	**20.23**	**9.75**	**9.84**	**4.72**	**30.07**	**14.47**

NOTES:

% Effective Impervious Cover is the value used for variable "RTIMP" on LE card (LE.5); See Hydrology Appendix for detail information.

Cross-hatched sections of the table indicates no information was generated. The subareas were subdivided after this information was developed.

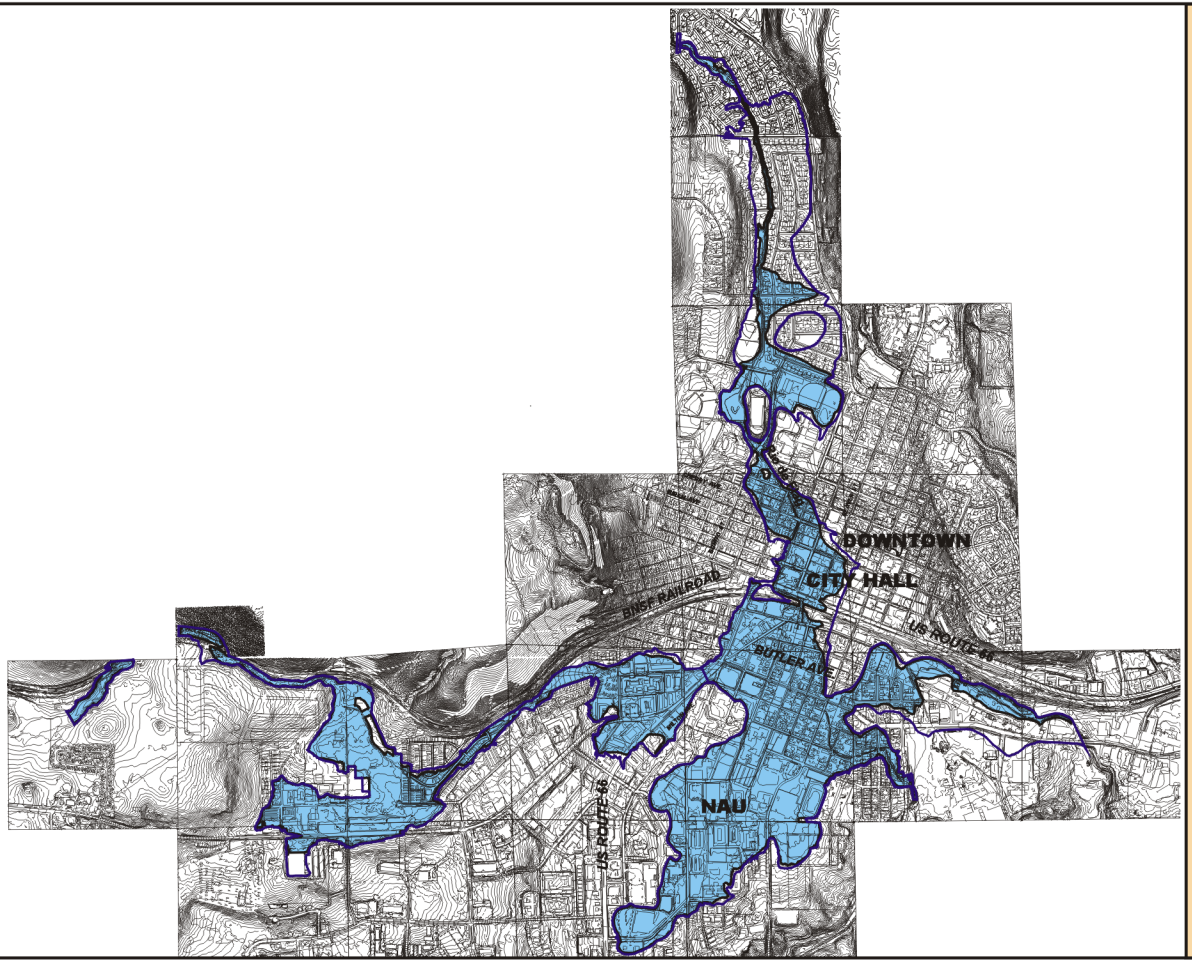
[1] Map provided by City of Flagstaff, Planning Division, reviewed 12/29/93.

[2] Based upon ratio of RTIMP, 1974 FPI, to 1974 Developed Area, 2.68/5.57 = 0.48. Based upon review of published % Imp Area, dependent upon type of development, indicates a range from 0.1 to 0.9. Hence, 0.48 is reasonable for use.

[3] Flagstaff Area, Regional Land Use and Transportation Plan, Scenario 1 "Current Trends" Source: Flagstaff Planning Division, prepared by Balloffet & Associates, September 1998.

[4] Effective Impervious cover is the product of the coefficient for land use type and area. The weighted average (i.e., DA x Impervious Cover) = 0.48. Because expected future development maps were available (Table Note 3, above), this information was distributed differentially over each subarea rather than use the simplified ratio developed previously. However, the integrated results over the entire basin were retained.

C:\PROJECTS\RIOD\FIDOWNTOWN.APR - W/O Project Downtown FP 2003 (11x17)



GENERAL INVESTIGATION
FLOOD DAMAGE REDUCTION STUDY
FOR
RIO DE FLAG,
FLAGSTAFF, ARIZONA

2003 FLOODPLAIN

Without-Project Conditions 100 & 500 Years Downtown Area

LEGEND

- 100 YEAR FLOODPLAIN 2003
- 500 YEAR FLOODPLAIN 2003

U.S. ARMY CORPS OF ENGINEERS
Los Angeles District
South Pacific Division

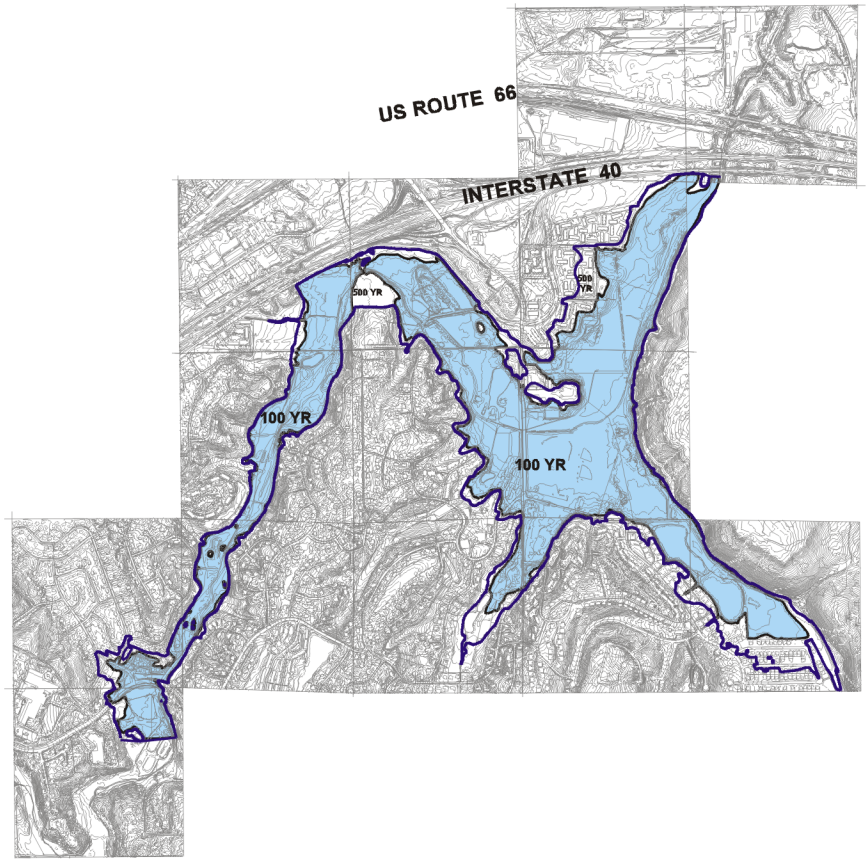
CITY OF FLAGSTAFF
ARIZONA

400 0 400 800 1200 1600 Feet

1:18000

October 15, 1999

C:\PROJECTS\RIOD\Fcon_flood.apr - Without Project Continental FP 2003



GENERAL INVESTIGATION
FLOOD DAMAGE REDUCTION
FOR RIO DE FLAG
FLAGSTAFF, ARIZONA

2003 FLOODPLAIN

Without-Project Conditions 100 & 500 Years Continental Area

LEGEND
100 Year Floodplain (Year 2003)
500 Year Floodplain (Year 2003)

U.S. ARMY CORPS OF ENGINEERS
Los Angeles District
South Pacific Division

CITY OF FLAGSTAFF
ARIZONA

400 0 400 800 1200 Feet

1:18000

October 15, 1999

Three reaches of Rio de Flag were defined for hydraulic analysis purposes, and two reaches for Clay Avenue Wash, as part of this study. The three Rio de Flag hydraulic reaches were identified as the Lower Reach, the Upper Reach, and the Historic-Channel Reach. Clay Avenue Wash was divided into Upper and Lower reaches. **Figure 4.8** shows the reach locations.

Rio de Flag

Lower Reach : The Lower Reach of Rio de Flag extends from just upstream of the State Route 66/BNSF Railroad/Interstate 40 crossings to Butler Avenue. The total length of the Lower Reach is approximately 3.2 miles. The Lower Reach begins in an area known as Continental Lake and traverses a dense residential area known as Continental Estates. The Continental Lake area serves as a large regional detention basin under current and projected future conditions.

This detention area near the downstream end of the study reach was initially formed by the construction of parallel embankments for the Burlington Northern Santa Fe Railroad (formerly known as the AT&SF) in the late 1800s. Later State Route 66, and most recently Interstate 40, were constructed with the railroad embankment and associated ponding upstream being an existing condition at the time of that construction. The "Continental Lake" has been in existence then for approximately 100 years, well before any significant development in the area. The detention area is normally empty, and is drained by a series of small culverts which pass through the embankments. There is a natural geologic drain feature contained within the periphery of Continental Lake which allows small discharges to exit into the karst formation and infiltrate underground.

Upper Reach : The Upper Reach of Rio de Flag extends from just downstream of Lonetree Road upstream to Crescent Drive. The total length of the Upper Reach is approximately 2.6 miles.

Estimated Historic Channel Reach : The historic channel reach generally parallels the railroad and extends downstream past the Butler Avenue crossing. The total length of the historic channel reach is approximately 0.68 miles.

Clay Avenue Wash

Lower Reach : The lower study reach for Clay Avenue Wash begins at the Rio de Flag confluence and extends upstream to the Pinnacle Street alignment. The total length of Clay Avenue Wash lower reach is approximately 0.87 miles.

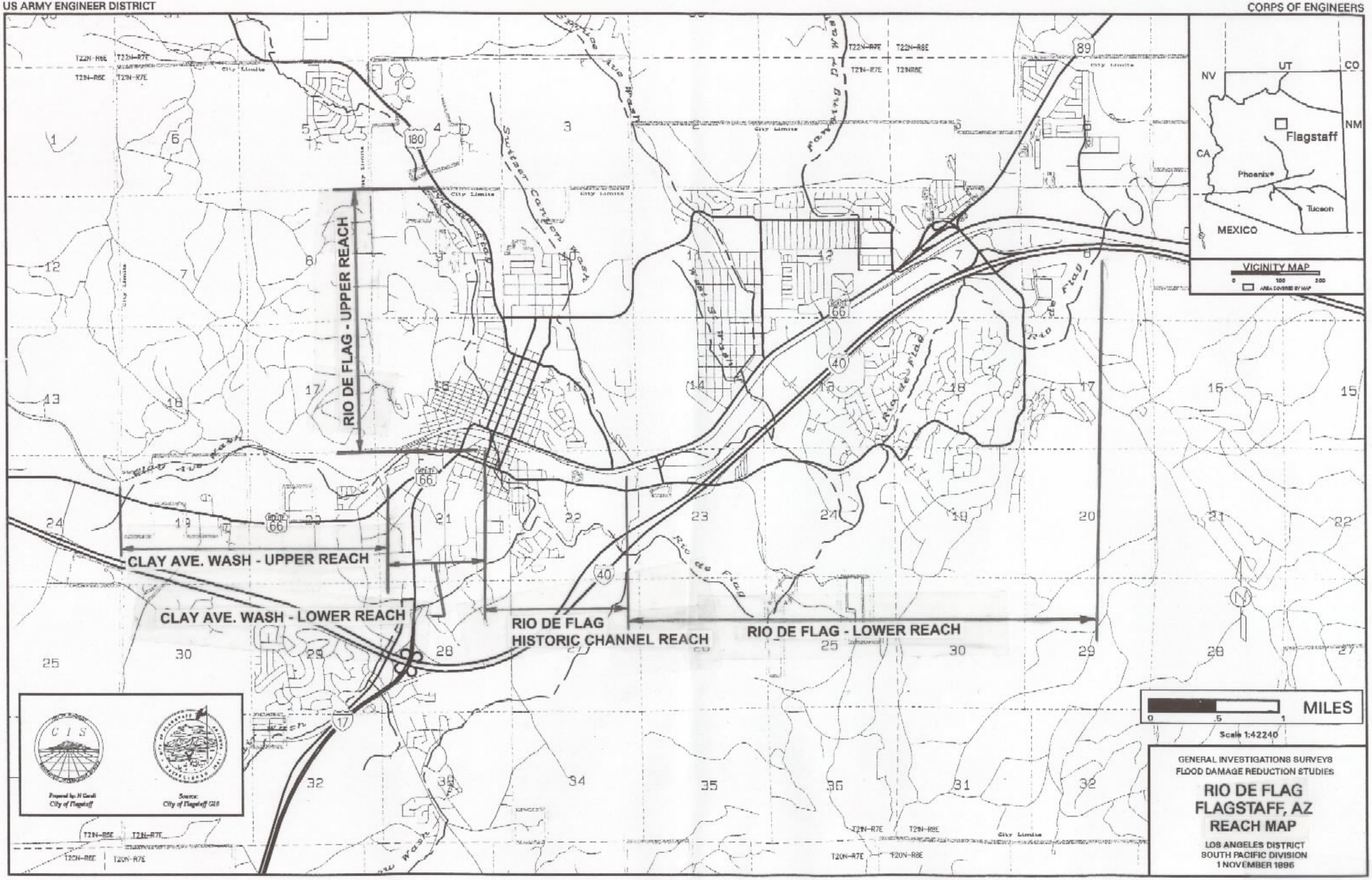
Upper Reach : The upper study reach for Clay Avenue Wash begins just upstream of Pinnacle Street and extends upstream through several new residential developments until reaching an area of State land where the City limits end. The total length is approximately one mile.

There is no defined main channel section for Clay Avenue Wash between the Rio de Flag confluence and Milton Road. Flood flows are conveyed to Rio de Flag by overland flow and local storm drains.

Modeling Results : Based on the results of the overall modeling effort, both Rio de Flag and Clay Avenue Wash exhibit complex flow patterns. The floodplain delineations were determined using the topography, the distribution of flow, the depths of flow, and the computed water surface elevations as a guide.

In general, the results of the hydraulic analysis indicate that the capacity of the Rio de Flag channel along the majority of the study reach ranges between the 2-year and 10-year peak discharge. Along the Lower Reach, the capacity approximates the 2-year discharge. Between Lonetree Road and Dale Road within the Upper Reach, the capacity approximates the 10-year to 25-year discharge. Upstream of Thorpe Park, the capacity approximates the 100-year peak discharge.

Along Clay Avenue Wash, overbank flooding begins when the peak discharge approaches the 2-year peak discharge, however, this is due to the lack of a defined channel in the area. Local drainage facilities and existing street drainages are adequate to convey these floodflows which originate in the upstream watershed up until an approximate 10-year frequency event, which then begins to cause some damages. The larger, less-frequent floodflows originating outside the local drainage area in the upstream watershed cause higher levels of flood damage.



GENERAL INVESTIGATIONS SURVEYS
FLOOD DAMAGE REDUCTION STUDIES

RIO DE FLAG
FLAGSTAFF, AZ
REACH MAP

LOS ANGELES DISTRICT
SOUTH PACIFIC DIVISION
1 NOVEMBER 1996

Figure 4.8

Comparison with Effective FIRM : The base year 100-year floodplain was compared to the floodplain shown on the effective Flood Insurance Rate Maps for the City of Flagstaff. The comparison included the areal extent of flooding, the peak discharges, the roughness coefficients, and the bridge and culvert modeling assumptions and other associated factors. The purpose of comparing the Corps' feasibility analysis against the 1983 FEMA analysis is to address public concerns relative to why there is a difference and what those differences are. In general, the old FEMA hydrology does not account for the growth and development which has occurred over the past 20 years, and the Corps new model is more rigorous, as discussed below.

Differences in the results between this feasibility study and FIS can be better understood by recognizing that the two studies were prepared for different purposes. The FIS maps are intended to be used for regulating floodplain development and for determining flood insurance rates, whereas the feasibility study was performed to support economic analysis of flood damages. The Corps study additionally accounts for the effects of future development, whereas the FIS study does not.

It is important to note that the results of this feasibility study, by themselves, will not alter the FEMA FIRM requirements. The analyses conducted for this feasibility study have been developed based upon criteria specific to the U.S. Army Corps of Engineers and are not to be construed as meeting the separate criteria required by the Federal Emergency Management Agency to effect a Flood Insurance Rate Map Revision.

The 100-year peak discharges used in this study are higher than the values used in the effective flood insurance study (FIS). For the Lower Reach, the discharge is approximately 25% higher than FIS discharge. For the Upper Reach, the discharges are between 15% and 80% higher than the FIS values. For Clay Avenue Wash, the discharge is approximately 5.7 times higher than the FIS discharge.

The hydrologic information developed within the framework of this Corps of Engineers feasibility study has a different basis than the previous FEMA analysis. The Corps hydrologic model is calibrated to actual observed discharges and stages, whereas the FEMA modeling made direct use of rainfall-runoff modeling. Hence, the two models are not directly related and there is no hydrologic equivalency between them. Generally, the Corps' current model discharges are greater because of development which has occurred since the FEMA model was developed, and due to accounting for development which is known will occur in the future. In addition, to match downstream gage readings and surveyed high water marks from recent flood events, runoff from

tributary subareas was increased. The current Corps hydrologic modeling accounts for urban growth and development, snow melt, base flow, channel infiltration, and channel breakout, and utilizes a rigorous representation of channel and overbank geometry and flow restrictions based upon current detailed (two-foot contour interval) topographic mapping.

The extent of flooding shown on the effective FIRMS for the Lower and Upper Reaches of Rio de Flag is very similar to the extent defined by this study. However, along Clay Avenue Wash, the without-project 100-year floodplain encompasses roughly 40% more area than was delineated on the effective FIRM. This is due to differences in discharges and hydraulic analysis between the two studies.

Comparison of the 100-year water surface and flowline profiles revealed no consistent trend or difference between the two studies. Both profiles fluctuate significantly above and below the FIS profiles. The noted differences can be attributed in large part to datum differences between the 1975 topographic mapping and this study's more recent and accurate GIS 1988-1996 mapping.

Geology and Soils

Flagstaff is astride a geologic contact between volcanic and sedimentary rocks. Generally, the City is on volcanic rocks at points north of Santa Fe Avenue, and on sedimentary rocks beginning a few tens to a few hundred feet south of Santa Fe Avenue. Basalt is also present under most of the existing Clay Avenue Wash channel, upstream of Blackbird Roost, and should be expected under northern Mike's Pike. The local volcanic rocks, at an age of generally less than one million years, are among the youngest in the San Francisco volcanic field. From its headwaters to the point where the river enters the northern City limit, Rio de Flag flows over two different Pleistocene-age andesites, colluvium, and possibly glacial outwash from the south slope of San Francisco Mountain.

The main significance of surficially exposed rocks to the study reach is the enhancement of runoff infiltration. Most rock types exposed at the surface in Rio de Flag have been recognized as contributing to rapid infiltration of surface water flow, including volcanic cinders (due to porosity), lava (porosity and fracturing), and basalt (porosity). The calcareous sedimentary rocks enhance infiltration only where they are fractured. The fractures can expand into extensive solution channels and cavities over time which then can absorb much surface runoff. This enhancement of infiltration of surface runoff is countered to some degree by the makeup of local soils, and infiltration may be virtually zero under frozen ground conditions.

The study area is characterized primarily by the presence of the differing types of rock, at or very close to the surface. Any proposed project will require extensive excavation of rock, which will result in higher than average costs for the alternatives.

There are several sites where remediation of hydrocarbons may be required. These sites are generally small localized occurrences. Additional clean up of hydrocarbons may be necessary in small pockets located on railroad property.

Environmental Resources

Cultural Resources

According to Museum of Northern Arizona Archeologist, Dr. David Wilcox, there are no known prehistoric archeological sites within the Area of Potential Effects (APE), and that there is very little potential for any to exist. However, the open areas below Butler Avenue have not been surveyed for cultural resources. Most of the remaining area along the existing channel has been disturbed by housing developments, a golf course, and grading near the wastewater treatment plant. The source of cultural resources for the study is the abundance of historic structures within the City of Flagstaff. Historic building surveys have been going on since the early 1980s with over 1,000 buildings either listed on the National Register of Historic Places or pending. There are approximately 350 buildings in the Southside/Oldtown Historic District (SOHD) alone. In addition the Downtown Historic Districts may be affected by a flood control project. Most of these historic structures are not located within the floodplain, and there are only a small number which may potentially be impacted by any flood control proposal.

Water Resources

Ground Water : The depth to the main aquifer in the vicinity of Flagstaff (Coconino aquifer) ranges from as much as 2,500 feet in the north to 1,100-1,200 feet in the southwest (the City's Woody Mountain Wellfield), and as little as 300 feet in the Lake Mary area south of town. The groundwater divide, located about eight miles southwest of Flagstaff, is indicative of a major groundwater recharge zone.

Localized aquifers, called perched aquifers, occur in the study area where lower permeability geologic materials impede the downward flow of water and prevent the water from reaching the main aquifer below. No data are available concerning perched aquifers within the study area, but wells in perched aquifers in volcanic rock about 10 miles west of Flagstaff intersected water at depths of 21 to 27 feet.

Surface Water : Within the region are two lakes which provide for surface water supply for the City of Flagstaff, upper and lower Lake Mary. These two lakes are distant from the study area and will not be impacted.

Two local permanent water resources exist along Rio de Flag in the study area: a duck pond (Francis Short Pond) behind Flagstaff Middle School, and effluent from the Rio de Flag Water Reclamation Plant, which creates an undamaged artificial low quality wetland where Rio de Flag crosses westbound I-40. Effluent discharge from this reclaimed water facility averages approximately 1.7 million gallons per day.

Biological Resources

Vegetation; Five vegetation types were identified in the study area: 1) Petran Montane Conifer Woodland, 2) Montane Meadow Grassland, 3)Wetland, 4) Mixed Riparian, 5) Disturbed/Urban. Elements of these communities are commonly intermixed throughout the study area. These five vegetation types and dominant plant species, including non-native species, are summarized below. Dominant plant species were identified based on total canopy cover. Complete descriptions and distribution of these communities is contained in the **EIS**.

Wildlife : Wildlife habitat quality in the study area depends largely upon the extent of human disturbances. From the upstream extent of the study area to the confluence of Sinclair Wash, wildlife habitat is limited by surrounding mixed residential and commercial developments.

The portion of the study area with the highest potential for wildlife utilization is below the confluence of Rio de Flag and Sinclair Wash, up to Herold Ranch Road. There are two reasons for this: 1) less disturbance in the form of development up to the edge of the channel and less disturbance in the river channel, and 2) the presence of perennial water from the Flagstaff wastewater treatment facility.

From Herold Ranch Road to the downstream end of the study area, wildlife habitat quality progressively declines from excellent to poor. The discharge from the wastewater treatment facility infiltrates the soils and surface flows disappear. Additionally disturbances from past agricultural activities, re-channelization, housing development, and construction of a golf course have already affected the overall quality of the wildlife habitat. Wildlife has more potential to occur in this section, albeit more sporadically and at lower densities.

Sensitive Areas : Other areas that have not been directly discussed above and have special attributes include the duck pond, the I-40 wetlands, and the wastewater treatment plant ponds. The duck pond is located immediately downstream of Thorpe Road. The pond provides both high recreational opportunities and high values for marsh birds and other shorebirds for foraging and roosting opportunities. The exterior portion of the pond is lined with reeds, rushes, and cattails, and it even appears as though an inner island exists. The inner island would also provide foraging and roosting opportunities as well as additional benefit for nesting opportunities.

The I-40 wetlands are located just upstream of I-40. A healthy stand of cattails and reeds exist at this site. Unlike the duck pond, this wetland is located on the outskirts of the city and is surrounded by little development. Functions of this wetland would be similar, but higher than those mentioned for the duck pond.

The wastewater treatment plant ponds are located downstream from the I-40 crossing. These ponds also provide benefits for aquatic species as well as marsh and shorebirds.

NEPA Compliance/Issues & Concerns

Fish and Wildlife Coordination Act, as amended : Coordination efforts with the USFWS and the State of Arizona Game and Fish (AGFD) are in process and will continue through the feasibility study. Formal coordination is completed integral to the feasibility study.

Endangered Species Act of 1973, as amended : As required by Section 7 of this Act, the Corps requested a list of threatened, endangered, proposed, and candidate species known to occur within the proposed project areas. All pertinent species information is addressed and incorporated into the **EIS**.

There are no known occurrences of threatened or endangered species in the proposed project areas.

Economics

Without-project structure and content damages were computed utilizing the HEC-FDA Flood Damage Reduction Model, Version 1.2. The model computes equivalent annual damages based upon the input parameters of structure data, category of structure (single family residence, multi-family residence, public, commercial, industrial, mobile home), stream location, ground elevation, first floor elevation, structure value and content value. These parameters are compared with hydrologic and hydraulic data including frequency-discharge and stage-discharge relationships. Data was input, including appropriate risk and uncertainty variables, for base year (2003) and future (2053) conditions.

The results of the base year computations are presented in **Table 4.3**, which displays the expected annual damages for the base year condition using current price levels. Economics for the year 2053 may be found below in Section C, "Future Without-Project Conditions."

Table 4.3 Base Year Expected Annual Damages (x1,000)

	Rio de Flag N. of Hwy 66	Rio de Flag S. of Hwy 66	Clay Ave. Wash	Historic Channel	Continental Area	TOTAL
Single Family Residence & Mobile Home	$130	$83	$60	$8	$43	$324
Multi-Family Residence	$46	$52	$41	$3	$107	$249
Commercial	$61	$46	$150	$0	$6	$263
Public	$40	$114	$916	$0	$0	$1,070
Industrial	$0	$22	$51	$5	$4	$82
Total	$277	$317	$1,218	$17	$160	$1,989

Socioeconomics

Growth Projections

Flagstaff and the surrounding areas are expected to sustain steady growth of one to two percent until beyond the year 2053. Growth is an important element to the feasibility study analysis because it affects the amount of developed area which in turn affects the runoff and flood damages. For the feasibility study, existing development was evaluated and future growth and development assessed. Future growth and development generally will not occur in the base year floodplain, since these areas are already intensely developed. The growth will occur primarily in

upland areas. Most future development will occur on privately owned land (approximately 5,000 acres), however, some future development will occur on public lands (approximately 2,000 acres) which are available for development through a variety of annexations, sales, or exchanges which are currently available. As an example, the Arizona State Lands Department is mandated to sell state-owned land to the highest bidder with the proceeds to made available for education.

For the economic analysis, damages (hence benefits) due to future growth and development that are, or would be, induced by a Federal project are not evaluated or included. A general land ownership map is displayed on **Figure 4.9**. Detailed information on growth and future development is displayed in the **Appendix F, Economics.**

Recreation

The beautiful natural environment surrounding Flagstaff draws both residents and tourists to the area. Approximately 384 of the 525 square miles that comprise greater Flagstaff are managed by Coconino National Forest, which is one of the world's largest Ponderosa pine forests. These forests provide critical habitat for elk, deer, antelope, bear and other wildlife. The San Francisco Peaks, including Mount Humphreys, are located north of the City, and Walnut Canyon, a national monument with pre-historic archaeological cliff dwellings, is located to the south. Grand Canyon National Park (which attracts about five million visitors annually) and Glen Canyon National Recreation Area, located outside the limits of greater Flagstaff, are the region's two largest tourist destinations.

Due to its 7,000-foot elevation, Flagstaff experiences heavy snowfall during the winter and mild temperatures during the summer. This allows for diverse recreation facilities ranging from snow skiing in the winter to horseback riding, hiking and other recreation in the summer. The City of Flagstaff operates and maintains 29 parks and six recreation centers. Neighborhood parks include playgrounds, activity areas, pedestrian and bicycle paths.

The City has also developed a number of trail systems, including Rio de Flag, Observatory, Sinclair Wash, Bow and Arrow, Route 66, and McMillan Mesa Trail Systems. These interconnected trails and linear recreation areas extend throughout the City. They offer and provide for alternative means of transportation, informal exercise and recreation opportunities. Uses include bicycling, hiking, jogging, cross country skiing, educational activities, as well as pedestrian and bike commuting.

The City's trail system also connects with the Arizona State and Coconino National Forest trail systems, as well as the Flagstaff Bikeways System. This extensive interconnected system allows access to forest wilderness areas, canyons, cultural centers, national monuments, NAU, downtown Flagstaff, and residential and shopping areas. The natural greenbelt setting of these trails promote enjoying the environment and provide exposure to diverse wildlife and plant life. The City plans on continued expansion of trail systems on city-owned land and through acquisition and utilization of easements, drainage ways, floodplains, high-slope areas, and less developable lands.

C. Future Without-Project Conditions

Definition of Future Without-Project Conditions

This condition represents the longer-term planning horizon that is reasonably expected to exist in the absence of project-related Federal-involvement. It consists of the base year (2003) conditions projected to a future year, utilizing reasonable assumptions of how the base year conditions may change if no Federal action takes place. The base and future year without-project condition serves to compare and evaluate any proposed actions which are developed. The future condition year for this study is 2053.

For the Rio de Flag Feasibility Study, base year conditions have been described and quantified above under "Base Year Conditions." For the future without-project condition, projected changes to those conditions have been made through the year 2053. The without-project conditions and assumptions are summarized below.

Basic Assumptions

No new flood control project is assumed to be in place prior to construction of a Federal project. In the event that a new feature is constructed by local interests prior to such authorization, the feature may be considered as an integral and compatible part of the Federal plan if prior approval is obtained.

The earliest projected year that a Corps of Engineers flood control project could begin to be operational is 2003. This is the first year (base year) that benefits could begin to accrue.

US ARMY ENGINEER DISTRICT

CORPS OF ENGINEERS

LEGEND

- Coconino National Forest
- State Trust
- Private
- Coconino County
- Northern Arizona University

VICINITY MAP

NV UT CO NM CA MEXICO

Flagstaff

Phoenix

Tucson

AREA COVERED BY MAP

MILES

Scale 1:42240

GENERAL INVESTIGATIONS SURVEYS
FLOOD DAMAGE REDUCTION STUDIES

RIO DE FLAG FLAGSTAFF, AZ LAND OWNERSHIP

LOS ANGELES DISTRICT
SOUTH PACIFIC DIVISION
1 NOVEMBER 1996

Figure 4.9

Hydrology

Consideration of increases/decreases in watershed runoff was made in order to predict study area discharge for the year 2053 without-project condition. The magnitude of anticipated future growth in the Flagstaff area was investigated based on the City's development plans. The increase in runoff due to an increase in urbanization is reflected in the discharge-frequency values for the future, without-project condition displayed in **Table 4.4**. In comparison with **Table 4.1** for the 2003 condition—and as would be expected—the smaller flood events (10-, 25-year) experience a greater percentage increase in discharge due to increased development. Future condition without-project discharges for the 100-year event increase from approximately 10% in the upstream study area to 25% further downstream. In addition, the volume of runoff increases resulting in higher stages in the Continental/Big Fill Lake area (see **Table 4.4**, CP-6).

During the progress of the study, the study area along Clay Avenue Wash was extended further upstream due to an identified technical need for more detailed analysis.

Hydraulics

The without-project hydrology was utilized to develop overflow delineation mapping. Water surface elevations are utilized to compute damages using the HEC-FDA economic model. Future without-project (2053) overflow mapping is presented on **Figures 4.10** and **4.11**.

The Route 66 outlet discharge is 90 cfs for the without-project condition. The FIS allowable discharge is 210 cfs. Inflows will continue to be detained upstream of the Route 66/RR outlet.

The Continental area is the adequate point of disposal since it is a designated floodway or "de facto" detention area for flood waters. Further, if no action is taken, the Continental area will continue to experience increases in the volume of water and higher water surface elevations due to ongoing upstream development and associated runoff. There is and will continue to be significant inflow volume from the drainage areas downstream of the downtown area.

The existing 10-foot by 3-foot box culvert under Butler Avenue between Milton and Rio de Flag does not convey significant flood flows for the without-project condition.

Flooding may result from the combination of runoff in Rio de Flag, local inflow, and runoff from Clay Avenue Wash, Sinclair Wash, and other tributaries.

The geologic drain feature is assumed to function for the without-project condition generally as it has in the past.

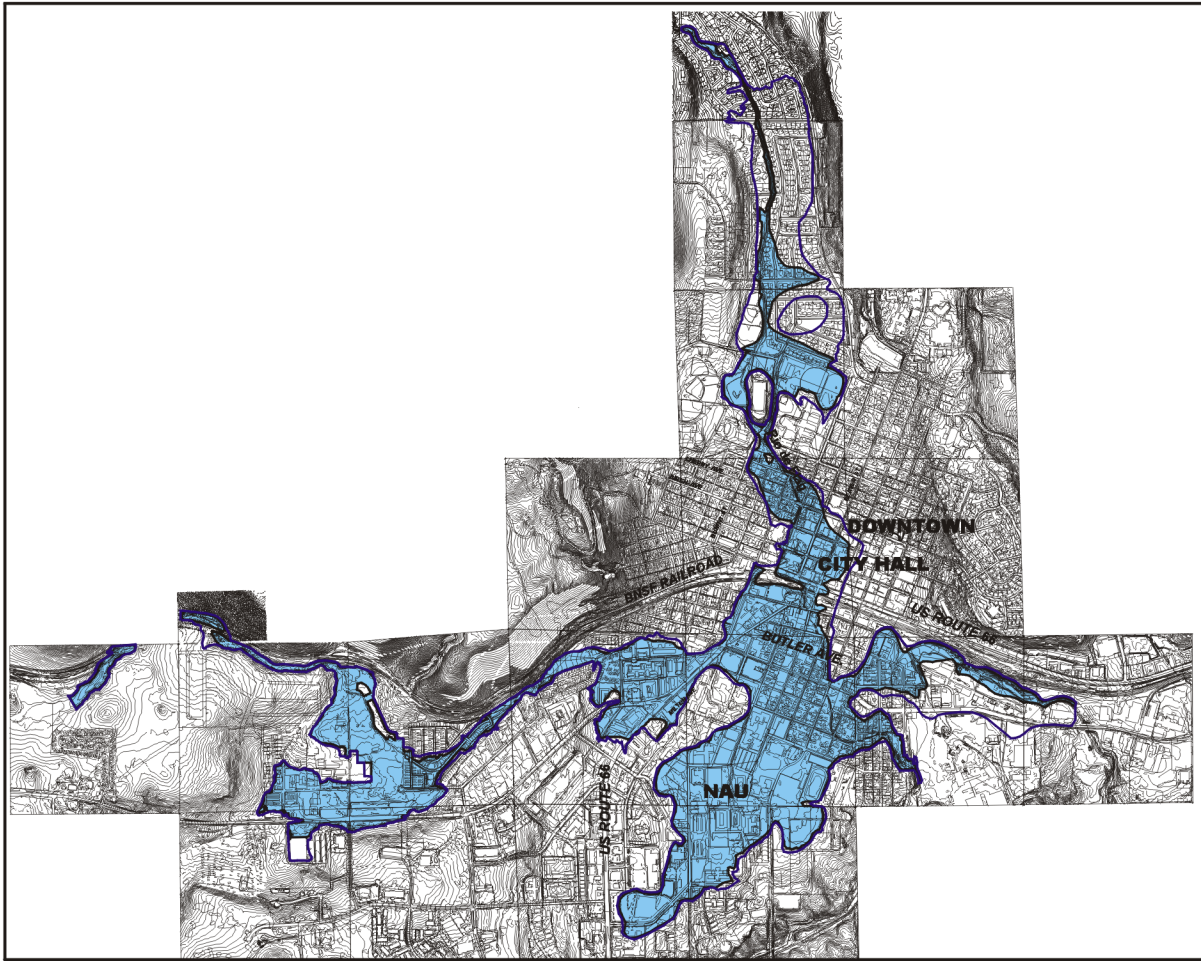
Table 4.4 Rio De Flag Future Without -Project Condition (2053) Results: Peak Discharge Frequency and Stage Frequency Results

CP NO.	LOCATION	EFFECTIVE DA (sq.mi.)	500-YR	100-YR	50-YR	25-YR	10-YR	2-YR
			Discharges in ft^3/s					
	RIO DE FLAG							
1	at Flagstaff (former gage site)	31.1	5070	2110	1590	1100	742	271
2	at Santa Fe Avenue (Route 66)	33.9	4370	1850	1460	702	500	157
3	above confluence with Sinclair Wash	49.2	3750	2530	2180	1430	586	147
4	below confluence with Sinclair Wash	60.8	5980	3750	3150	1830	1030	289
5	below confluence with Switzer Wash	76.1	9880	5070	4080	2460	943	346
6	above AT & SF Railroad embankment (Continental Lake)	85.3	9940	5160	4180	2570	819	292
	below AT & SF Railroad embankment (outlet from culverts)	85.3	102	88	85	80	58	18
	CONTINENTAL LAKE STAGE							
6	Maximum Water Surface Elevation, ft NGVD	85.3	6772.0	6766.2	6764.7	6761.0	6753.7	6750.4
6	Inflow to geologic drain	85.3	262	227	216	184	106	2

NOTES:

- Results include impacts of channel routing, breakouts from channel and overbank routing based upon hydraulic data provided by RS Engineers:
  To include split flow leaving Rio de Flag in vicinity of (1) Thorpe Road, (2) West Cherry Avenue, and (3) Butler Avenue;
  Return flow (overbank) in the vicinity of (1) Bonito Street, (2) Route 66/Santa Fe Avenue, and (3) Rio de Flag via the Historic Channel, respectively
- Clay Avenue Wash is presumed to enter Rio de Flag along a lateral front, which was quantified for modeling purposes as the vicinity of Butler Avenue.
- Results include impact of the detention basin on Sinclair Wash in vicinity of Palmer Road.
- Outflow based upon culverts being partially blocked. In the vicinity of Continental Lake a portion of stored water exits the basin to the geologic drain.

C:\PROJECTS\RIODF\DOWNTOWN.APR - W/O Project Downtown FP 2053 (11x17)



GENERAL INVESTIGATION
FLOOD DAMAGE REDUCTION STUDY
FOR
RIO DE FLAG,
FLAGSTAFF, ARIZONA

2053 FLOODPLAIN

Without-Project Conditions 100 & 500 Years Downtown Area

LEGEND

- 100 YEAR FLOODPLAIN 2053
- 500 YEAR FLOODPLAIN 2053

U.S. ARMY CORPS OF ENGINEERS
Los Angeles District
South Pacific Division

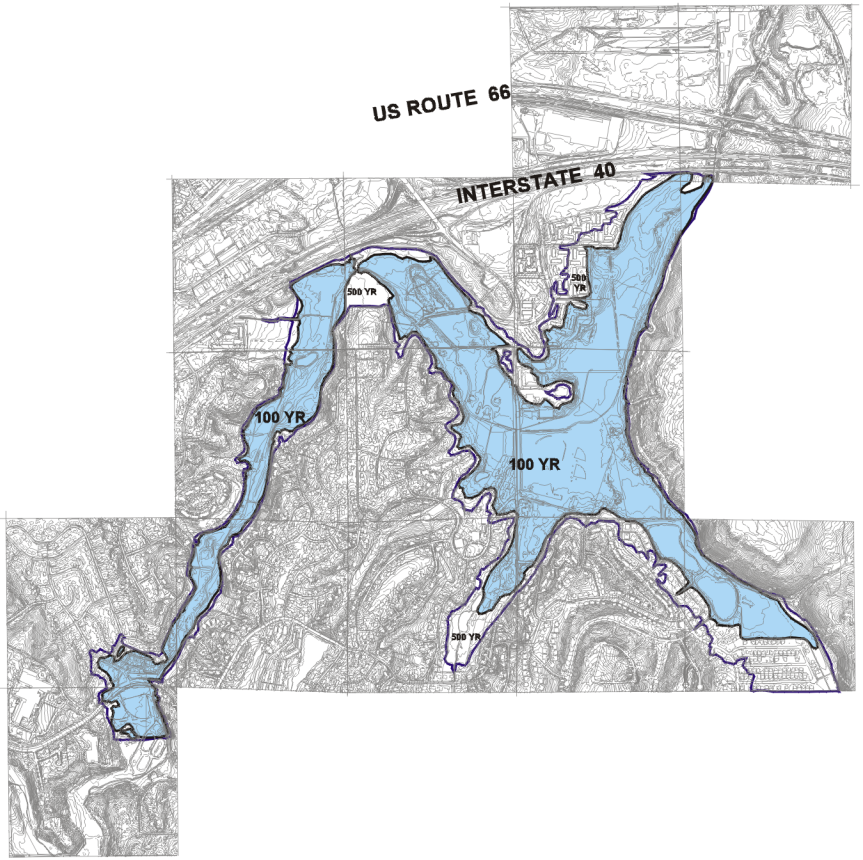
CITY OF FLAGSTAFF
ARIZONA

400 0 400 800 1200 1600 Feet

1:18000

October 15, 1999

C:\PROJECTS\RIODP\cm_flood.apr - Without Project Continental FP 2053



GENERAL INVESTIGATION
FLOOD DAMAGE REDUCTION
FOR RIO DE FLAG
FLAGSTAFF, ARIZONA

2053 FLOODPLAIN

Without-Project Conditions
100 & 500 Years
Continental Area

LEGEND
100 Year Floodplain (Year 2053)
500 Year Floodplain (Year 2053)

U.S. ARMY CORPS OF ENGINEERS
Los Angeles District
South Pacific Division

CITY OF FLAGSTAFF
ARIZONA

400 0 400 800 1200 Feet

1:18000

October 15, 1999

Economics

Economic damages include damages to structures, content damages, emergency and clean-up costs, transportation damages, and future floodproofing expenditures. Structure and content damages are based upon flood depths. Transportation damages are based upon time and reroute distances. Physical damages to utilities (power lines, sewer systems and water supply systems) are included.

A category of damages includes physical damages to the railroad embankment and tracks. During a large flood, the railroad tracks adjacent to City Hall could potentially be damaged or washed out through two scenarios: First, overtopping and wash-out of the railroad embankment could occur, and second, saturation of the embankment could result in a geotechnically unstable condition of "impending failure" that would preclude use of the tracks for a specific period of time. The area most subject to these conditions is directly south of City Hall—the location of flood conveyance—for a length of approximately 400-600 feet. In this area, the potential damage to the railroad embankment depends upon the magnitude and duration of flooding. In addition to operational disruption and delays for up to 75 trains per day, there are emergency repair costs to the tracks, and repair costs after flooding subsides.

Damages to Structures and Contents

Without-project structure and content damages as well as risk and uncertainty analyses were computed for the year 2053 using current price levels. Results are shown below in **Table 4.5**.

Table 4.5 Without-Project Condition (Year 2053) Expected Annual Damages (x 1,000)

	Rio de Flag N. of Hwy 66	Rio de Flag S. of Hwy 66	Clay Ave. Wash	Historic Channel	Continental Area	TOTAL
Single Family Residence & Mobile Home	$215	$125	$107	$8	$81	$536
Multi-Family Residence	$90	$91	$80	$3	$186	$450
Commercial	$82	$77	$275	$0	$16	$450
Public	$48	$148	$1,587	$1	$0	$1,784
Industrial	$2	$33	$70	$6	$6	$117
Total	$437	$474	$2,119	$18	$289	$3,337

Expected annual damages for the years between 2003 and 2053, inclusive, were converted to equivalent values using standard discounting procedures. The results of these calculations using current price levels are shown below in **Table 4.6.**

Table 4.6 Without-Project Conditions, Equivalent Annual Damages (50 years, 6-5/8%)
(x 1,000)

	Rio de Flag N. of Hwy 66	Rio de Flag S. of Hwy 66	Clay Ave. Wash	Historic Channel	Continental Area	TOTAL
Single Family Residence & Mobile Home	$152	$95	$72	$8	$53	$380
Multi-Family Residence	$57	$63	$51	$3	$128	$302
Commercial	$67	$54	$183	$0	$9	$313
Public	$43	$122	$1,093	$1	$0	$1,259
Industrial	$1	$24	$55	$5	$5	$90
Total	$320	$358	$1,454	$17	$195	$2,340

As shown above, without-project equivalent annual damages total approximately $2.34 million. Approximately 29% of damages are attributable to residential structures, and nearly 54% are attributable to public structures. Commercial and industrial structures account for 13% and 4% of total damages, respectively. Damages along the upper Rio de Flag and Clay Avenue Wash floodplains represent 29% and 62% of inundation damages, respectively. Damages in the Continental Area represent about 8% of total inundation damages. Damages along the Historic Channel are negligible.

Expected annual damages to NAU structures and contents, including basement and tunnel damages, total approximately $1.2 million, or about half of total inundation damages.

Emergency and Clean Up Costs

Emergency and clean-up costs incurred during a flood disaster include (1) efforts to monitor and forecast flood problems, (2) actions taken by public or private relief agencies, medical teams, and the police and fire departments to warn and evacuate floodplain occupants, to direct traffic, and to maintain law and order, (3) flood fighting efforts, such as sandbagging and building closures, and (4) evacuation and reoccupation costs for floodplain residents. Emergency and cleanup costs are shown in **Table 4.7** using current price levels.

Table 4.7 Emergency and Clean-up Costs

Frequency	Area (acres)**	Estimated Costs
10	50	$375,000
25	219	$1,640,000
50	480	$3,598,000
100	518	$3,882,000
500	702	$5,262,000
Expected Annual		**$211,000**

* Note: Approximately 300 floodplain acres that are in remote and/or undeveloped areas which would not require clean-up or impact existing or proposed development are not included.

Transportation Costs

Transportation costs related to flooding damages were investigated. Consideration was given to the costs associated with rerouting trains due to flood inundation. Due to the relatively short duration of even the 500-year event (6.2 hours), rerouting of trains would not likely occur and, thus, costs associated with this potential delay were determined to be negligible. Automobile transportation impacts were also analyzed, and found to result in significant increases in vehicle

Table 4.8 Time Delay and Vehicle Operating Costs

Frequency	Time Delay Costs	Vehicle Operating Costs	Total
10	$60	$100	$160
25	$3,620	$5,930	$9,550
50	$26,770	$14,380	$41,150
100	$32,340	$17,380	$49,720
500	$43,980	$23,640	$67,620
Expected Annual	**$1,060**	**$740**	**$1,800**

hours traveled (VHT) and vehicle miles traveled (VMT) due to the occurrence of flooding. Costs associated with the delays, including both time delay costs and vehicle operating costs, were calculated and found to result in the expected annual costs shown in **Table 4.8** using current price levels. Additional details may be found in the **Appendix F, Economics**.

Future Floodproofing Costs

As a participant of the National Flood Insurance Program (NFIP), development within the City of Flagstaff must comply with regulations and development requirements related to the 100-year floodplain in order to be eligible for flood insurance coverage. Based upon an analysis conducted by the City of Flagstaff's Planning Department, approximately 2.1% of future residential development, and about 2.6% of nonresidential development, would be subject to floodproofing requirements for elevation above the 100-year floodplain. Floodproofing costs per parcel were applied to these development projections to derive projected future floodproofing expenditures, as shown in **Table 4.9** using current price levels, below. Only those benefits attributable to structures constructed after the base year are claimed. Additional details may be found in the **Appendix F, Economics**.

Table 4.9 Projected Future Floodproofing Expenditures (Post Base Year only)

	Cumulative Expenditures		
Year	**Residential**	**Non-Residential**	**Total**
2003	$49,000	$63,000	$112,000
2013	$511,000	$696,000	$1,207,000
2023	$793,000	$1,262,000	$2,055,000
2033	$793,000	$1,690,000	$2,483,000
Net Present Value (2003-2053)*	$468,000	$771,000	$1,239,000
Annual (6-5/8% , 50 yrs)	$32,000	$53,000	$85,000

*No future floodproofing expenditures included for period prior to base year in computation of NPV.

Flood Insurance Administrative Costs

Home purchases within the 100-year floodplain typically require flood insurance from the National Flood Insurance Program (NFIP). Administrative costs related to this program include (1) funding for NFIP administrative and overhead costs, including policy-writing, floodplain management, salaries, etc., and (2) funding for payouts after flood events. The amount paid by policyholders for administrative and overhead costs represent a NED loss, since this money would not have to be expended if the properties were not located in a floodplain. Therefore, reduction in the size of the floodplain would be associated with a reduction in the administrative and overhead costs whether or not flooding occurs. Based on overhead and administrative costs of approximately $146 per flood insurance policy, the total administrative and overhead costs associated with the future, without-project condition floodplain total $27,300, annually. This benefit is based solely upon the number of existing policies at the time of this report.

Summary of Damages in the Without -Project Condition

Table 4.10, below, summarizes the expected annual damages discussed above using current price levels, and is further detailed in the **Appendix F, Economics**.

Table 4.10 Without-Project Conditions, Expected Annual Damage Summary

Category	Expected Annual Damages
Structure & Content	$2,344,000
Emergency/Clean-Up	$211,000
Transportation	$2,000
Future Floodproofing (Post Base Year Only)	$85,000
Flood Insurance Admin Costs (Existing Policies only)	$27,000
TOTAL	**$2,669,000**

Geotechnical

The following determinations have been made regarding without-project geotechnical conditions:

- It is expected that the existing fill/plugs that are in the estimated historic channel will remain in place, thereby affecting flood flows.

- Areas where a potential project could be planned are stable and constructable.
- Potential areas for retention/detention options are suitable or can be made suitable for such uses.
- Depth to bedrock is generally between 3 and 15 feet.
- HTRW concerns along proposed project alignments are minimal.
- There are local sources of material, such as rip-rap or embankment fill, that would be acceptable for a flood control project.

Environmental

There are no known occurrences of Federal or state threatened or endangered species in areas affected by or under consideration for a project. No species are currently under consideration for listing as either threatened or endangered in the area. It is not expected that there will be any T&E species which will be impacted. One sensitive species, the goshawk, has been sighted in the vicinity of the Flagstaff area.

The occurrence of native vegetation is sparse within the developed areas of Flagstaff where Rio de Flag, Clay Avenue Wash and Sinclair Wash flow. No increases to native vegetation are expected to occur.

Flagstaff will remain an attainment area for air quality standards.

There are no existing or potential Superfund sites.

The City of Flagstaff is actively pursuing implementation of a City-wide recreation plan and trails system. Any flood control project could include the more austere elements of the current plan. For the without-project condition, the major elements of the current City plan are expected to be in place.

Near I-40 there are wetlands which are sustained by WWTP outflows. These wetlands are expected to remain essentially the same as current conditions.

Recreation Demand

The City's research indicates that the local population will continue to desire outdoor recreation and parks to satisfy their leisure demands. Regional population growth and increased tourism will also prompt higher use of natural and recreational areas.

D. Problems and Opportunities Summary

Problems

The major problem in the study area is flooding which results in inundation damage, railroad damage, emergency response costs, and transportation delays. Information that is available is in the form of general descriptions of flooding given in newspapers; recollections of city officials, including the former city engineer and former director of public works; statements from Flagstaff "old timers," and information obtained from AT & SF Railroad files. Apparently floods have occurred in 1888, 1896, 1903, 1916, 1920, 1923, 1937, 1938, 1950, 1963, 1966, 1973, 1983, 1990, 1993 and 1995. Floods may also have occurred in 1905, 1915, 1936, and 1949.

Without-Project Summary (No Action Plan)

Under the Without-Project Condition, the City of Flagstaff will continue to be subject to significant economic, social and environmental consequences from severe floods. Approximately 1,500 existing structures, worth about $395 million could suffer about $93 million worth of damage from a one percent flood event. In addition to structural damage throughout a major portion of the City, historic properties could be destroyed, the Burlington Northern & Santa Fe Railroad could be damaged or its primary east-west operations disrupted, and public infrastructure and services would remain at risk. Transportation problems would occur, with a large portion of the City and the Continental area inaccessible for a few days, impacting several thousand people. A significant portion of Northern Arizona University is within the floodplain, and during severe flood events the University would incur closing and other disruptions and physical damage to facilities and historic buildings on campus. Numerous residential, commercial, downtown business & tourism, and industrial properties would remain at risk.

Opportunities

Flood Control

Flood Control opportunities include structural and non-structural measures in combination with more natural floodways in select areas. There is an additional opportunity associated with flood control to plan a project compatible with the Flagstaff 2020 and Flagstaff Urban Trails programs, which would provide opportunities for recreation and aesthetic treatments.

Environmental Restoration

There is no opportunity for large scale ecosystem restoration as a project purpose. However, in selected specific areas, there may be some small scale, isolated opportunities for environmental features. These more limited opportunities may include:

- Improving Land Management/Development Practices

- Planting Riparian Species
- Removing Exotic Species
- Creating and/or Enhancing (Urban) Wetlands
- Enhancing/Widening Stream courses
- Supply Additional Water to Stream courses
- Removing Barriers

Recreation

The opportunity exists to provide recreational resources in conjunction with any Federal project implemented for flood control purposes. The facilities could consist of trail corridors, exercise areas, parkland, and open space designations associated with the rights-of-way of channel improvements and detention basin areas, compatible with the Flagstaff Urban Trails System.

Water Resource Management

Water resource management opportunities include:

- Improve Water Management Practices
- Enhance water supply and water quality
- Provide a point of disposal for localized runoff from streets
- Alternative uses of wastewater treatment plant effluent

CHAPTER V
PLAN FORMULATION

A. Study Methodology

This chapter presents plan formulation rationale used during this feasibility study. Plan formulation was used to develop, evaluate, and compare the array of candidate plans which have been considered.

The plan formulation process consisted of the following major steps:

1. Description and specification of flooding and water resources related problems and opportunities in the study area;

2. Identification of planning objectives and constraints within the study area;

3. Formulation of preliminary alternative plans;

4. Evaluation and comparison of alternative plans; and

5. Evaluation of Federal Interest for a cost-shared flood control solution.

Plan formulation is a creative and analytical process in which alternative plans are formulated. The intent is to solve the identified problem while maximizing the NED objectives. The alternative plans developed are based upon the available data and information presented elsewhere in this report.

B. Planning Objectives

Federal Planning Objectives

In accordance with the Federal Government's *Economic and Environmental Principles and Guidelines for Water and Related Land Resource Implementation Studies* , all water resource projects undertaken by the Corps of Engineers must "contribute to national economic development consistent with protecting the nation's environment, pursuant to national environmental statutes, applicable executive orders, and other Federal planning requirements." National Economic Development (NED) contributions include increases in the net value of the national output of goods and services, and can be measured in terms of both monetary and non-monetary outputs. For example, flood control projects result in outputs which can be measured monetarily, such as reductions in flood damages and cost savings from developing a regional flood control system rather than constructing individual projects. Habitat restoration is an example of a water resource project whose benefits would primarily be measured in terms of non-monetary outputs.

The general objective of the Feasibility Study Phase is to complete the plan formulation process initiated in the Reconnaissance Study Phase by identifying the most cost-effective means of providing flood control in the study area while remaining in compliance with the National Environmental Policy Act of 1969 (NEPA). The most cost-effective plan is the alternative that maximizes contributions to National Economic Development (the NED plan). Contributions to National Economic Development are the net benefits of a project; these are the total benefits minus the total costs. It should be noted that the NED plan is the plan that maximizes net benefits rather than the plan that maximizes the benefit/cost ratio.

Specific Planning Objectives

Specific planning objectives were identified for this feasibility effort through coordination with local and regional agencies, the public involvement process, site assessments, and review of prior studies and reports. The specific objectives for this feasibility study have been identified as follows:

1. Minimize flood damages to residential, commercial, public, industrial, and historic property;

2. Develop a comprehensive plan;

3. Provide consistency with local initiatives and the cultural and environmental character of the community, including aesthetics; and

4. Protect and improve environmental and cultural resources.

C. Planning Constraints

In order to develop flood control alternatives that would best meet the established objectives, consideration of the existing constraints must be made. The following planning constraints have been identified for consideration in developing alternatives

Frequency-Discharge Requirements

Federal participation in flood control is defined by the Flood Control Act of 1944 and modified by the Water Resources Development Act of 1986 to include "channel and major drainage improvements and flood prevention improvements." In urban or urbanizing areas, provisions of a basic drainage system to collect and convey local runoff, such as from street drains, is a non-Federal responsibility. Water damage problems may be addressed under the Federal flood control authorities downstream from the point where the flood discharges are greater than 800 cubic feet per second (cfs) for the 10 percent flood (one chance in ten of being exceeded in any given year). Drainage areas of less than 1.5 square miles are assumed to lack adequate discharge to meet the above criterion. Exceptions may be granted in areas of hydrologic disparity producing limited discharges for the 10 percent flood but in excess of 1,800 cfs for the one percent flood. The study area meets the requirements for an exception. The Los Angeles District has requested and received an exception.

Endangered Species

The study area is located in an urban area that is not known to contain endangered or threatened species. Any potential project would be required under the Endangered Species Act to not jeopardize the continued existence of threatened or endangered species or to destroy or adversely modify their habitat.

Displacement of People

The Uniform Relocation Assistance and Real Property Acquisition Policies Act of 1970 requires any local sponsor acquiring land for a project involving the Federal government comply with provisions of this act.

Rapid Growth

The steady growth in the area creates constraints for potential flood-control solutions. Future development could influence where problems arise. Growth may also hinder future project-related land acquisitions by the local sponsor.

Real Estate

Real estate costs vary considerably in the study area and can significantly affect project costs. Since right-of-way costs are not uniform in both (1) location along the channel reaches, and (2) width of acquisition, real estate costs represent a plan formulation constraint that would change according to the configuration of an alternative. Also, availability of land, proximity to structures that can't reasonably be relocated (such as City Hall), and willingness of the land owner to enter into an easement or fee title exchange all affect plan formulation.

County and State Lands

The State of Arizona and Coconino County own lands which could be affected by a flood control solution to Rio de Flag.

Federal Lands

The Federal Government owns land in the study area.

Regulatory Floodplain

The regulatory floodplain downstream from the outlet point at Route 66 is set by FEMA Flood Insurance Rate Map (FIRM) requirements for the 100-year event. No increase of the discharges below this point is possible without transferring flooding problems from the study area to a point outside the study area.

Specific Constraints by Reach

The study area is divided into four reaches for constraint purposes:

- Rio de Flag Reach (Thorpe Park to South Beaver St),
- Clay Avenue Wash Reach,
- Confluence (South Beaver St to Butler Ave) Reach, and
- Continental Reach.

The Rio de Flag Reach is constrained by narrow rights-of-way that pass through a well-established neighborhood. Most channel improvements through this area would necessarily involve acquisition of real estate and relocation of homes. Thorpe Park provides recreational and community facilities needs to the adjacent community and should be preserved. The new Library and new City Hall are adjacent to Rio de Flag and would have prohibitive relocation costs.

The Clay Ave Reach is also constrained by narrow rights-of-way that pass through an established neighborhood. This area is adjacent to land owned by the U.S. Forest Service that may not be easily acquired. State land also exists in this reach and it may be difficult to acquire these parcels due to laws regarding the disposal of this land. Further downstream near the confluence, the terrain and urbanized aspect of Mike's Pike precludes a cost-effective, open channel alignment.

The Confluence Reach is in the southside business area and near Northern Arizona University. Any channel alignments should utilize existing rights-of-way whenever possible. Railroad operational utilization and railroad policy practices constrain the types of channel configurations that could fit within the available space without large-scale relocation of the businesses that exist in that area. Open channels must be 50 feet from the tracks and the current right-of-way is approximately 70 feet through select areas. The minimal channel size for a concrete channel

would be approximately 40 feet. Thus, an open channel would likely not fit inside the existing rights-of-way. A covered channel configuration could be located within 12 feet of the tracks. This would allow the existing rights-of-way to be utilized.

Another constraint within the Confluence Reach relates to Northern Arizona University's series of underground tunnels and storage areas that contain files, books, artifacts, and electrical/utility/HVAC equipment. Hundreds of vents, stairways, and doors to these tunnels and underground corridors exist throughout the University that represent potential conveyance routes for floodwaters. It is impractical and technically infeasible to flood proof these openings and still maintain their functionality.

The Continental Reach is constrained by drainage law that specifies that damages must not be induced beyond the without-project condition. Therefore, whether or not there are improvements recommended for the Continental Reach, the water surface elevations must not be increased as a result of upstream improvements. Any upstream improvements that convey water quicker and/or in larger quantities than currently exist must be managed by either local or upstream detention, flood proofing, flood control structures, or some other means. This constraint also exists for the outfall at Route 66 which must not discharge more than 210 cfs, the current FEMA-designated discharge. Because of this constraint, no practical solution exists that would remove the area from a ponded lake condition during flood flows, since (1) outflows cannot increase beyond the 210 cfs, and (2) previous studies have clearly established that local, upstream detention could not provide enough storage to effectively reduce the ponding. For this reason, the Continental Reach area will always be a flood-dedicated site. Alternative solutions under this constraint include localized berming, excavation to increase storage as mitigation for any upstream-related increases in the water surface elevation, and downstream maintenance to ensure the capacity of the 210 cfs outlet.

It should be noted that Continental Reach also has geologic features that drain a portion of the flood waters through infiltration and sub-surface conveyance. Since this is unpredictable in its conveyance capacity, it can not be relied upon in the formulation of alternatives.

D. Alternative Development Rationale

The alternatives are developed for the purposes related specifically to the requirements for a Corps of Engineers Feasibility Report. As such, the alternatives described in this feasibility report are not proposals for actual construction, nor are they to be considered to be of sufficient design detail to be constructed. Following the completion of the feasibility report, **EIS**, and project authorization by Congress, if such action occurs, detailed design analysis and preparation of plans and specifications would take place.

Alternatives were formulated to address a comprehensive Federal project for flood control to:

a. Comply with NEPA and other environmental laws and regulations;

b. Address specific flooding characteristics within the floodplains and major contributing watersheds;

c. Provide an acceptable means of capturing and conveying flows into and through a formal flood-control system;

d. Convey peak discharges and ensure that the comprehensive system of flood water collection would not increase flood flows or worsen flooding conditions downstream in the existing developed areas;

e. Provide the potential to implement a comprehensive flood-control plan that would comply with FEMA guidance for a FIRM revision;

f. Reduce NED losses while positively contributing to the Environmental Account, Regional (RED) Account, and Social Account;

g. Provide decision makers with information which could be utilized to help determine the balance between construction costs, real estate costs, and social issues and concerns;

h. Provide a framework for responding to future urban development in the floodplain, consistent with Executive Order 11988;

i. Completely eliminate or significantly reduce the requirement for FEMA flood insurance; and

j. Match existing and proposed improvements where possible to take advantage of these local improvements and to be consistent with the future flood-control plans and master planning efforts of the local community.

E. Alternative Development and Evaluation Process

The Rio de Flag feasibility study consists of successive iterations of solutions to the defined flood problem, based upon the study objectives and designed to address the opportunities while remaining within the limitations imposed by the identified constraints. The general feasibility criteria that are required to be met are as follows:

Technical Feasibility: Solutions must be technically capable of performing the intended function, have the ability to address the problem, and conform to Corps of Engineers technical standards, regulations, and policies;

Environmental Feasibility: Solutions must comply with all applicable environmental laws, including the National Environmental Policy Act;

Economic Feasibility: Solutions must be economically justifiable in that the economic benefits must exceed the economic costs, in accordance with applicable regulations, policies, and procedures; and

Public Feasibility: Solutions must be publically acceptable as evidenced by a cost sharing non-Federal sponsor and further documented through an open public involvement process that incorporates the public's input into the formulation of the solutions.

Initially, specific measures were developed to satisfy the four feasibility criteria. Measures are specific stand alone features, both structural and nonstructural, to address the defined problems. There are numerous specific measures that can be utilized to provide flood protection depending upon site location, technical considerations, environmental conditions, and a host of other factors. In determining the set of measures to be evaluated for this study, specific consideration was given to public input and suggestions, Corps experience with similar flooding situations, technical considerations based upon the specifics of the area, and environmental considerations for minimizing impacts.

Each measure was then evaluated in terms of the feasibility criteria. All criteria must be adequately met since any one criteria can serve to eliminate a measure from further consideration. Those measures satisfying all the criteria were carried forward for additional development and evaluation while those that were shown not to meet the criteria were eliminated from further consideration.

Measures that were carried forward were then combined in various configurations to form a preliminary set of alternatives, which was then subjected to a more rigorous evaluation against the criteria. Some measures became alternatives, while other measures were combined to form alternatives. A total of 12 preliminary alternatives, in addition to 2 no-action alternatives, were developed, evaluated, and compared. In comparing the preliminary alternatives, the without-project condition (no-action) is the basis against which each alternative was compared. Each alternative was evaluated and compared in terms of the criteria against the without-project condition. Economic feasibility was a critical screen in the evaluation of the preliminary alternatives, however, an alternative still was required to meet all criteria for further consideration.

Of the 14 preliminary alternatives, 4 met all four criteria the best and were carried forward into the final array, in addition to one no-action plan, for further detailed evaluation. Detailed evaluation includes complete environmental analysis for the **EIS**, detailed cost estimates and development of project features, and specific real estate evaluations based upon proposed project boundaries. Economic analysis further defined the justifiability of the alternatives in the final array, including the refined costs for construction, real estate, mitigation, recreation, and other project features. The results of the evaluation of the final array formed the basis for the proposed action or recommended plan.

Only those alternatives which were carried forward into the final array are eligible for consideration as a proposed action. The most detailed evaluations took place at this level, including specific NEPA compliance and EIS level analysis. Each successive iteration, from the initial development of measures to the final array of alternatives, evaluated the solutions in terms of environmental feasibility as one of four screens.

The specific measures, preliminary alternatives, final array and the associated evaluations and comparisons are described in the following sections.

F. Flood Damage Reduction Measures

The feasibility study identified a wide variety of flood control measures which could be used to meet the planning objectives. The broad categories of flood reduction measures investigated are discussed below.

Non-Structural Measures

Relocation of Existing Structures

Existing structures could be purchased to allow floodplain residents to move away from the floodplain. Purchased structures could be removed.

Flood Proofing of Existing Structures

Existing structures in the floodplain could be flood-proofed by installing sealants to walls and doors, installing individual or groups of flood walls or dikes, or raising the structure above the inundation elevation. New development is currently required to be constructed one foot above the FEMA 100-year water surface elevation.

Flood Warning System

A flood warning system could provide advance notice of high stage situations and enable people to move themselves, their vehicles, and some high value property out of the flood zone.

Structural Measures

Detention/Retention

Detention or retention of flood flows can reduce flood peaks to levels that are within the capacity of existing channels or improved channels. Detention can be the on-line or off-line type. On-line detention is within the channel or its alignment and typically consists of an embankment with an outlet structure that significantly reduces the downstream flow compared to pre-project conditions. Off-line detention occurs adjacent to the channel or its alignment and requires diversion structure facilities.

Lined Flood Control Channels

Lined flood control channels are a versatile and effective method of conveying detention/retention basin releases or flood flows. The measure includes channel improvements to increase channel capacities and convey flood flows to a safe and adequate point of disposal. Lined channels include collector channels for the capture of tributary flow, the diversion of flood waters between washes, or manmade channels to take advantage of the various capacities in the most efficient manner. Concrete covered channels would be used for areas where rights-of-way requirements would be prohibitive or when an underground channel is the only practical method to convey the flows. Lining of open channels typically consists of rock revetment, rock revetment with grass cover, natural stone, or concrete.

Unlined Flood Control Channels

Unlined flood control channels have the advantage of providing flood protection by utilizing the existing or modified topography and terrain. Earth bottom channels or channels which utilize the natural rock as a channel may be less costly to construct than concrete or rip-rap lined channel and may be more aesthetically pleasing. Unlined channels have been favored by the City of Scottsdale and the City of Phoenix in their desert greenbelt concept, and are considered as potential solutions for the City of Flagstaff as well.

G. Preliminary Evaluation of Measures

Relocation of Existing Structures and Floodproofing

Implementation of non-structural measures such as floodproofing existing structures and the relocation of existing residences and businesses to reduce the overall damage potential has been evaluated. Floodproofing offers the opportunity to provide flood protection on an individual, structure-by-structure basis. Each structure or reasonable group of structures would either be surrounded by a floodwall or elevated in-place. Elevation of structures could be accomplished by raising on piers, foundation walls, or fill material. Floodwalls or levees surrounding structures would consist of either a concrete or masonry wall, or soil material built-up and compacted around the structure. Walls surrounding structures would still require closures that would allow

doors, windows, and driveways to be used while preventing water from entering the building. These closures typically would be manually operated based on flood forecasting and prediction that would alert the operator. Relocation involves either actually moving the structure out of the floodplain, or destroying the structure and either building or finding a replacement in another location.

Rio de Flag and Clay Avenue Wash floodplain contains approximately 1,487 structures including 1,241 residences and 246 business/commercial/public/industrial structures. In the downtown area, relocation is not a viable option since the floodplain encompasses almost half of the entire town. Further, the sheer density of the structures requires more costly means of floodproofing, such as concrete floodwalls immediately adjacent to the structures rather than soil levees or berms. A conservative estimate for floodproofing the residences is approximately $25,000 each, and the business/commercial/public strictures would cost approximately $40,000 each, for a subtotal of approximately $40,865,000.

In addition, NAU would require automated closures to allow quick response for more than 20 large (100,000 square feet or greater) buildings and about two miles of underground tunnels. A comprehensive flood proofing system would be required since all of the buildings and tunnels are interconnected. The tunnels themselves are approximately ten feet wide and sixteen feet tall, with numerous at grade tunnel access openings, while the buildings have stairs down on at least two sides, several below grade openings, and at grade windows. Floodproofing costs are additionally increased due to the historic designation (mortared sandstone construction) of the buildings, some of which are nearly 100 years old. The estimated cost of NAU floodproofing alone is approximately $25,000,000.

In the Continental area, floodproofing of individual structures was estimated. The area is currently a designated floodway and development is required to be elevated above the designated FEMA 100-year water surface without causing a significant increase to that water surface. However, there are approximately 20 structures which were constructed within the current 100-year floodplain prior to FEMA designation, and there are approximately 100 structures located around the 100-year floodplain fringe which may suffer damage from a less frequent (i.e. 500-year) event. Most of these homes are higher than average value structures, generally between $200,000 and $3,000,000. Individual floodproofing would be costly and only protect against events greater than the 500-year.

Downstream of the Continental area are numerous properties that could be purchased for relocation. This would allow a shifting of the adequate point of disposal of floodwaters further downstream rather than continuing to utilize the area as a designated floodway and detention area for floodwaters. The estimated average annual benefits for the entire Continental Estates area is $50,000 for the 100-year and $160,000-for the 500-year. Therefore, any relocation or floodproofing options would need to cost less than approximately $700,000 total for a 100-year level of protection and less than approximately $2,240,000 for a 500-year level of protection to be economically justified. Both within Continental and downstream, real estate valuations are

higher than average and few structures suffer damages in the 100-year event. For these reasons floodproofing and relocation are not viable options for the Continental area

Aside from the cost, a significant percentage of floodproofed homes and businesses would still suffer flood damages due to the potentially incomplete nature of the solution. The enclosures of the windows, doors, and driveways require human action in order to fully implement the solution. And, this would have to occur in a relatively short amount of time. Due to the size of the floodplain within the City, it is infeasible to expect that a complete response to a flood threat would take place on the part of the property owners.

Do to the excessive costs and lack of practicality of floodproofing and relocation measures, they are not carried forward for formulation of alternatives.

Flood Warning System

The nature of flooding within the damage areas is such that there is a relatively slow rise of flood waters to their peak levels, a relatively short duration of the peaks, a then a long slow recession of the floodwaters. In terms of lead times, a flood warning system in this area would not significantly increase the lead times already present due to the nature of the watershed and associated runoff. Typically under base year conditions there is approximately one day of rising flood waters until the peak, which currently allows people located within the floodplain to make some preparations. Since a flood warning system by itself would not result in a significant change in either lead times or preparatory behaviors, and associated damage reductions, this nonstructural measure was not considered further for plan formulation

Structural Measures

Detention

Thorpe Park Detention : Preliminary evaluation of this measure indicated that a detention structure which utilizes the natural topography in the Thorpe Park area could reduce the 100-year discharge to an approximate equivalent of the without-project 25-year discharge downstream on Rio de Flag. The channel capacity approximates a without-project 10-year level of protection downstream of Thorpe Park where Rio de Flag passes through the northern downtown area. By utilizing the natural topography, excessive excavation costs can be avoided, further, channel improvements downstream could be reduced due to the limited outflows from the detention facility. Since the preliminary costs of detention at Thorpe Park are relatively low and significant benefits may be obtained between the 25- and 100-year current damages, this measure was carried forward for detailed evaluation and inclusion in the formulation of alternatives

Clay Avenue Wash Detention : Preliminary evaluation of this measure indicated that a detention structure which utilizes the natural topography in the upper Clay Avenue Wash area could reduce the 100-year discharge to an approximate equivalent of the without-project 25-year discharge downstream along the wash through several developed areas. The channel capacity approximates a without-project 10-year level of protection or less. By utilizing the natural topography, excessive excavation costs can be avoided, further, channel improvements downstream could be reduced due to the limited outflows from the detention facility. Since the preliminary costs of detention along Clay Avenue Wash are relatively low and significant benefits may be obtained between the 10- and 100-year current damages, this measure was carried forward for detailed evaluation and inclusion in the formulation of alternatives

Continental Area Detention : The Continental area currently serves as a large designated floodway and detention area for floodwaters. A detention option at Continental would involve excavation to increase the storage capacity of the existing area, or small detention structures could be placed immediately upstream. The additional capacity of detention would need to be substantial in order for any significant effect on water surface elevations in the area. This measure may be cost effective depending upon low much excavation is required, and so is carried forward for additional evaluation as an alternative.

Lined Flood Control Channels

Rectangular Concrete Channels : An evaluation was performed for the potential for utilizing concrete channels, due primarily to the ability to limit the real estate right-of-way requirements. Real estate costs are a constraint since Rio de Flag and Clay Avenue Wash pass through densely developed areas of town. Rectangular concrete channels are more efficient hydraulically and, depending upon real estate costs, can be the most cost effective solution as well. It is known that there are several areas where rectangular concrete channels may be needed to convey floodwaters. Based upon these considerations, rectangular concrete channels are carried forward for plan formulation of the alternatives.

Trapezoidal Rip-Rap Lined Channels : An evaluation was performed for the potential for utilizing trapezoidal rip-rap lined channels, due to the reduced construction costs and improved aesthetics of such channels. Rip-rap is a protective layer of processed rock to prevent erosion of the channel sides and/or bottom. In some cases the rip-rap can be covered with overplanting such as grass. Real estate costs are a constraint since Rio de Flag and Clay Avenue Wash pass through densely developed areas of town. In areas where real estate costs are not as critical, trapezoidal rip-rap lined channels are the most cost effective measure to convey flood flows. Based upon these considerations, trapezoidal rip-rap lined channels are carried forward for plan formulation of the alternatives.

Covered Channels : An initial evaluation indicated that for some reaches of Rio de Flag and Clay Avenue Wash covered channels may be the most cost effective solution. This would be due to differences in the need for a real estate easement only versus the cost of needing to acquire properties in fee title for open channel configurations. Covered channels additionally provide the flexibility to follow an alignment under existing streets or other rights of way, which can shorten the length of any improvements while causing minimal disruption to adjacent and surrounding properties at no real estate cost. Since real estate costs are a constraint due to the dense development within the areas under consideration for channelization, this measure is carried forward for detailed evaluation in the formulation of alternatives.

Unlined Flood Control Channels

Unlined flood control channels consist of wider, shallower slope channels which can be constructed primarily with grading, shaping, and landscaping techniques. The areas can be overplanted with various types of vegetation and grasses for aesthetics. Construction costs can be minimized if real estate costs are low. Generally the natural topography of the existing channel can be re-formed to accommodate increased flood flows. There are specific reaches in the study area where unlined grade channels could be utilized. Other specific reaches may be able to utilize the natural rock which underlies the currently undersized channel. The natural rock could be excavated and then serve as a "lining" for the bottom and sides of the channel. These types of more aesthetic options would receive high levels of support from the citizens of Flagstaff, and due to the potentially low costs of construction, this measure is carried forward for plan formulation.

Levees

A preliminary evaluation of levees as a measure was performed for both the Downtown and Continental areas. Levees can provide significant levels of protection in a cost effective manner, however, there are disadvantages such as increases of flood stages, real estate and access considerations, higher environmental impacts, and the potential for failure or overtopping.

For the downtown area, Rio de Flag and Clay Avenue Wash are incised channels. No practical locations exist where protective levees could be placed which would avoid significant and excessive real estate costs. Generally, widening and/or deepening of the existing incised channels is much more cost effective both in terms of construction and real estate. Additional consideration was given to a levee that would provide protection to the Northern Arizona University, a major damage area. The preliminary construction costs of such a levee are approximately $7 million, but the real estate costs are excessive (greater than $20 million through the dense development). The estimated costs of both a levee system and a single levee for NAU cannot be justified based upon a comparison with the without-project damages. This measure is not carried forward for plan formulation of the alternatives for the Downtown area.

For the Continental area, there is one location where a protective levee could provide a 100-year level of protection for about 20 structures, and several location where localized levees could

provide a 500-year level of protection to about 100 structures located around the fringe of the FEMA floodplain. The real estate and access constraints in these open, undeveloped areas, which are within the FEMA flood zone and designated floodway, are not as severe as in the Downtown area. Maximum average annual damages are estimated at $160,000, so that depending upon the location, sizing, and cost of such localized levees, there is a potential for economic justification if a low cost solution can be further developed. Levees as a measure for the Continental area are carried forward for additional consideration in the formulation of alternatives.

Other Structural Measures

In the process of evaluating the measures and during the progress of the feasibility study, other measures were developed for specific areas to address control of flood flows. These additional localized measures are discussed below.

Floodwalls : In evaluating detention measures and levee measures for the downtown area and Thorpe Park, consideration was given to protective floodwalls in place of levees. This measure has the advantage that the floodwalls can be designed with aesthetically pleasing characteristics, and have a small footprint which minimizes environmental impacts and real estate costs. Since the channel is incised already, floodwalls may be provided at a lower cost than levees and provide significant levels of protection over and above the current channels with or without widening and deepening. This measure is carried forward for Thorpe Park detention and the associated downstream channel. For Clay Avenue Wash detention basin and downstream Continental areas, floodwalls are impractical due to the required heights (approximately 20 feet) and would not be less expensive than levees, and so this measure is not carried forward for those areas.

Increase Outflow from the Continental Area : A preliminary evaluation was performed for the Continental area to examine the effect of increasing the outflow to areas downstream. Under the without-project condition, the outflow is estimated to be 90 cfs, however, the FEMA floodplain which has regulated development downstream is based upon an outflow of 210 cfs. A preliminary plan to provide improvements which would match the FEMA requirement was estimated to cost approximately $300,000. The downstream areas are outside of the study area for this feasibility study, and the without-project condition is that the Continental area will remain a designated floodway and detention area. The inflow under the without-project condition to the Continental area is approximately 4,200 cfs for the 100-year event. Although it would appear that increasing the outflow by only 130 cfs would not be significant due to the large volume of the impounded area at Continental, this is in comparison to the without-project condition and evaluated initially as a stand alone measure. Without knowing the hydrologic and hydraulic effects of upstream alternatives on the with-project inflows, it would be premature to eliminate this measure during this stage of screening. Due to its relatively low cost, this measure is carried forward for consideration for plan formulation, contingent upon with-project hydrologic and hydraulic results for other upstream alternatives

H. Preliminary Alternatives

The development of preliminary alternatives to provide flood control solutions in the City of Flagstaff is discussed in this and subsequent sections. Extensive work to develop alternative flood control solutions, prior to this feasibility study, has been performed, both by the City of Flagstaff independently and most recently during the reconnaissance phase of study. Since this previous work provided a starting point for development of measures and alternatives for this feasibility study, some brief background is provided below. A complete discussion of the process leading to this feasibility study is included in the Corps of Engineers Reconnaissance Report.

City of Flagstaff Efforts

During 1990 - 1993, the City of Flagstaff conducted an engineering study of flood control alternatives including a public involvement and acceptability program. A variety of flood control measures and alternatives were developed. A total of eight measures were combined into a series of eleven alternatives and evaluated in terms of cost and public acceptance. This effort resulted in the City of Flagstaff Alternative.

For the northern area of Flagstaff, the City's alternative consists of rip-rap sides and open channel improvements with linear park/grass lined channels or covered channels in selected areas. Through the south side of the city, Rio de Flag would be rerouted into the estimated historic channel, with rip-rap sides and open channel improvements combined with a linear park/grass lined channel concept. The alternative included converting and improving the existing Rio de Flag through the south side with a linear park concept.

Reconnaissance Alternatives

Development of alternatives for the Corps' Rio de Flag Reconnaissance Study considered information previously developed by the City of Flagstaff. A wide range of alternative methods of flood damage reduction was evaluated on an initial screening level prior to selecting specific alternatives for detailed evaluation.

The reconnaissance alternatives were formulated based upon two physical conditions of flow: split flow versus combined flow. The split flow concept developed alternative scenarios whereby flows from Rio de Flag are routed into the historic Rio De Flag channel while tributary flows from Clay Avenue Wash are routed into the historic Clay Avenue Wash channel. The combined

flow concept routes Clay Avenue Wash flows into Rio De Flag further upstream. All reconnaissance alternatives recognize that (1) Clay Avenue Wash flows are significant in relation to Rio de Flag flows, (2) may occur at approximately the same time during a flood event, (3) are not physically separable elements, (4) would require substantial construction costs to control, and (5) cannot be ignored due to the contribution to residual damages in the south side.

Reconnaissance Results

The Reconnaissance Study results concluded that at least one flood control solution is economically feasible. It also concluded that one alignment was more cost efficient than other channel alignments, namely, the existing Rio de Flag channel until the Route 66/railroad crossing, then along historic Rio de Flag to Continental Lake. Clay Avenue Wash follows the existing alignment until Mike's Pike and the follows Mike's Pike until it intersects Rio de Flag. This alignment is the shortest in length for any improvements and additionally minimizes real estate costs. It is this alignment upon which formulation of the feasibility alternatives is based.

I. Preliminary Feasibility Alternative Development - Screening Process

The preliminary alternatives were developed by utilizing those measures which were carried forward for plan formulation. A screening process was developed for the preliminary alternatives to evaluate each alternative in terms of cost effectiveness and level of protection.
The feasibility screening process identified all reasonably likely combinations of the following components: detention, lined channels, and unlined channels. An approximately 50-by-130 cell matrix was developed that displayed preliminary costs including construction and real estate costs.

The cost estimate quantity items were developed for each alternative by reach for the 50-, 100-, and 500-year design discharges. Additionally, by reach and level of protection, a variety of channel cross sections were evaluated in terms of initial construction costs for:

- Rectangular concrete channels,
- Trapezoidal rip-rap lined channels,
- Covered channels, and
- Landscaped/greenbelt-type channels.

These cost estimates were then utilized to evaluate the most cost effective channel configuration by reach for a given level of protection. Each alternative cost estimate, then, consists of that

combination of features which is most cost effective for that particular alternative, thereby allowing a consistent comparison of those alternatives in terms of real estate versus construction and the aggregate of the two for a given level of protection. Development and screening of preliminary alternatives considered the following:

- The channel improvements that were investigated included open channels with rock revetment lining, open channels with concrete lining, unlined channels, and covered channels.

- Reaches were broken down for cost comparison purposes into the following:
  - Clay Avenue detention basin
  - Thorpe Park detention basin
  - Clay Avenue Wash from the detention basin to McCracken Place
  - McCracken Place to Mike's Pike
  - Mike's Pike alignment
  - Thorpe Road to Beaver Street
  - Beaver Street to Gabel Street
  - Gabel Street to Butler Street
  - Continental Reach

- Three levels of protection (50-, 100-, and 500-year events) were analyzed for all combinations.

- Protection was achieved through combinations of either:
  - Full detention to achieve the 50-, 100-, and 500-year levels of protection
  - One or the other or both detention basins plus channel improvements to achieve the three levels of protection (50-, 100-, and 500-year events). Each combination of detention basin and channel used channel sizes to convey the 50-, 25-, and 10-year outflow from the respective basin.
  - Channel improvements only to achieve the 50-, 100-, and 500-year levels of protection

An assessment of the least costly alternative type was made, by reach, in order to formulate the preliminary alternatives. Based upon the overall benefits and level of protection, likely NED candidates could then be identified.

The problems and opportunities that exist in the Continental area were addressed in a regional approach considering upstream alternatives as well as those specific to the Continental area. Downtown area alternatives were formulated and screened with consideration given to the combination of both Downtown and Continental alternatives. Detention alternatives, for example, were recognized for the benefits provided to both areas.

Optimization of Level of Protection

As a result of the evaluations of the preliminary alternatives, it was apparent that the costs in any given reach for a 50-year level of protection were on average about 80% of the costs for the 100-year level of protection while accruing approximately one-half of the benefits. The costs for providing a 500-year level of protection were much higher than the costs for the 100-year level of protection while accruing little in additional benefits. For each reach the level of protection was optimized in terms of cost by channel configuration type. Consequently, the alternatives in the preliminary array are comparable in terms of optimal cost versus level of protection and are evaluated based upon cost versus benefits provided against the without project condition.

J. Feasibility Alternatives - Preliminary Array

All feasibility alternatives are formulated to address the regional flooding problem and address both the Upper Reach/Downtown area and the Lower Reach/Continental area together. For organizational purposes, however, these two areas will be presented as separate elements that could be combined during the plan selection phase of the study.

The alternatives to be evaluated that have features in the downtown area are numbered as Alternatives 1 through 6 (Alternative 6 is the no-action alternative).

The alternatives to be evaluated that have features in the Continental are lettered A through E.

For both sets of alternatives a no action plan was evaluated.

The methodology for preliminary screening and analysis initially considers alternatives that appear technically feasible, cost effective, and publicly acceptable, and proceeds to a cost- and benefit-estimating methodology to assess the economic justification of each respective preliminary plan. Thus far through the screening process, the 50-, 100-, and 500-year designs have been considered for most of the configurations detailed below. The Preliminary Alternative Screening process identifies those alternatives which are to be carried forward for detailed evaluation, in order to select a proposed plan for implementation. Based upon the screening process described above, preliminary alternatives were developed and compared. These alternatives consist of those combinations of measures which have been identified to be the most cost-effective.

Downtown Area Alternatives (1 through 6)

Alternative 1 (Full Detention, No Channelization)

This alternative calls for the construction of a detention basin and floodwalls at Thorpe Park to minimize outflow into Rio de Flag. This alternative would also include a detention basin on Clay Avenue Wash west of the City of Flagstaff. This alternative does not include any channel improvements downstream of these basins, and the existing channels are not adequate to contain all flows downstream of the detention basins. Significant flooding would still be realized in the downtown area and the south side of town including the Northern Arizona University. **Figure 5.1** shows the major features of Alternative 1.

Alternative 2 (Thorpe Park Detention Basin, Channelization on Clay Avenue Wash)

This alternative involves the construction of a detention basin and floodwalls at Thorpe Park. The alternative would also include the construction of an improved channel along Rio de Flag, and would provide flood protection to the downtown area. This channel would begin at approximately the Birch Street crossing of Rio de Flag. The channel would follow the current Rio de Flag alignment until just downstream of Route 66. The channel would then be directed south under the railroad tracks. From this point, the channel would parallel the railroad tracks until it joins the historic Rio de Flag alignment and continues to just downstream of Butler Avenue. The channel would be constructed as an earthen-bottom channel with natural rock revetment.

This alternative would also involve improving Clay Avenue Wash channel from just upstream of the Railroad Springs development. The improved rectangular concrete channel would follow the current alignment through the upper reaches, and would be sized to include all upstream and local drainage. The channel would be routed through a concrete box culvert at just upstream of Blackbird Roost. This culvert would follow the McCracken Place alignment, and would surface downstream of Malpais Lane. A concrete open channel would continue to the intersection of Butler Avenue and Milton Road. Flows would then be directed into a concrete box culvert that would follow the Mike's Pike alignment, and would resurface north of Phoenix Avenue, thereby forming the confluence with Rio de Flag upstream of Beaver Street.

From this point, an improved channel would parallel the railroad tracks until it joins the historic Rio de Flag alignment and continues to just downstream of Butler Avenue. Right-of-way constraints require a concrete box culvert from Beaver Street to downstream of the major railroad

crossings at approximately the alignment of Elden Street. From there the channel would consist of an earthen greenbelt designed to function as a natural channel with vegetated side-slopes. **Figure 5.2** shows the major features of Alternative 2.

Alternative 3 (Clay Ave. Wash Detention Basin, Channelization on Rio de Flag)

This alternative involves the construction of a detention basin on Clay Avenue Wash west of the City of Flagstaff. This alternative would also involve improving Clay Avenue Wash channel from just upstream of the Railroad Springs development. The improved rectangular concrete channel would follow the current alignment through the upper reaches, and would be sized to include all upstream and local drainage. The channel would be routed through a concrete box culvert at just upstream of Blackbird Roost. This culvert would follow the McCracken Place alignment, and would surface downstream of Malpais Lane. A concrete open channel would continue to the intersection of Butler Avenue and Milton Road. Flows would then be directed into a concrete box culvert that would follow the Mike's Pike alignment, and would resurface north of Phoenix Avenue, thereby confluencing with Rio de Flag upstream of Beaver Street.

The alternative would also include the construction of an improved channel along Rio de Flag, and provide flood protection to the downtown area. This channel would begin at approximately the Bonito Street crossing of Rio de Flag. The channel would follow the current Rio de Flag alignment until just downstream of Route 66. The channel would then be directed south under the railroad tracks. The channel would be constructed as an earthen-bottom channel with natural rock revetment.

From this point, an improved channel would parallel the railroad tracks until it joins the historic Rio de Flag alignment and continues to just downstream of Butler Avenue. Right-of-way constraints require a concrete box culvert from Beaver Street to downstream of the major railroad crossings at approximately the alignment of Elden Street. From there the channel would consist of an earthen greenbelt designed to function as a natural channel with vegetated side-slopes.

While the channel alignments and slope treatment/configuration of Alternatives 2 and 3 are similar, the relative sizes required to provide any specific level of protection differ due to the different detention basin locations, sizing, and outflows. **Figure 5.3** shows the major features of Alternative 3.

Alternative 4 (Channel Improvements, No Detention)

This alternative represents the full channelization plan, with no detention basins. The alternative would also include the construction of an improved channel along Rio de Flag, and provide flood protection to the downtown area. This channel would begin at approximately the Bonito Street crossing of Rio de Flag. The channel would follow the current Rio de Flag alignment until just downstream of Route 66. The channel would then be directed south under the railroad tracks. The channel would be constructed as an earthen-bottom channel with natural rock revetment.

This alternative would also involve improving Clay Avenue Wash channel from just upstream of the Railroad Springs development in an identical alignment and channel treatment configuration to Alternatives 2 and 3.

At the confluence, an improved channel would parallel the railroad tracks until it joins the historic Rio de Flag alignment and continues to just downstream of Butler Avenue. **Figure 5.4** shows the major features of Alternative 4.

Alternative 5 (Full Detention with Channel Improvements)

This alternative includes detention basins at both Thorpe Park and on Clay Avenue Wash, with channel improvements downstream of both basins. Clay Avenue Wash channel improvements would be provided throughout most of the reach, while Rio de Flag channel improvements would begin just upstream of Birch Street. This alternative would also include the construction of an improved channel between the confluence and Butler Avenue. **Figure 5.5** shows the major features of Alternative 5.

Alternative 6 (No-Action)

This alternative represents the without-project condition. No improvements would be made to alleviate any flooding in the City of Flagstaff.

Continental Area Alternatives

The following alternatives are displayed schematically on **Figure 5.6**.

Alternative A

This alternative involves excavation within Continental Lake downstream of Country Club Drive, to increase storage capacity and reduce flood damages. It also represents a mitigation feature to reduce any increases in the water surface elevation that may occur to the Continental Reach due to upstream channelization and the increased conveyance that would subsequently occur if there were no upstream detention basins on Clay Avenue Wash or at Thorpe Park. Any material excavated would be located onsite. There are therefore two configurations of this alternative. The first, Alternative A1, would reduce the water surface elevation to reduce base year and future without-project damages from affected properties. The second, Alternative A2, would be an additional increment as a mitigation measure to reduce adverse affects of implementing upstream alternatives.

Alternative B

This alternative would involve upgrading or improving the State Route 66/BNSF drainage structures that currently cannot convey the FEMA 100-year discharge rate of 210 cfs. Increasing the discharge rate would reduce the peak lake elevation. Even though SR 66 and the railroad bridge culvert currently limit flow to 90 cfs, downstream floodplain mapping reflects the FEMA discharge rate. This alternative represents a solution that would necessitate a downstream floodplain maintenance plan to ensure meeting the regulatory discharges.

Alternative C

The construction of a detention basin or series of localized detention basins immediately upstream of the Continental Area could reduce peak flows and flood damages in the area. This alternative includes combinations of Thorpe and Clay detention basins to reduce inflow into the Continental Area.

Alternative D

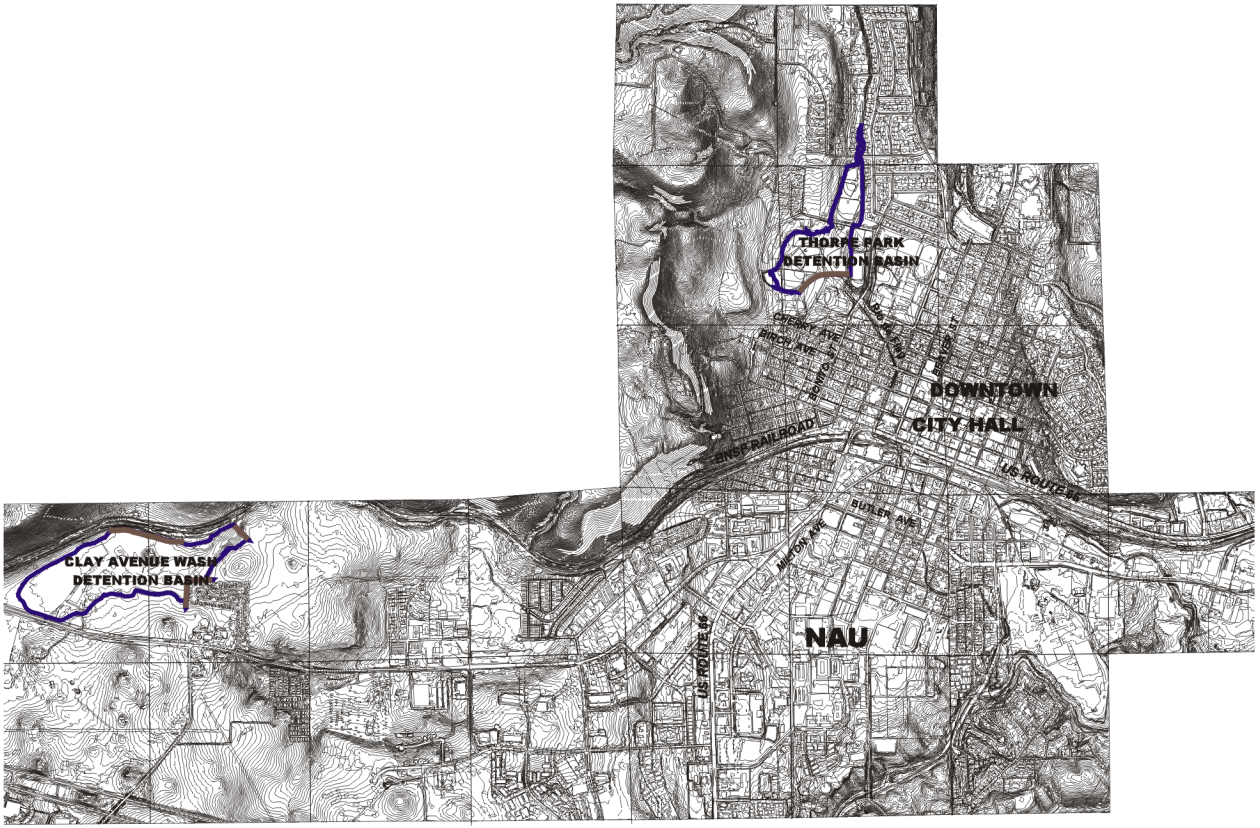
This alternative involves the implementation of localized levees for properties around the periphery of the Continental floodplain, especially in the vicinity of Butler Avenue and the Country Club Drive area. This would be accomplished through construction of protective levees around localized, specific areas/homes.

Alternative E (No-Action)

This alternative represents the without-project condition. No improvements would be made in the immediate area to alleviate any flooding in the Continental Area.

[This page left intentionally blank.]

C:\PROJECTS\RIOD\PRDOWNTWN2.APR - FULLDET



GENERAL INVESTIGATION
FLOOD DAMAGE REDUCTION STUDY
FOR
RIO DE FLAG,
FLAGSTAFF, ARIZONA

ALTERNATIVE 1

FULL DETENTION
NO CHANNELIZATION

LEGEND
- BERM
- RIPRAP CHANNEL
- CONCRETE BOX CULVERT
- OPEN CONCRETE CHANNEL
- GREENBELT CHANNEL
- DETENTION BASIN
- SECTION LINE

U.S. ARMY CORPS
OF ENGINEERS
Los Angeles District
South Pacific Division

CITY OF FLAGSTAFF
ARIZONA

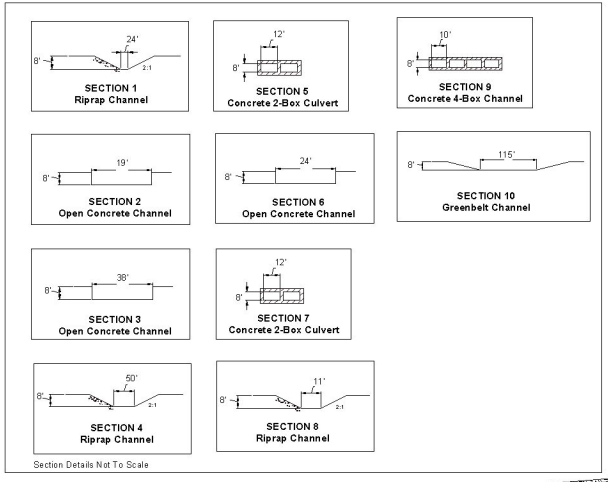
500 0 500 1000 1500 Feet

1:19000

May 3, 1999

FIGURE 5.1

C:\PROJECTS\RIO\DFIDOWNTWN2.APR - THORPE



GENERAL INVESTIGATION
FLOOD DAMAGE REDUCTION STUDY
FOR
RIO DE FLAG,
FLAGSTAFF, ARIZONA

ALTERNATIVE 2

THORPE PARK DETENTION BASIN WITH CHANNEL IMPROVEMENTS

LEGEND
- BERM
- RIPRAP CHANNEL
- CONCRETE BOX CULVERT
- OPEN CONCRETE CHANNEL
- GREENBELT CHANNEL
- DETENTION BASIN
- SECTION LINE

U.S. ARMY CORPS OF ENGINEERS
Los Angeles District
South Pacific Division

CITY OF FLAGSTAFF
ARIZONA

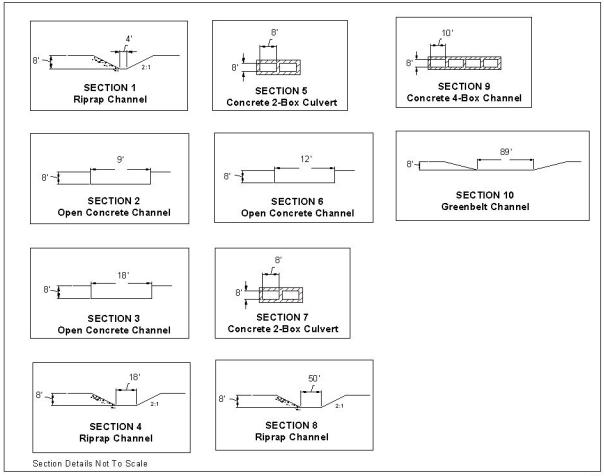
500 0 500 1000 1500 Feet

1:19000

May 3, 1999

FIGURE 5.2

C:\PROJECTS\RIODF\DGVWTWN2.APR - CLAY



GENERAL INVESTIGATION
FLOOD DAMAGE REDUCTION STUDY
FOR
RIO DE FLAG,
FLAGSTAFF, ARIZONA

ALTERNATIVE 3

CLAY AVENUE WASH DETENTION BASIN WITH CHANNEL IMPROVEMENTS

LEGEND
- BERM
- RIPRAP CHANNEL
- CONCRETE BOX CULVERT
- OPEN CONCRETE CHANNEL
- GREENBELT CHANNEL
- DETENTION BASIN
- SECTION LINE

U.S. ARMY CORPS
OF ENGINEERS
Los Angeles District
South Pacific Division

CITY OF FLAGSTAFF
ARIZONA

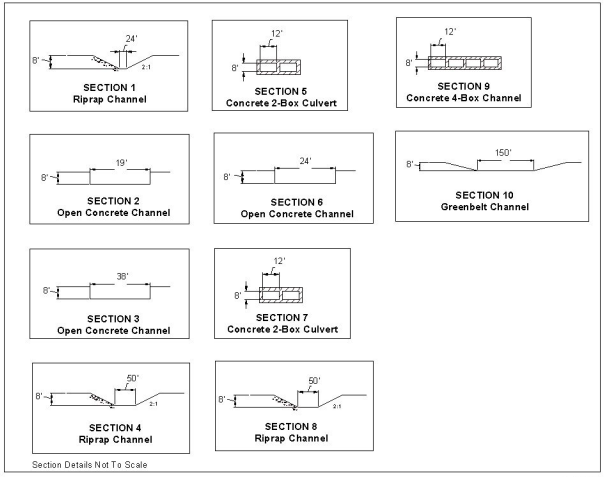
500 0 500 1000 1500 Feet

1:19000

May 3, 1999

FIGURE 5.3

C:\PROJECTS\RIVDFDOWNTWN2.APR - NODET



GENERAL INVESTIGATION
FLOOD DAMAGE REDUCTION STUDY
FOR
RIO DE FLAG,
FLAGSTAFF, ARIZONA

ALTERNATIVE 4

NO DETENTION CHANNEL IMPROVEMENTS

LEGEND
- BERM
- RIPRAP CHANNEL
- CONCRETE BOX CULVERT
- OPEN CONCRETE CHANNEL
- GREENBELT CHANNEL
- DETENTION BASIN
- SECTION LINE

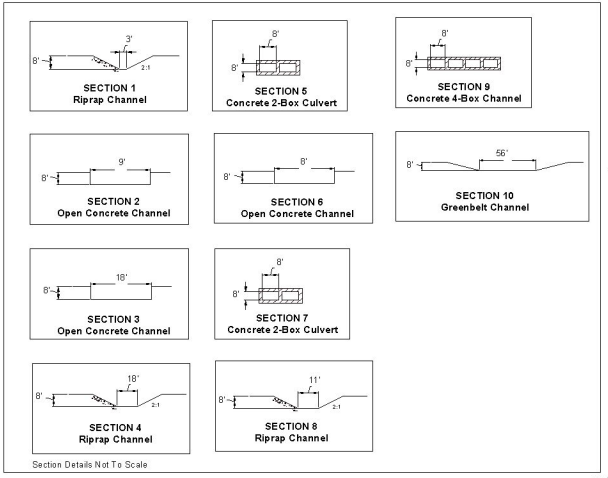
U.S. ARMY CORPS
OF ENGINEERS
Los Angeles District
South Pacific Division

CITY OF FLAGSTAFF
ARIZONA

500 0 500 1000 1500 Feet
1:19000

May 3, 1999

FIGURE 5.4



GENERAL INVESTIGATION
FLOOD DAMAGE REDUCTION STUDY
FOR
RIO DE FLAG,
FLAGSTAFF, ARIZONA

ALTERNATIVE 5

FULL DETENTION WITH CHANNEL IMPROVEMENTS

LEGEND
- BERM
- RIPRAP CHANNEL
- CONCRETE BOX CULVERT
- OPEN CONCRETE CHANNEL
- GREENBELT CHANNEL
- DETENTION BASIN
- SECTION LINE

U.S. ARMY CORPS
OF ENGINEERS
Los Angeles District
South Pacific Division

CITY OF FLAGSTAFF
ARIZONA

500 0 500 1000 1500 Feet

1:19000

May 3, 1999

FIGURE 5.5

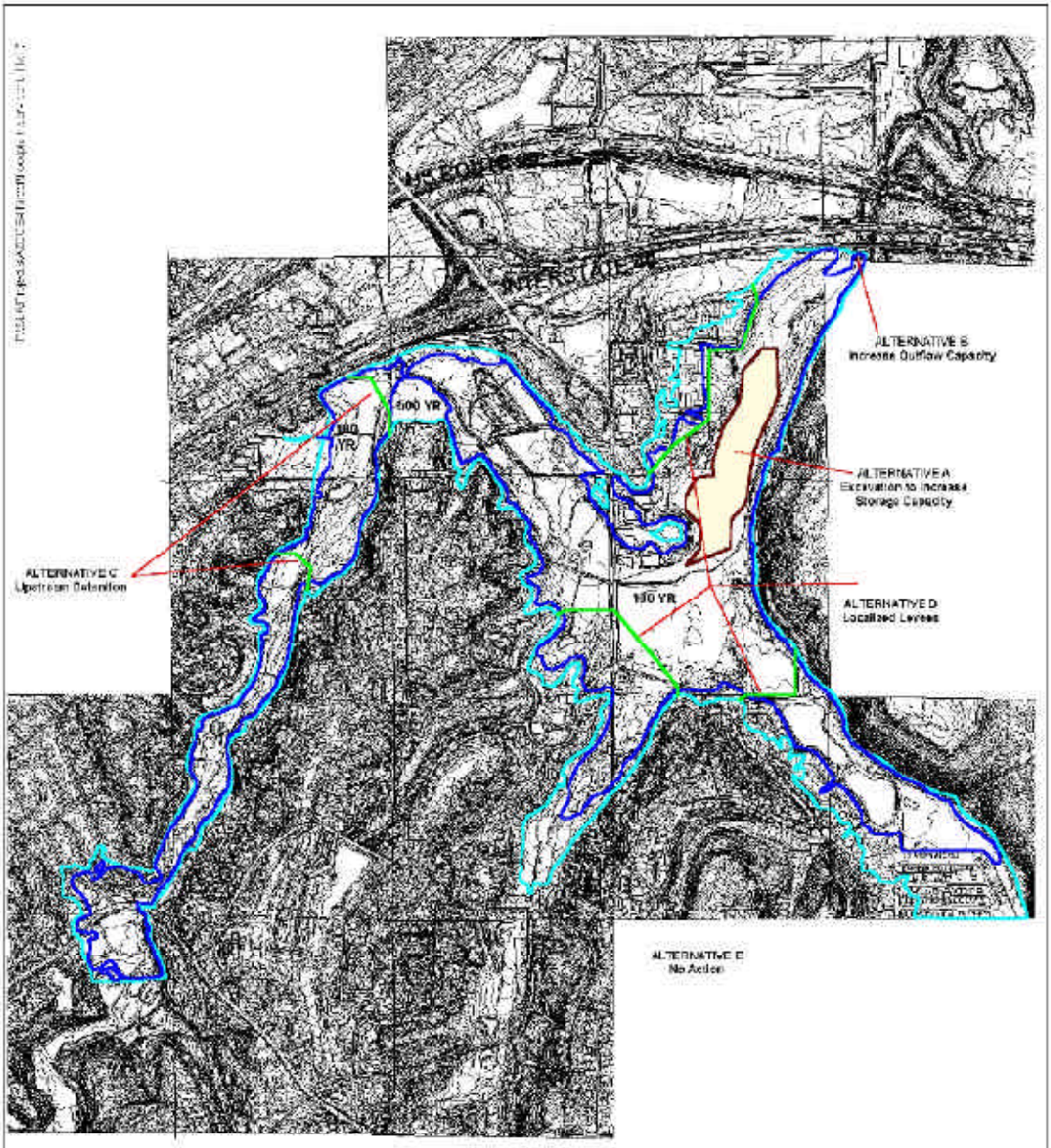

ALTERNATIVE B
Increase Outflow Capacity
ALTERNATIVE A
Excavation to Increase
Storage Capacity
ALTERNATIVE C
Upstream Detention
ALTERNATIVE D
Localized Levees
ALTERNATIVE E
No Action
500 YR
100 YR
100 YR
LEGEND
September 12, 2000
U.S. ARMY CORPS
OF ENGINEERS
Los Angeles District
South Pacific Division
CITY OF FLAGSTAFF
ARIZONA
GENERAL INVESTIGATION
FLOOD DAMAGE REDUCTION STUDY
FOR
RIO DE FLAG,
FLAGSTAFF, ARIZONA
CONTINENTAL AREA
ALL ALTERNATIVES

Figure 5.6

K. Screening of Preliminary Alternatives

The following represents a discussion and evaluation of the preliminary alternative solutions presented above. The preliminary alternatives were developed based upon the most cost effective combination of measures for each alternative, these alternatives are then screened based upon the potential for economic justification. The final array is then subjected to additional screening based upon more detailed economic and environmental considerations. These considerations include refined benefit cost analyses, incremental evaluation, project impacts, and mitigation requirements.

Preliminary Evaluation

Initially Selected Plan

The Corps of Engineers conducted a screening evaluation based upon feasibility criteria and selected Alternative 5 as the recommended plan in the "Rio de Flag, Flagstaff, Arizona Draft Feasibility Report" dated November 1999. Alternative 5, and the rationale for its selection, is discussed in detail in the previous report. The previous draft report was released for public and agency comment in compliance with the requirements of the National Environmental Policy Act, as amended, in November 1999. Prior to and concurrently with the release of the draft report, an independent technical review of all aspects of the plan was conducted by the Corps of Engineers. A discussion of the results of these reviews is presented briefly as follows.

Alternative 5 involved high floodwalls in order to accomplish detention at Thorpe Park. In addition to the permanent, unmitigable impacts associated with these high floodwalls, a detention structure at the downstream end of Thorpe Park was proposed. The Corps of Engineers received numerous comments on this plan, primarily from affected residents in the neighborhood, as well as from agency review. As a result, the public comment period was extended until the end of March 2000 to allow for all interested parties to comment. Additional public meetings were held and all comments received during the official public comment period are included and considered in the **EIS** to this report. In addition, public comments received, but not during the official public comment period, were considered and addressed by the Corps and are included in **Appendix H, Public Involvement**.

Additional engineering, design, and cost estimating work proceeded in order to more accurately define detention options at Thorpe Park. This was in response to the public concerns that were expressed, including the Arizona State Department of Water Resources requirements, related to

dam safety, as well as to the Corps' technical review process. Upon a more detailed examination of Thorpe Park detention, it was determined that the costs of providing all of the required detention at Thorpe Park alone increase. Therefore, it was determined that, based upon public and agency review, and independent technical review, there was an identified need to re-evaluate the alternatives and verify or change the selection of the plan, as necessary.

Costs

Table 5.1 displays the costs of the five alternatives for the upstream/downtown area including Rio de Flag, Clay Avenue Wash, and the reach downstream of the confluence. The costs shown are for a 100-year level of protection except for Alternative 1, which is able to detain the 100-year flow with minimal outflow (approximately 170 cfs from Clay Avenue Wash and 350 cfs from Thorpe Park) but is unable to control downstream flow from causing channel overflow during a 100-year event without additional channel improvements. **Table 5.2** displays the costs for the Continental Area alternatives. Costs are displayed using current (2000) price levels.

Costs of recreational components and environmental mitigation are not included in the cost estimates for the preliminary alternatives. Recreation and mitigation costs are evaluated in detail for the final array.

Table 5.1 Alternative Costs - Downtown Area

Item	Alternative 1	Alternative 2	Alternative 3	Alternative 4	Alternative 5
Detention Basins					
Cheshire Park Detention Basin					
Construction	$0	$0	$0	$0	$0
Real Estate	$0	$0	$0	$0	$0
Thorpe Park Detention Basin					
Construction	$8,447,000	$8,447,000	$500,000	$500,000	$8,447,000
Real Estate	$535,000	$535,000	$0	$0	$535,000
Clay Ave. Wash Detention Basin					
Construction	$960,870	$0	$960,870	$0	$960,870
Real Estate	$2,259,994	$0	$2,259,994	$0	$2,259,994
Reaches					
Rio de Flag (U/S of Thorpe Park)					
Construction	$330,000	$330,000	$330,000	$330,000	$330,000
Real Estate	$0	$0	$0	$0	$0
Rio de Flag (Bonito to Confluence)					
Construction	$0	$1,516,460	$2,299,870	$2,299,870	$1,516,460
Real Estate	$0	$105,000	$2,234,826	$2,234,826	$105,000
Clay Avenue Wash (to Confluence)					
Construction	$0	$4,234,048	$3,024,320	$4,234,048	$3,024,320
Real Estate	$0	$4,046,000	$1,573,703	$4,046,000	$1,573,703
Confluence (to Butler)					
Construction	$0	$8,516,754	$5,457,305	$9,017,739	$5,009,855
Real Estate	$0	$375,000	$675,000	$675,000	$375,000
Butler					
Construction	$0	$452,250	$452,250	$452,250	$452,250
Real Estate	$0	$0	$0	$0	$0
Sub-Total - Construction	$9,737,870	$23,496,512	$13,024,615	$16,833,907	$19,740,755
Contingency on Construction (20%)	$1,947,574	$4,699,302	$2,604,923	$3,366,781	$3,948,151
PED/EDC	$1,350,000	$1,600,000	$1,900,000	$2,100,000	$1,900,000
S&A (6.5%)	$632,962	$1,527,273	$846,600	$1,094,204	$1,283,149
Sub-Total - Construction	$13,668,406	$31,323,088	$18,376,138	$23,394,892	$26,872,055
Real Estate	$2,794,994	$5,061,000	$6,743,523	$6,955,826	$4,848,697
Total First Cost	**$16,463,400**	**$36,384,088**	**$25,119,661**	**$30,350,718**	**$31,720,752**

Table 5.2 Alternative Costs - Continental Area

Item	Alternative A1	Alternative A2	Alternative B	Alternative D

Excavation and disposal	$50,400,000	$7,200,000	$15,000	$139,000
Import, fill, and compaction of embankment			$32,000	$1,021,000
4'x8'x125" concrete box culvert			$120,000	
Concrete Spillway Apron & Abutments			$15,000	
R&R Route 66 Pavement & Base			$25,000	
Impermeable Layer				$50,000
Sub-Total - Construction	$50,400,000	$7,200,000	$214,000	$1,210,000
Contingency on Construction (20%)	$10,080,000	$1,440,000	$41,400	$242,000
PED/EDC	$5,443,200	$777,600	$15,000	$109,000
S&A (6.5%)	$3,276,000	$468,000	$13,910	$78,650
Sub-Total - Construction	$69,199,200	$9,885,600	$284,310	$1,639,650
Real Estate				$500,000
TOTAL	**$69,199,000**	**$9,886,000**	**$284,000**	**$2,140,000**

Benefit Cost Evaluation

Tables 5.3 and 5.4 display the summary of costs and benefits for the alternatives for the downtown and Continental areas, respectively. Costs are displayed using current (2000) price levels.

Table 5.3 Cost and Benefit Summary - Downtown Area

	ALT 1 (100-yr)	**ALT 2** (100-yr)	**ALT 3** (100-yr)	**ALT 4** (100-yr)	**ALT 5** (100-yr)
Sub-Total - Construction	$9,737,870	$23,496,512	$13,024,615	$16,833,907	$19,740,755
Contingency on Construction (20%)	$1,947,574	$4,699,302	$2,604,923	$3,366,781	$3,948,151
PED/EDC[1]	$1,350,000	$1,600,000	$1,900,000	$2,100,000	$1,900,000
S&A (6.5%)[2]	$632,962	$1,527,273	$846,600	$1,094,204	$1,283,149
Sub-Total - Construction	$13,668,406	$31,323,088	$18,376,138	$23,394,892	$26,872,055
Real Estate	$2,794,994	$5,061,000	$6,743,523	$6,955,826	$4,848,697
Total First Cost	**$16,463,000**	**$36,384,000**	**$25,120,000**	**$30,351,000**	**$31,721,000**
Interest During Construction	$400,826	$1,185,894	$818,757	$1,190,942	$1,456,847
Gross Investment	**$16,864,000**	**$37,570,000**	**$25,939,000**	**$31,542,000**	**$33,178,000**
Annualized (6-5/8%, 50 yrs)	$1,164,000	$2,594,000	$1,791,000	$2,178,000	$2,291,000
Operation & Maintenance	$70,000	$70,000	$60,000	$50,000	$80,000
Total Annual Cost	**$1,234,000**	**$2,664,000**	**$1,851,000**	**$2,228,000**	**$2,371,000**
Expected Annual Benefits	$1,237,000	$2,224,000	$2,219,000	NC	$2,279,000
Net Benefits	$3,000	($440,000)	$368,000	NC	($92,000)
Benefit/Cost Ratio	1.00	0.83	1.20	NC	0.96

[1] Planning, Engineering & Design/Engineering During Construction
[2] Supervision and Administration
[4] NC - Not Calculated

Table 5.4 Cost and Benefit Summary - Continental Area

	ALT A1	**ALT A2**	**ALT B**	**ALT D**
Sub-Total - Construction	$50,400,000	$7,200,000	$214,000	$1,210,000

Contingency on Construction (20%)	$10,080,000	$1,440,000	$41,400	$242,000
PED/EDC[1]	$5,443,200	$777,600	$15,000	$109,000
S&A (6.5%)[2]	$3,276,000	$468,000	$13,910	$78,650
Sub-Total - Construction	$69,199,200	$9,885,600	$284,310	$1,639,650
Real Estate	-	-	-	$500,000
TOTAL	**$69,199,000**	**$9,886,000**	**$284,000**	**$2,140,000**
Interest During Construction	$1,782,790	$83,490	NC	$57,970
Gross Investment	**$70,981,790**	**$9,969,490**	**NC**	**$2,198,000**
Annualized (6-5/8%, 50 yrs)	$5,100,310	$716,410	NC	$152,000
Operation & Maintenance	$50,000	$30,000	NC	$50,000
Total Annual Cost	**$5,150,310**	**$746,410**	**NC**	**$202,000**
Expected Annual Benefits	NC	NC	$0	$53,000
Net Benefits	NC	NC	NC	($149,000)
Benefit/Cost Ratio	NC	NC	NC	0.26

[1] Planning, Engineering & Design/Engineering During Construction
[2] Supervision and Administration
[4] NC - Not Calculated

As a result of the engineering, design, and cost re-evaluations which were performed in response to the review process, it was determined that Alternative 3, or some variation, should be pursued further. This is due primarily to the cost savings which can be achieved through downstream channelization options. However, public and agency concerns focused on additional upstream detention and storage options which were potentially more feasible than detention at Thorpe Park alone. All of the new alternatives limit floodwall heights to 5 feet at Thorpe Road, as identified from public and agency comments. Accordingly, three new alternatives were developed for detailed analysis and evaluation. A brief description of these alternatives (Alternatives 6A, 6B, and 7) follows.

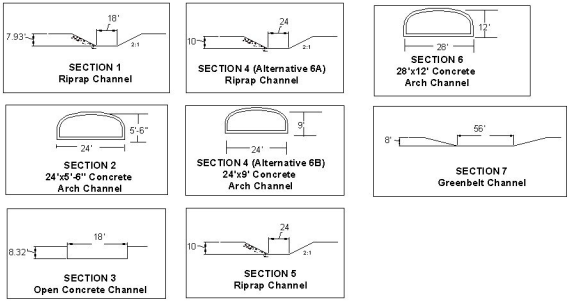
Alternative 6

This alternative involves elimination of detention at Thorpe Park and instead relies on channelization to convey the 100-year flow downstream. Two potential options were investigated: Alternative 6A, which would utilize a trapezoidal channel section from Thorpe Park to Route 66; and Alternative 6B, which would utilize a trapezoidal channel section similar to Alternative 6A except that, in those areas downstream of Thorpe Park with real estate constraint, a covered channel section (arch) would be evaluated in order to avoid the necessity of acquiring residential properties. These two new alternatives, shown on **Figure 5.7**, are refinements of the re-evaluated Alternative 3 previously described.

Alternative 7

This alternative involves additional excavation at Thorpe Park and utilizing upstream sites to obtain additional detention. Increased channelization downstream of Thorpe Park would also be necessary to convey increased outflows as a result of any decrease in detention capacity. This alternative was developed in response to public and agency comments on the previously selected plan. It was determined that there was a defined need to compare upstream options (this alternative) versus downstream options (Alternative 6 above) in order to adequately evaluate any proposed new alternatives. Costs, benefits, public acceptance, and environmental impacts were evaluated for a total of 13 different detention options at a total of five upstream detention sites identified by the public. The most cost-effective sites with the least environmental consequences were combined into a total of 12 potential combinations. Of these, three were identified as potentially being cost justified to be included as potential options as a selected plan. Of these three, the one that limited floodwall heights at Thorpe Road to 5 feet was developed into further detail to be compared against Alternative 6. Alternative 7, shown on **Figure 5.8**, consists of detention at Clay Avenue Wash, Cheshire Park, combined with reduced detention at Thorpe Park, in conjunction with increased releases and additional downstream channelization.

C:\PROJECTS\RIOD\DOWNTWN2NED.APR - Alternative 6A/6B



GENERAL INVESTIGATION
FLOOD DAMAGE REDUCTION STUDY
FOR
RIO DE FLAG,
FLAGSTAFF, ARIZONA

ALTERNATIVE 6A/6B

RIO DE FLAG IMPROVEMENTS WITH CLAY DETENTION

LEGEND
- BERM
- RIPRAP CHANNEL
- COVERED CONCRETE ARCH CHANNEL
- OPEN CONCRETE CHANNEL
- GREENBELT CHANNEL
- DETENTION BASIN
- SECTION LINE
- FLOODWALL
- 6A: RIPRAP CHANNEL
- 6B: COVERED CONCRETE ARCH CHANNEL

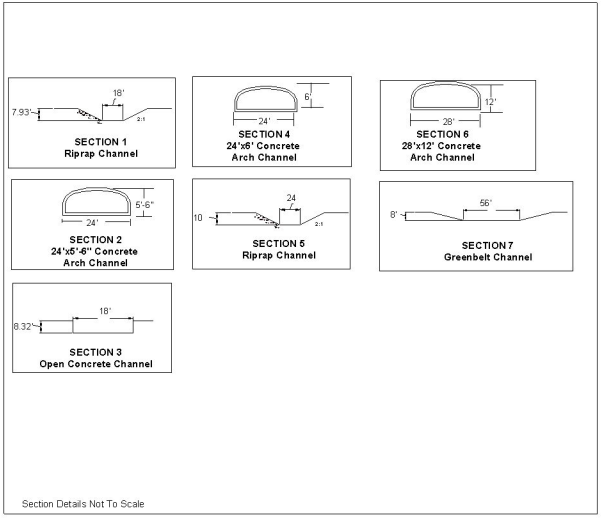
U.S. ARMY CORPS OF ENGINEERS
Los Angeles District
South Pacific Division

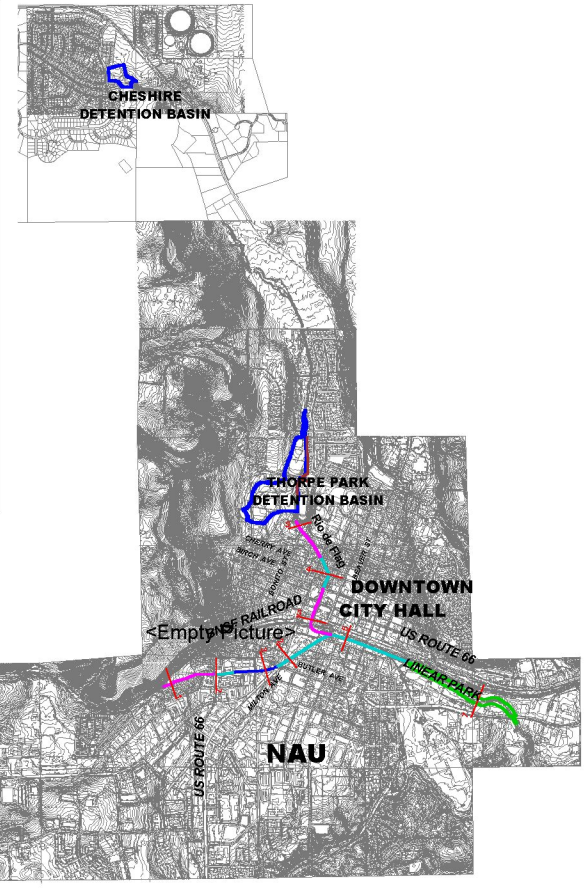
CITY OF FLAGSTAFF
ARIZONA

500 0 500 1000 1500 Feet
1:19000

June 5, 2000

C:\PROJECTS\RIODF\DOWNTWNDRNED.APR - Alternative 7





<Empty Picture>

GENERAL INVESTIGATION
FLOOD DAMAGE REDUCTION STUDY
FOR
RIO DE FLAG,
FLAGSTAFF, ARIZONA

ALTERNATIVE 7

THREE DETENTION BASINS WITH CHANNEL MODIFICATIONS

LEGEND
- BERM
- RIPRAP CHANNEL
- COVERED CONCRETE ARCH CHANNEL
- OPEN CONCRETE CHANNEL
- GREENBELT CHANNEL
- DETENTION BASIN
- SECTION LINE
- FLOODWALL

U.S. ARMY CORPS OF ENGINEERS
Los Angeles District
South Pacific Division

CITY OF FLAGSTAFF
ARIZONA

700 0 700 1400 2100 Feet
1:27000

June 9, 2000

Figure 5.8 Alternative 7

The evaluation of Alternatives 6A, 6B, and 7 is presented in **Table 5.5** below.

Table 5.5 Cost and Benefit Summary - Alternatives 6A, 6B, and 7

Item	Alternative 6A	Alternative 6B	Alternative 7
Detention Basins			
Cheshire Park Detention Basin			
Construction	$0	$0	$2,224,200
Real Estate	$0	$0	$120,000
Thorpe Park Detention Basin			
Construction	$388,065	$388,065	$2,095,000
Real Estate	$0	$0	$535,000
Clay Ave. Wash Detention Basin			
Construction	$665,003	$665,003	$665,003
Real Estate	$2,259,994	$2,259,994	$2,259,994
Reaches			
Rio de Flag (U/S of Thorpe Park)			
Construction	$302,780	$302,780	$302,780
Real Estate	$0	$0	$0
Rio de Flag (Bonito to Confluence)			
Construction	$2,175,787	$2,613,613	$2,071,860
Real Estate	$2,234,826	$214,474	$104,374
Clay Avenue Wash (to Confluence)			
Construction	$3,294,779	$3,294,779	$3,024,320
Real Estate	$1,169,132	$1,169,132	$1,169,132
Confluence (to Butler)			
Construction	$6,003,067	$6,003,067	$5,909,555
Real Estate	$675,000	$675,000	$375,000
Mitigation Costs	$87,000	$177,300	$577,000
Sub-Total - Construction	$12,916,481	$13,444,607	$16,869,718
Contingency on Construction (20%)	$2,583,296	$2,688,921	$3,373,944
PED/EDC	$1,854,000	$1,854,000	$2,054,000
S&A (6.5%)	$839,571	$873,899	$1,096,532
Sub-Total - Construction	$18,193,348	$18,861,428	$23,394,193
Real Estate	$6,338,952	$4,318,600	$4,563,500
Total First Cost	**$24,532,300**	**$23,180,028**	**$27,957,693**
Interest During Construction	$2,173,300	$1,919,200	$2,252,100
Gross Investment	**$26,705,600**	**$25,099,228**	**$30,209,793**
Annualized (6-5/8%, 50 years)	$1,844,000	$1,733,000	$2,086,000
Operation and Maintenance	$60,000	$60,000	$85,000
Total Annual Cost	**$1,904,000**	**$1,793,000**	**$2,171,000**
Expected Annual Benefits	$2,387,000	$2,387,000	$2,387,000
Net Benefits	$483,000	$594,000	$216,000
Benefit/Cost Ratio	1.25	1.33	1.10

Real Estate Costs include $13,600 in credits and exclude $418,000 in relocation assistance payments

Screening Evaluation for Final Array

Downtown Area

Alternative 1, the basin-only alternative, would significantly reduce peak discharges through the downtown area including NAU, and would produce the greatest reduction in peak discharges in the Continental area compared to other alternatives. The reductions in contributory peak discharges from the Thorpe and Clay basins would only enable the existing downtown area channels to control the 50-year flood event. This is because additional downstream runoff contributes to flows entering below the basins that would still overtop the existing channels. A 100-year event would have residuals that approximate the without-project 50-year event. The attenuation of peak discharges by the upstream basins would have a positive effect through the Continental area. Alternative 1 is marginal in terms of economic justification and is not carried forward for the final array.

In general, Alternatives 2 through 7 would all eliminate flooding along Rio de Flag, downstream of Bonito Street, and along Clay Avenue Wash according to their relative levels of protection. Significant benefits would be realized in the downtown area and at NAU. Local drainage facilities that are currently overwhelmed by significant floods would be adequate to contain runoff from the immediate area. The alternatives terminate at an "adequate point of disposal," which is defined as a location where discharge conveyed by a project does not result in adverse impacts compared to the without-project condition.

Alternative 2 consists of Thorpe basin and channelization along Clay Avenue Wash. This combination plan reduces the overall discharge from Thorpe and increases capacity throughout the downtown area. The residual flooding from a 500-year flood event with a 100-year level of protection in place, for example, would result in flooding that approximates the 25- to 50-year floodplain in the without-project condition. For the Continental area, the reduction from Thorpe is offset by the efficiency of the channelization such that the net effect is a minimal reduction in peak water surface elevations. Alternative 2 is not economically justified and is not carried forward into the final array.

Alternative 3 consists of Clay Avenue basin and channelization. This combination plan is similar to Alternative 2 in that it reduces the overall discharge from Clay Avenue and increases capacity throughout the downtown area. Further, the residual flooding from a 500-year flood event with a 100-year level of protection in place, for example, would result in flooding that approximates the 25- to 50-year floodplain in the without-project condition. For the Continental area, the reduction from the Clay basin is offset by the efficiency of the channelization such that the net effect is a minimal reduction in water surface elevations. Alternative 3 is economically justified and is the least cost alternative. Additional refinement of Alternative 3 resulted in Alternatives 6A and 6B, both of which are carried forward into the final array.

Alternative 4 is a channelization plan with no detention. Residual flooding would be reduced compared to Alternatives 1, 2, and 3. Channelization, however, modifies flood flow routing and timing such that the peak discharges entering the Continental area increase. Without detention basins or some other means of significant attenuation, higher peak flows are conveyed to the Continental area, and associated increases in water surface elevations would occur. An approximately 1 foot increase in water surface elevation over and above the without-project condition in the Continental Lake area would occur with implementation of this alternative during a 100-year event. Alternative 4 induces downstream damages and is not economically justified and therefore eliminated from further consideration.

Alternative 5 consists of basins on Thorpe and Clay Avenue with downstream channelization that would be designed to provide a specific level of protection. Alternative 5 is not economically justified and is not carried forward into the final array.

Alternatives 6A and 6b would provide 100-year flood protection along the Rio de Flag's downtown reach and would also reduce flooding along the Clay Avenue Wash, I-40, and Continental Reach. Both alternatives are economically justified and provide the highest net benefits and are carried forward into the final array.

Alternative 7 was developed as an option to compare more cost-efficient upstream detention options against downstream channelization. In addition, Alternative 7 specifically responds to numerous public and agency comments regarding alternative detention sites to reduce the need for detention at Thorpe Park. Since Alternative 7 is marginally economically justified and is a direct response to public comments, it is carried forward into the final array for comparison in terms of economic justification and environmental analysis in the **EIS**.

Continental Area

Alternative A1 was evaluated on a stand alone basis to provide additional capacity at Continental for the increased flows due to upstream runoff under future conditions, without any features in place upstream that would serve to alleviate the problem at Continental. This allowed the alternative to be evaluated independently for the case that none of the upstream alternatives would be economically justified. Without upstream alternatives, the volume of excavation required would be substantial and excessive. Specifically, increasing the detention capacity to the point that water surface elevations would not be higher involves substantial excavation. Additional excavation would be required to actually lower water surface elevations. The high cost before obtaining any benefit whatsoever, and the limited benefits available in the Continental area show that Alternative A1 cannot be economically justified and so was eliminated from additional consideration.

Alternative A2 was evaluated in conjunction with upstream alternatives in place. With Alternatives 2, 3, and 5, there is already some reduction in water surfaces at Continental. Alternative A2 was evaluated in terms of reducing water surface elevations by one foot over and above the reduction provided by the upstream alternatives. These costs were then qualitatively

evaluated against without-project damages hence maximum benefits that could be available for the area. Alternative A2 cannot provide sufficient benefits over and above the upstream alternatives to be economically justified and so is eliminated from further consideration.

Alternative B, Increase Outflow Capacity at Route 66. The Continental area stores a large volume of water during flood events. Due to the existing FEMA floodplain, there is little development within the 100-year floodplain. Development of relatively high value structures is present within the 500-year floodplain, right up to the fringe of the 100-year FEMA mapping. The 100-year inflow to the Continental area is 4,200 cfs, and the without-project outflow is 90 cfs. It is possible to increase the outflow to the FEMA discharge to downstream areas to 210 cfs. This can be accomplished at relatively low cost. However, due to the duration and large volume of water stored at Continental, and the large areal extent of the detention basin, substantial volumes of water have only slight effect on the water surface elevations. The hydraulic impact of increasing the outflow to 210 cfs would have a negligible effect on peak water surface elevations, hence available benefits. Increasing outflows above 210 cfs would involve inducing damages downstream. Purchase of downstream property was previously determined as too costly. Since the costs, although low, cannot provide significant benefits, this alternative is eliminated from further consideration.

Alternative C, upstream detention, was evaluated in terms of the upstream detention proposed for Clay Avenue Wash and Thorpe Park, and additional localized detention areas between the downtown area and Continental. Alternatives 1 and 5 provide benefits to the Continental area. The volume and capacity of additional smaller detention areas would be insufficient to provide significant benefits over and above those provided by the large upstream detention facilities. No feasible location was identified for an additional large detention facility. The limited damages under the without-project condition and the reduction of damages from upstream options preclude economic justification of this alternative; so Alternative C in terms of localized detention areas upstream of Continental is eliminated from additional consideration.

Alternative D, localized levees at Continental, were evaluated for a 100-year level of protection based upon with-project floodplain delineations. These localized levees are situated for particular groupings of structures to provide the protection. At the preliminary alternative screening level, the 100-year level of protection is not economically justified. However, 100-year average annual benefits are $53,000, while 500-year average annual benefits are approximately $150,000, a nearly three fold increase. The 500-year water surface elevation at Continental is approximately 4 feet higher than the 100-year water surface elevation, but the 100-year levee heights average about 16 feet. The additional cost of an approximately 20-foot high levee versus a 16-foot high levee was qualitatively assessed in relation to the potential increases in benefits that could be obtained. Alternative D is carried forward for additional evaluation of cost and benefits into the final array, at the 500-year level of protection.

Environmental

The environmental consequences of the with-project condition were addressed qualitatively within an impact matrix as described in Section 4.0 of the **EIS**. For the preliminary alternatives, a maximum footprint was determined that would encompass the areas that would be impacted. As such the initial environmental evaluation is not alternative specific, but does provide an estimate of potential significant impacts from a qualitative standpoint. This allows a qualitative examination of the environmental considerations for preliminary alternatives to assist in the initial screening of the preliminary alternatives. Alternatives that are carried forward into the final array for additional evaluation for potential implementation are evaluated in detail for specific impacts, mitigation, and compliance with environmental laws and regulations. The **EIS** comprehensively addresses those alternatives considered for implementation. For each environmental resource area, the maximum footprint was evaluated in terms of the study reaches outlined below.

For the maximum footprint, qualitative potential impacts are rated as either (1) *significant, unmitigable,* (2) *significant, mitigable* , (3) *adverse, not significant* , (4) *no measurable effect*, or (5) *beneficial*. The information and evaluations collected and utilized for this phase of screening are expanded in much greater detail, and specific to the proposals for implementation based upon the alternatives carried forward into the final array of the **EIS**.

Generalized, Qualitative Impacts are estimated as follows: The following resources represent those that would have either *significant, mitigable* or *significant, unmitigable* impacts

Cheshire Park Detention Basin

- · Water Quality - Mitigable
- · Transportation - Mitigable
- · Noise - Mitigable
- · Air Quality - Mitigable
- · Aesthetics - Mitigable

Thorpe Park:

- · Water Quality - Mitigable
- · Transportation - Mitigable
- · Noise - Mitigable
- · Air Quality - Mitigable
- · Aesthetics - Mitigable

Clay Avenue Wash Detention Basin:

- · Water Quality - Mitigable
- · Transportation - Mitigable
- · Noise - Mitigable
- · Air Quality - Mitigable
- · Aesthetics - Mitigable

Thorpe Park to Upstream of Beaver Street:

- · Water Quality - Mitigable
- · Land/Water Use - Unmitigable
- · Recreation - Mitigable
- · Socioeconomics - Unmitigable
- · Transportation - Mitigable
- · Noise - Mitigable
- · Aesthetics - Mitigable
- · Hazardous and Toxic Substance - Mitigable

Clay Avenue Wash Detention Basin to Mike's Pike:

- · Water Quality - Mitigable
- · Land/Water Use - Unmitigable
- · Socioeconomics - Unmitigable
- · Environmental Justice - Mitigable
- · Transportation - Mitigable
- · Noise - Mitigable
- · Aesthetics - Mitigable

· Hazardous and Toxic Substance - Mitigable

Mike's Pike Alignment:

· Transportation - Mitigable
· Noise - Unmitigable
· Hazardous and Toxic Materials - Mitigable

Upstream of Beaver Street to Butler Avenue:

· Water Quality - Mitigable
· Land/Water Use - Mitigable
· Socioeconomics - Mitigable
· Noise - Unmitigable
· Hazardous and Toxic Materials - Mitigable

Cultural

There are five cultural resources in the area of potential effects (APE) that may be affected by construction of Clay Avenue Wash Detention Basin (CAWDB). Construction of a dam on the eastern end of the CAWDB may have an affect on the historic Atlantic and Pacific Railroad Bridge and embankment. The bridge was built in 1885, and abandoned when the railroad tracks were realigned a little further north. The bridge will likely be determined to be eligible for listing in the National Register of Historic Places (NRHP). A recent Corps of Engineers survey of the APE was conducted in April 1999. Three late historic trash scatters and the totally destroyed remains of a small cabin were identified. However, these three historic features are not considered eligible for inclusion in the National Register of Historic Places. A ranch complex on the southwestern end of the proposed detention basin has not been inventoried or evaluated for NRHP eligibility. Its disposition as a potential historic property is unknown at this time.

The preferred mitigation plan for the railroad bridge and the ranch complex is avoidance. If this is not feasible, impacts should be made as minimal as possible. If adverse affects are unavoidable, the property(s) should be fully documented in their original setting and context avoidance according to either HAB/HAER guidelines or the State Historic Preservation Act, Documentation Standards for Historic Properties. Should the remaining historic trash scatters or cabin be determined eligible for inclusion in the NRHP mitigation will be accomplished through development and implementation of a Historic Property Treatment Plan.

Compliance with Section 106

Compliance with Section 106 will be achieved through a Programmatic Agreement (PA). The PA will stipulate the required actions, to evaluate all affected properties in the APE, and mitigate adverse affects that will occur as a result of the project. The PA will also contain a stipulation specifying what measures are to be taken if prehistoric archeological materials are encountered during ground disturbing activities. If prehistoric archaeological materials are found during ground disturbing activities, all work will cease in the area until the provisions of 36 CFR 800, 11, *Properties discovered during implementation of an undertaking* , are met.

Recreation

All alternatives are formulated to inherently incorporate appropriate, austere recreational features. These include such things as unimproved trails, paved trails when they can also be used as maintenance access roads, and parkland features when they can be combined with the need for wider channels. Additional recreational features, including upgraded facilities, would be subject to separate cost sharing requirements than those applied to the NED Plan. These are described in subsequent sections of the report as part of the selected plan.

L. Feasibility Alternatives - Final Array

The Final Array of Alternatives is as follows:

(1) Alternatives 6A and 6B - detention along Clay Avenue Wash with no detention along the Rio de Flag, including channel improvements along Clay Avenue Wash and the Rio de Flag;

(2) Alternative 7 - detention at Clay Avenue Wash, Cheshire Park, and Thorpe Park, including channel improvements along Clay Avenue Wash and the Rio de Flag;

(3) Alternative D for Continental - 500-year localized levees; and

(4) The No Action Plan for both Downtown and Continental

The final array of alternatives is subjected to the following specific process to enable selection of a plan:

- Cost and benefits for each alternative are refined
- Environmental impacts for each alternative are evaluated
- Each alternative is evaluated and rated for:
  - Technical Feasibility
  - Economic Justification
  - Environmental Acceptability
  - Public Supportability

Based on the above evaluations, Alternative 6B provides the least costly approach to obtaining flood protection. This plan best meets the planning objectives of the study while conforming with the stated constraints when compared to the other alternatives evaluated. Alternative 6B is the most cost-effective means of providing flood control in the study area while remaining in compliance with the National Environmental Policy Act of 1969 (NEPA). Alternative 6B maximizes NED contributions by reducing flooding along Rio de Flag in the downtown Flagstaff area, as well as along Clay Avenue Wash. Alternative 6B also reduces the peak flows that enter the Continental area and increases the amount of time that it takes for the detention area to become filled, while providing a decrease in future water surface elevations during the more severe floods.

[This page left intentionally blank.]

CHAPTER VI

DESCRIPTION OF THE SELECTED PLAN

A. Selected Plan

The Selected Plan is Alternative 6B. The Selected Plan is the NED Plan and is shown on **Figure 6.1**. This plan was selected because it meets the planning objectives identified for this study and best satisfies the feasibility criteria in accordance with applicable laws, rules, regulations, and policies of the U.S. Army Corps of Engineers.

Alternative 6B is also the Locally Preferred Plan. The Local Sponsor, the City of Flagstaff, fully supports selection of Alternative 6B for implementation.

The Selected Plan has undergone preliminary design at a feasibility report level of detail. Additional design of the Selected Plan will occur during the Preconstruction Engineering Design phase (PED) based upon the recommendations of this feasibility report. The PED phase will be initiated upon approval of this feasibility report and specific Congressional authorization.

B. Plan Features

The Selected Plan (Recommended Plan) would provide flood protection along the Rio de Flag's Downtown Reach and would also reduce flooding along the Clay Avenue Wash and at Continental. It includes the Clay Avenue Wash detention basin, as well as channel modifications along Clay Avenue Wash and the Rio de Flag. The with-project floodplain is shown on **Figures 6.2** and **6.3**. There would be no residual flooding during a 100-year event except for just downstream of the Clay Avenue Wash Detention Basin, between the basin and the proposed channel improvements that begin just north of the Chateau Royal Apartments. Residual flooding during a 500-year event would be greatly reduced, when compared to the without-project condition. Plan features are described below.

During a 10-year flood event, water would be discharged from the detention basins over a period of 50 to 60 hours from the time that the basin reaches maximum storage volume, depending on the amount of rainfall and snow melt. By extending the period of flow in the downstream channels, the amount of flow within the channels at any one time is reduced. An "on-line" detention basin would be constructed along the Clay Avenue Wash to the west/southwest of downtown Flagstaff, just west of the city limits and north of Route 66.

Water would pass through the detention basin unrestricted during periods of relatively low flow. During periods of higher flow, however, the influx of water into the basin would exceed the discharge capacity of the basin's outlet structures, and the detention basin would begin to fill. Only after the rate of water entering the basin drops below the capacity of the outlet structure would basin water level begin to drop.

During flood events in excess of the design event (approximately 100-year level of protection), if the detention basin reaches full storage capacity and water continues to flow into the basin in excess of the basin's outlet structure capacity, then the excess water will flow out of the basin over an emergency spillway.

The Rio de Flag channel modifications would consist of two basic components: (1) expanding the existing channel from Bonito Street downstream to just south of Route 66, and (2) creating a new channel starting south of Route 66, continuing roughly parallel to the railroad tracks through downtown (immediately south of the tracks), and joining a remnant portion of the historic Rio de Flag channel approximately 1,700 feet upstream of Butler Street.

The following is a more detailed description of the features associated with the selected plan.

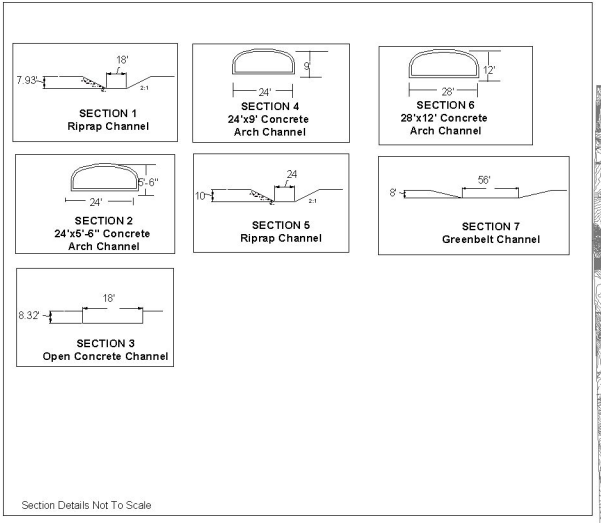
Rio De Flag

Flood control features along the Rio de Flag would consist of three basic components: 1) bridge modifications upstream of Thorpe Park, 2) flood control structures and road modifications in Thorpe Park, and 3) channel modifications downstream of Thorpe Park. These features are described below.

Bridge Modifications

Upstream of Thorpe Park, three bridges would be modified along the Rio de Flag at Meade Lane, Anderson Road, and Beal Road. New inlet wingwalls would be constructed upstream of the Meade Lane bridge, and the existing bridge would remain in place. The Anderson Road and Beal Road bridges would be demolished and replaced.

C:\PROJECTS\RIOD\PDOWNTWN2NED_APR - Alternative 6



GENERAL INVESTIGATION
FLOOD DAMAGE REDUCTION STUDY
FOR
RIO DE FLAG,
FLAGSTAFF, ARIZONA

ALTERNATIVE 6B
NED PLAN

RIO DE FLAG IMPROVEMENTS WITH CLAY DETENTION

LEGEND
- BERM
- RIPRAP CHANNEL
- COVERED CONCRETE ARCH CHANNEL
- OPEN CONCRETE CHANNEL
- GREENBELT CHANNEL
- DETENTION BASIN
- SECTION LINE
- FLOODWALL

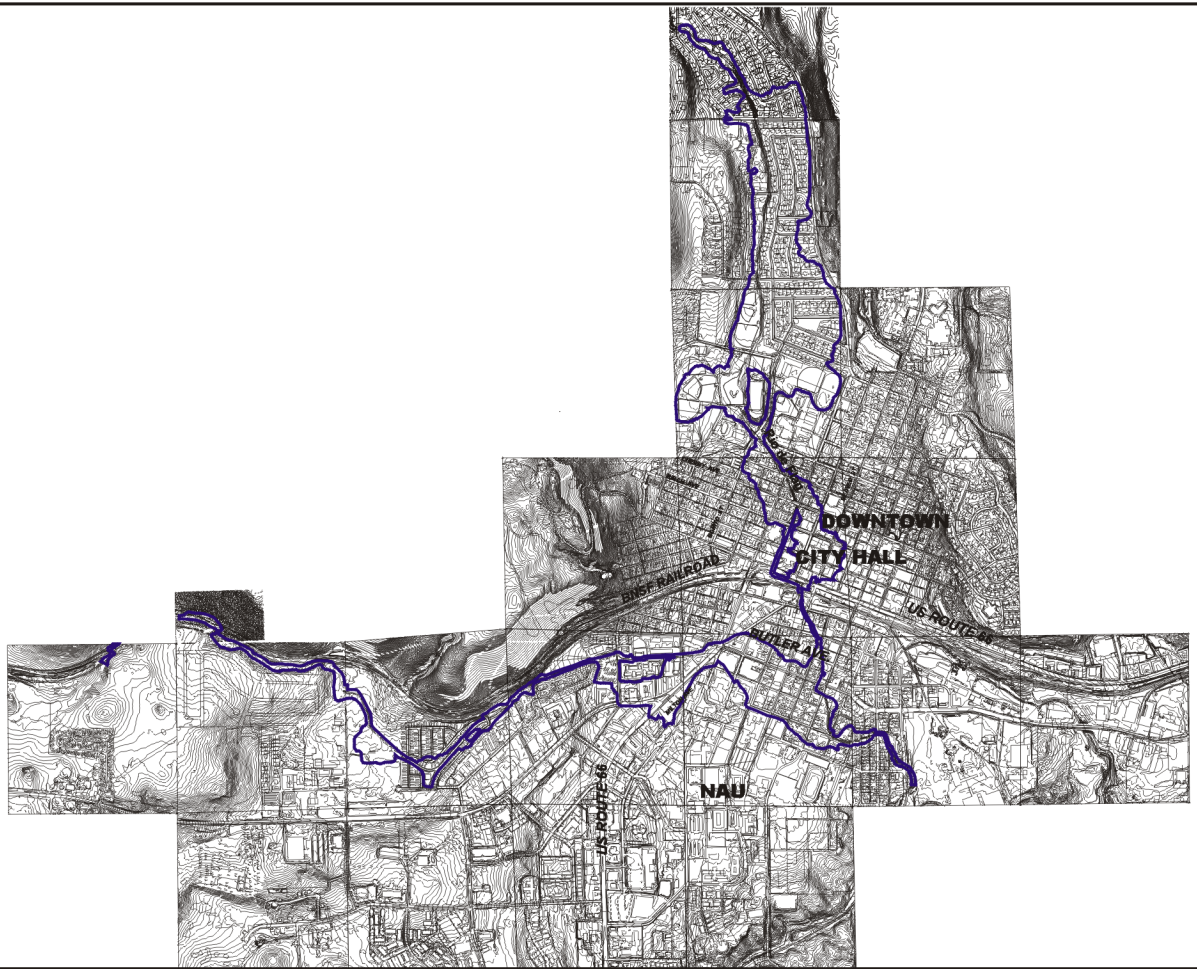
U.S. ARMY CORPS OF ENGINEERS
Los Angeles District
South Pacific Division

CITY OF FLAGSTAFF
ARIZONA

500 0 500 1000 1500 Feet
1:19000

June 9, 2000

C:\PROJECTS\RIODF\DOWNTOWN.APR - W Project Downtown FP 2053



GENERAL INVESTIGATION
FLOOD DAMAGE REDUCTION STUDY
FOR
RIO DE FLAG,
FLAGSTAFF, ARIZONA

2053 FLOODPLAIN

With-Project Conditions
500 Year
Downtown Area

LEGEND

500 YEAR FLOODPLAIN 2053

U.S. ARMY CORPS OF ENGINEERS
Los Angeles District
South Pacific Division

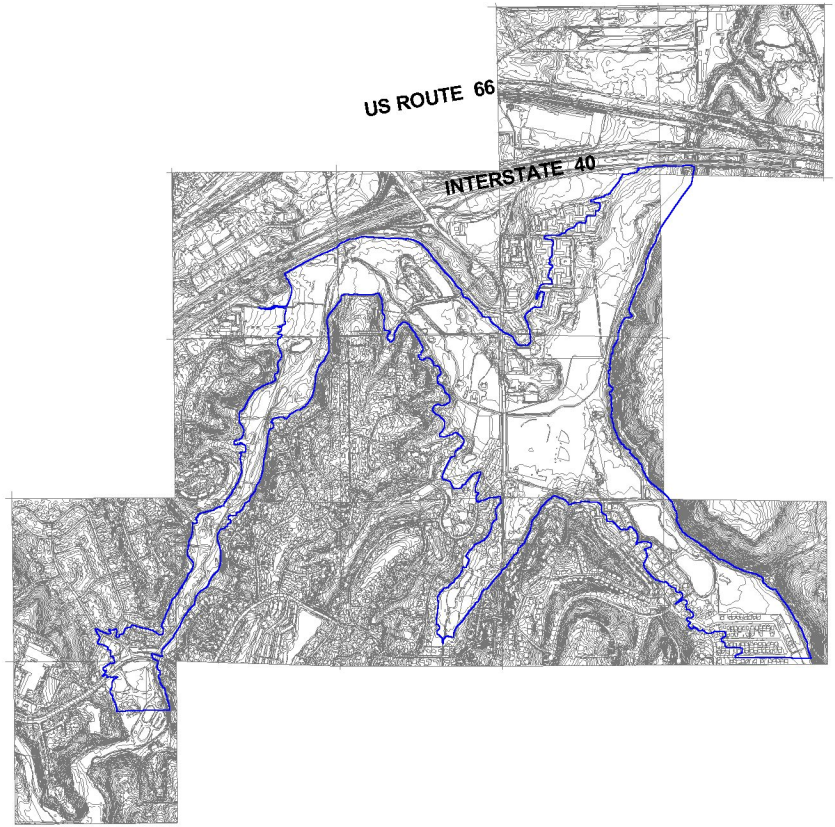
CITY OF FLAGSTAFF
ARIZONA

400 0 400 800 1200 1600 Feet

1:18000

October 15, 1999

C:\PROJECTS\RIODF\con_flood.apr - W Project Continental FP 2053



GENERAL INVESTIGATION
FLOOD DAMAGE REDUCTION
FOR RIO DE FLAG
FLAGSTAFF, ARIZONA

2053 FLOODPLAIN

With-Project Conditions
500 Year
Continental Area

LEGEND

500 Year Floodplain (Year 2053)

U.S. ARMY CORPS OF ENGINEERS
Los Angeles District
South Pacific Division

CITY OF FLAGSTAFF
ARIZONA

400 0 400 800 1200 Feet

1:18000

October 15, 1999

Figure 6.3 With-Project Floodplain - Continental Area

Thorpe Park

The Thorpe Park area, shown on **Figures 6.4** and **6.5**, would not be utilized for major flood control features, however, some structures would be constructed on the southern and eastern boundaries of the park. Existing recreational facilities in Thorpe Park will remain and the duck pond will be preserved and enhanced. The key components (details shown on **Figure 6.12**) at Thorpe Park are as follows:

Floodwalls

A series of floodwalls would be constructed along the eastern edge of Thorpe Park. These floodwalls are necessary to ensure that floodflows do not overtop the eastern edge of Thorpe Park and cause flooding to the homes along Navajo Drive as well as breaking out to the east and south, and causing damages to other downstream areas. The walls would be constructed approximately 3 feet west of the property lines of Flagstaff Junior High School and 14 residential properties that front North Navajo Drive. The exact locations of these property lines as well as any existing utility easements will be surveyed and resolved during the design phase. Floodwalls adjacent to the residential properties would gradually increase in height until reaching Thorpe Road at a height of five feet or less. During the PED phase, a combination of earthen berms and floodwalls will be investigated further. Aesthetic treatments of local rock fascia would be incorporated into the design, and uniform fencing provided as necessary between Beale Road and the Junior High School. The cost of the floodwalls has been estimated at approximately $440,000, of which $40,000 is for the aesthetic treatments. Appropriate plantings of native trees and other vegetation would be included to offset the removal of any vegetation that would be necessary to construct the floodwalls/berms. The design of the footings for these floodwalls will ensure that no negative impacts will occur to the groundwater wells in the area. Interior drainage features would also be investigated during the PED phase. Options would be evaluated on a lot-by-lot basis for any drainage on the land-side of the floodwalls/berms that becomes ponded. It is expected that if ponding occurred, it would only be within a foot of the floodwalls/berms. Depending on the location, drainage could be either graded to the street, allowed to infiltrate through gravel subdrains, or drained into the basin with a 4"-6" pipe that is fitted with a one-way flow valve.

North Thorpe Road Modification

In order to minimize flooding of North Thorpe Road and adjacent property, an approximately 350-foot section of the road would be rebuilt at a higher elevation. This would require the use of retaining walls up to 5 feet in height along the side of the elevated road. North Thorpe Road would be closed for two weeks while pavement is removed, fill added, and the road repaved. This road closure would also occur during the summer to avoid access impacts to the nearby school. The existing culvert at the Rio de Flag crossing under Thorpe Road would be replaced.

Embankment/Wingwalls

Small embankment/wingwalls would be constructed immediately south (downstream) of the existing weir at Frances Short Pond. At the outlet location, the embankment/wingwalls would have a height of approximately 4 feet, as measured from the base of the downstream side. The embankment/wingwalls would serve to direct flows into the existing channel downstream. They would be aesthetically treated with a local rock fascia and blend in with the surrounding environment.

Rio de Flag Channel Modifications

The channel modifications to the Rio de Flag are designed to convey the discharges from the Thorpe Park detention facility and significantly reduce flooding in the downtown area. The modifications utilize the exiting channel to the maximum extent, with some widening and deepening required to reach the appropriate size. The proposed channel modifications are shown on **Figures 6.6**, **6.7**, and **6.8**, and described in more detail below. Maintenance access roads would parallel the majority of open channel segments.

Beginning at Bonito Street just downstream of the Thorpe Park embankment/wingwalls, there would be a trapezoidal channel with a earth or excavated rock bottom and 2:1 rip-rap lined slopes. (Slopes are described in terms of horizontal to vertical [H:V] ratios; accordingly, a 2:1 side slope will extend 2 feet horizontally from the channel bottom for every 1 foot of vertical rise.) This segment would have a channel bottom width of approximately 24 feet and depth of approximately 7.9 feet. The rip-rap would be covered with soil and either sodded with grass or planted with other groundcover. The City of Flagstaff would be responsible for ongoing maintenance of this vegetation once it becomes established. This segment of riprap-lined channel would extend from Bonito Street to just upstream of Dale Avenue.

Just upstream of Dale Avenue, the trapezoidal channel would transition into a covered channel arch section. As discussed in the previous chapter, a covered channel offers savings in real estate costs compared to an open, trapezoidal section through this more-constrained portion of the channel. This arch would be 24 feet wide and 9 feet deep, and the top of the arch would be at grade. The area over the arch would be filled in and a recreational trail put over the top. The area would be revegetated with native grasses and shrubs, and trees in selected locations. This arch would continue downstream until ending just south of Birch Street. Between Cherry and Birch, Kendrick Street would remain in place.

Beginning at Birch Street and continuing to Route 66, there would be a trapezoidal channel with a earth or excavated rock bottom and 2:1 riprap lined slopes. This segment would have a channel bottom width of approximately 24 feet and depth of approximately 7.9 feet. The riprap would be covered with soil and either sodded with grass or planted with other groundcover, and would look similar to the existing channel that runs along the edge of Wheeler Park and the City Hall. The existing channel is currently about 32 feet wide at the top and about 8 feet deep, whereas the proposed channel will be approximately 56 feet wide at the top.

At the Route 66 crossing, two underground culverts would be constructed: (1) a 24-foot by 9-foot concrete arch for drainage conveyance, and (2) a parallel 12-foot by 8-foot arch for bicycle/pedestrian access (which would be a continuation of the Flagstaff Urban Trail System [FUTS] trail) - see **Figure 6.12, Detail I-5**. The portion of the project south of Route 66 would entail the construction of a new channel and adjacent recreational trail. The first segment of this new channel would curve into an east/southeast heading, forming an alignment parallel to and south of the railroad tracks. This channel segment would be similar to, but slightly larger than, the rip-rap lined channel described above, with a depth of approximately 8.2 feet. The rip-rap lined channel and recreation trail would extend from just south of Route 66 to a point approximately 170 feet west of South Beaver Street.

At approximately 170 feet west of South Beaver Street, the Rio de Flag channel would be joined by an underground (covered) concrete channel conveying flows from Clay Avenue Wash. Both channels would converge and transition into an arch-shaped underground concrete channel that would parallel the railroad tracks through downtown. The underground channel would be approximately 28 feet wide at the base and approximately 12 feet tall at its center. This section of underground channel would extend east/southeast through downtown Flagstaff for approximately 1,900 feet. At a point approximately 250 feet south/southeast of the North Elden Street/Route 66 interchange, the underground concrete channel would transition into an open greenbelt channel. The term "greenbelt" is used because this section of Rio de Flag would include several features favoring the establishment of vegetation in and along the channel, including a 56-foot wide channel bottom and shallow 4:1 (H:V) side slopes. Additionally, the channel would not be lined with rip-rap or concrete. This segment would extend east and south from the underground channel, joining an existing remnant section of the historic Rio de Flag channel approximately 1,700 feet upstream of Butler Avenue.

Gabion or alternative grade control structures would be constructed approximately 150 feet and 400 feet upstream of Butler Avenue. These two structures would reduce the elevation of the channel by roughly 12.5 feet over a distance of approximately 250 feet. The channel flows would proceed under Butler Avenue through a 24-foot wide by 8.5-foot high concrete arch that would replace the existing culverts. Wingwalls would be constructed near the entrance to direct flows into the arch.

Fencing will be effectively integrated into existing development and are needed (such as along residential properties) for safety. Vehicular barriers will be provided where a rip-rap lined channel is located along a street, and pedestrian barriers will be placed where warranted.

Warning signs would be posted at major access points (such as gates) and periodic maintenance inspections and police patrols for vagrants/campers would be implemented along the modified channel.

Clay Avenue Wash Detention Basin

This detention basin, shown on **Figures 6.9** and **6.10**, would be located along the Clay Avenue Wash to the west/southwest of downtown Flagstaff, just west of the city limits and north of Route 66. The proposed site consists of primarily privately-owned land including a rural residence and its associated agricultural buildings.

The Clay Avenue Wash detention basin was designed to convey a detained 100-year event through a 48-inch culvert without overtopping the main embankment. Flows in excess of this design flow would be conveyed over the face of the concrete covered main abutment through a two-stage concrete weir. The weir would have a 330-foot long lower section at an elevation of 7,065.6 feet and a cumulative length of 293 feet in two sections at an elevation of 7,068 feet. The spillway has been designed superimposed upon a full detention basin. At the base of the face of the embankment would be 24-inch rock riprap, six feet thick to dissipate energy.

The bottom six feet of the detention basin would not drain via the outlet. Locating the main outlet at the bottom of the basin would pose a risk of pipe sedimentation, and adversely affect the hydraulic performance of the outlet. A small bleed off pipe may be required to fully drain the structure in a reasonable period of time. The requirements for such a pipe would be determined during the PED phase of the project.

The northeast and southeast embankments are required to contain flow within the basin and have been designed to withstand water impounded during spillway flow. These two embankments are regulatory impoundments and therefore have embankment elevations of three feet above the spillway design elevation. The spillway design elevation is the water surface elevation required to pass 2.5 times a 500-year event over the designed spillway of 7,069.3 feet. The top of the regulatory embankments is three feet above this elevation, at elevation of 7,072.3 feet.

Grading and site work would consist of three embankments tied into high ground, with the site's natural topography serving to contain detained flood flows within the basin. Each of these embankments are described below. The capacity of the Clay Avenue Wash detention basin would be approximately 295 acre-feet. When filled to capacity, water contained within the basin would cover approximately 71 acres. The basin would be sized to completely drain within 48 to 60 hours for the 100-year event, 36 hours for the 50-year event, and less than 24 hours for other more frequent events.

Northeast Embankment

The embankment constructed at the northeast edge of the detention basin would contain the outlet structure and spillway. The outlet structure would consist of a single 42-inch diameter corrugated metal pipe, with a capacity of approximately of up to 165 cfs. In addition, a smaller "bleed off" pipe or irrigation gate valve would be installed at the channel invert to eliminate long-term ponding. The spillway would be at an elevation of 7,065.6 feet above mean seal level. Below the spillway a colorized concrete apron will protect the embankment from erosion from spillway flows. The top of the embankment would be approximately 21 feet above ground level. **Figure 6.12** shows cross sections of the proposed Clay Avenue Wash detention basin embankments.

Northwest Embankment

An embankment would be constructed just south of the Burlington Northern and Santa Fe (BNSF) railroad tracks along the northern boundary of the detention basin. The embankment is for the purpose of preventing ponded waters from coming up against the railroad track embankment.

Southeast Embankment

This embankment would be adjacent to the Hidden Hollow Mobile Home park, and it would be specifically constructed to protect the mobile home park from flooding. This embankment would not contain an outlet structure or spillway, and it would be approximately 12 feet tall at its highest point. It would extend approximately 475 feet along the northern edge and 500 feet along the western edge of the mobile home park.

Clay Avenue Wash Channel Modifications

The Clay Avenue Wash channel modifications would generally entail either (1) expanding and lining the existing channel with concrete or rip-rap, or (2) diverting the channel underground through developed areas. The channel modifications are described below and illustrated on **Figure 6.11.**

The Clay Avenue Wash channel modifications would start immediately north of the Chateau Royal mobile home park (also referred to as the Chateau Royal Apartments) in western Flagstaff. This segment of the channel would be modified into a trapezoidal channel with a earth or excavated rock bottom and 2:1 (H:V) rip-rap side slopes. Three grade control structures would be located in the first 500 feet of the rip-rap lined channel. This rip-rap lined segment of the Clay Avenue Wash channel would extend east to Blackbird Roost. The eastern section of this channel segment would traverse the mobile home park at 703 South Blackbird Roost, and it would require the relocation of up to 15 mobile homes from this park to an offsite location. The affected tenants and landlord of the mobile home park may be compensated for this action in accordance with applicable Federal and state laws, including the Federal Uniform Relocation Assistance and Real Property Acquisition Policies Act of 1970, as amended (42 U.S.C. §4601 (1996)). However, this section of channel will be reassessed during the PED phase to determine if a covered channel and/or revised alignment in this reach would be more feasible to avoid these relocation costs.

From Blackbird Roost east to the edge of the parking lot at McCracken Place, Clay Avenue Wash would be diverted into an arch-shaped underground concrete channel. This segment of the wash currently follows a cul-de-sac and driveway which extend east from Blackbird Roost into an adjacent apartment building complex. The underground concrete channel would be approximately 24 feet wide at the base and approximately 5.5 feet tall at its center.

The covered underground channel would open up into an uncovered concrete-lined box channel at the eastern edge of the McCracken Place parking lot. This segment of box channel would be approximately 18 feet wide and 8.3 feet deep. The open box concrete channel would extend east (downstream) to South Milton Road/Route 66. Aesthetic treatments may be provided as appropriate during further detailed design.

Downstream from South Milton Road/Route 66, Clay Avenue Wash would transition back to a covered, underground concrete channel. This underground channel would be similar to the one constructed east of Blackbird Roost. The underground channel would generally follow the alignment of the street "Mike's Pike." terminating approximately 250 feet northeast of Mike's Pike at a confluence with the Rio de Flag channel. This route would require construction within the intersection of Clay Avenue, South Milton Road/Route 66, and Mike's Pike.

The Clay Avenue Wash channel modifications would be completed within the overall 15-month schedule described for the Rio de Flag channel modifications. Construction would result in the

temporary (approximately 1 week) closure of Chateau Drive, Blackbird Roost, and Malpais Lane, respectively. Only short segments of these roads would be closed during the construction of the underground culvert. Along Mike's Pike, trenching would occupy nearly the full width of the road. Construction would occur in a series of segments that progress along Mike's Pike, with approximately 350 feet of trench open at any given time. The arched underground channel would be constructed by pouring concrete into a form built with the trench and backfilling the trench as soon as the concrete sets. Approximately 50 feet of concrete channel would be poured per day with a 7 day cycle of excavation, forming, pouring, curing, and backfill. The underground channel would be constructed in sections, as to maintain access during the 6 weeks construction process. Detours would be required and would change daily; however, access would be maintained to all businesses and residences during the construction period.

[This page left intentionally blank.]

VALUE ENGINEERING PAYS

SAFETY PAYS

SYMBOL	DESCRIPTIONS	DATE	APPROVAL
	REVISIONS		

RIO DE FLAG FLOOD CONTROL
FLAGSTAFF, ARIZONA
PLAN
RIO DE FLAG

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

DESIGNED BY: RAB
DRAWN BY: CRT,RAB
CHECKED BY: RAB,RLS
APPROVED: DATE:
CHIEF, ENGINEERING DIVISION
CADD FILE NAME: PLAN9.dwg

SUBMITTED BY: DATE:
CHIEF, DESIGN BRANCH

PREPARED UNDER THE DIRECTION OF:
JOHN P. CARROLL
COL, CORPS OF ENGINEERS
L.A. DISTRICT COMMANDER

SPEC. NO.
DISTRICT FILE NO.

SIMONS, LI & ASSOCIATES, INC.

SHEET 9 OF 16 SHEETS

VALUE ENGINEERING PAYS

SEE SHEET 9

SEE SHEET 6

LEGEND

Ineffective Flow Boundary

X — Cross Section Location For Determining Adjustment to Roughness Coefficient

X.XXX — Cross Section River Milepost

LEVEE
15' ACCESS ROAD
PROJECT
PARCEL BOUNDARY

SECTION 4
24'X9' CONCRETE ARCH CULVERT

TYPICAL SECTIONS
SEE PROFILE FOR "d" and "D"

SECTION 5
RIP RAP CHANNEL
D50=6"

GRAPHIC SCALE
100 0 50 100 200
(IN FEET)

Contour Interval = 2 Feet
Mapped by the City of Flagstaff
Topography from aerial photographs taken 1988-1996

SAFETY PAYS

SYMBOL	DESCRIPTIONS	DATE	APPROVAL
	REVISIONS		

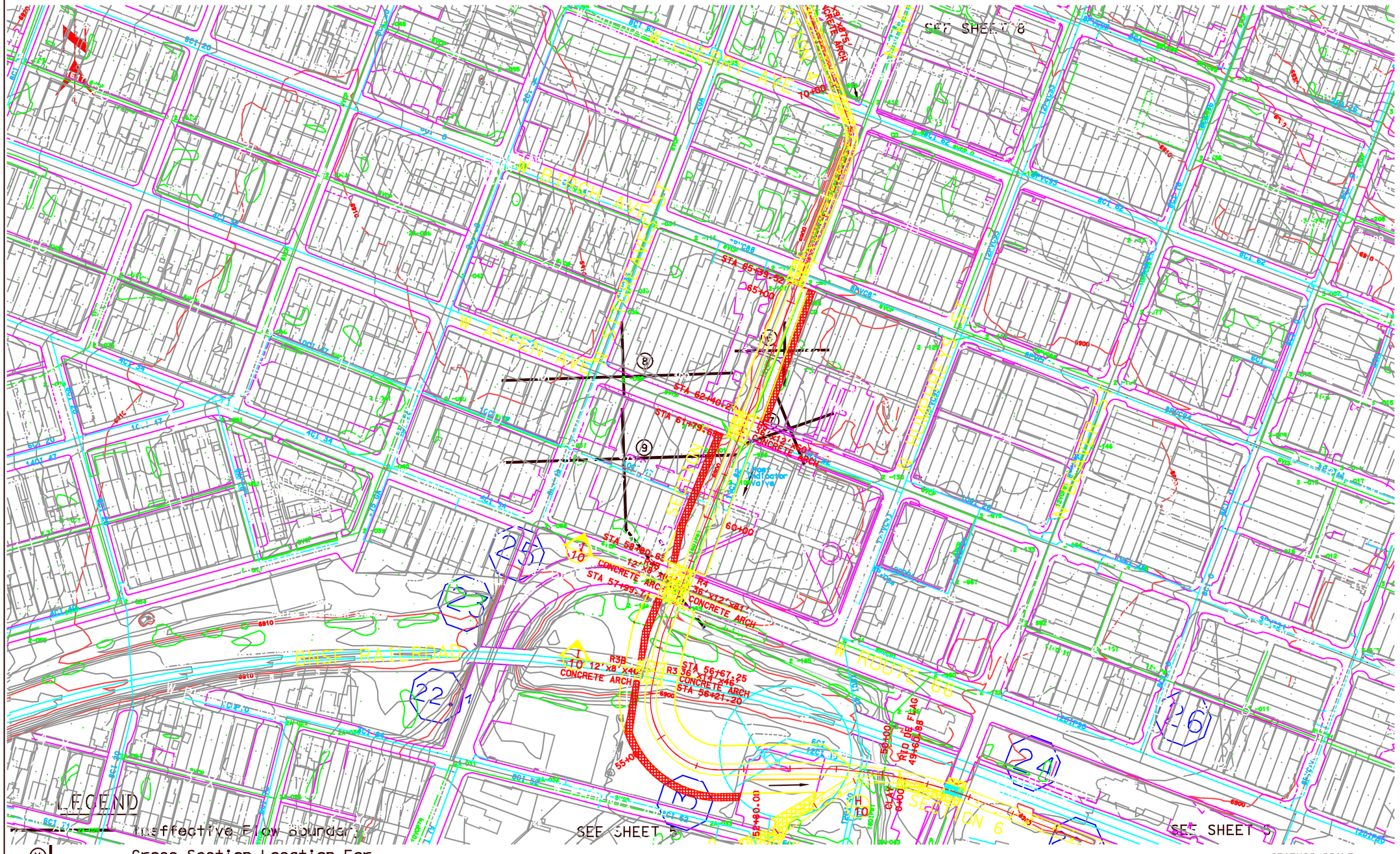
RIO DE FLAG FLOOD CONTROL
FLAGSTAFF, ARIZONA
PLAN
RIO DE FLAG

U.S. ARMY ENGINEER DISTRICT, LOS ANGELES
CORPS OF ENGINEERS
DESIGNED BY: DATE: DRAWN BY: CHECKED BY: APPROVED: DATE:
SUBMITTED BY: DATE: CHIEF, DESIGN BRANCH
CHIEF, ENGINEERING DIVISION
CADD FILE NAME: PLAN8.dwg
SPEC. NO.

PREPARED UNDER THE DIRECTION OF:
JOHN P. CARROLL
COL., CORPS OF ENGINEERS
L.A. DISTRICT COMMANDER
DISTRICT FILE NO.

SHEET 8 OF 16 SHEETS

VALUE ENGINEERING PAYS



LEGEND

Ineffective Flow Boundary

X.XXX Cross Section Location For Determining Adjustment to Roughness Coefficient

Cross Section Location

River Milepost

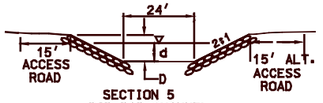
PARCEL BOUNDARY

LEGEND

15' ACCESS ROAD

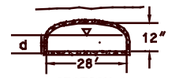
PROJECT

SECTION 4
24'X9' CONCRETE ARCH CULVERT



SECTION 5
RIP RAP CHANNEL
D_{50} =6"

TYPICAL SECTIONS
SEE PROFILE FOR "d" AND "D"



SECTION 6
28'X12' CONCRETE ARCH CULVERT

GRAPHIC SCALE

100 0 50 100 200

(IN FEET)

Contour Interval = 2 Feet
Mapped by the City of Flagstaff
Topography from aerial photographs taken 1988-1996

SAFETY PAYS

SYMBOL	DESCRIPTIONS	DATE	APPROVAL
	REVISIONS		

C:\FAZ\CDE41\PLANTIES\P1at5.dwg

RIO DE FLAG FLOOD CONTROL
FLAGSTAFF, ARIZONA
PLAN
RIO DE FLAG CHANNELIZATION

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

DESIGNED BY: RAB | DRAWN BY: GRT.-RAB | CHECKED BY: RAB.-RLS | DATE:
SUBMITTED BY: | DATE: | APPROVED: | CHIEF, ENGINEERING DIV'S10
CADD FILE NAME: PLAN6.dwg

U.S. ARMY ENGINEER DISTRICT
CHIEF, DESIGN BRANCH
SPEC. NO.

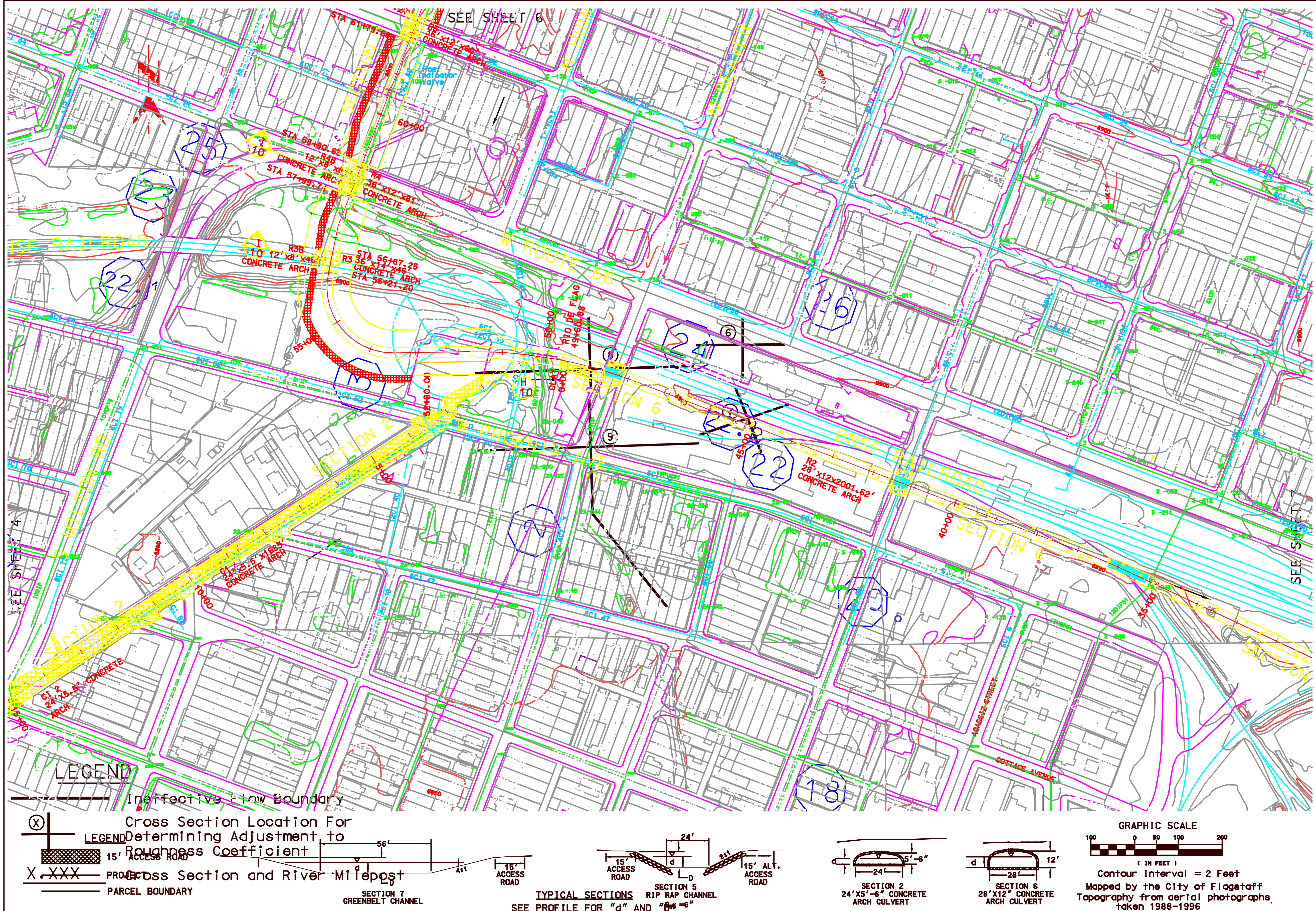
PREPARED UNDER THE DIRECTION OF:
JOHN P. CARROLL
COL., CORPS OF ENGINEERS
DISTRICT ENGINEER

DISTRICT FILE NO.

SHEET 6 OF 16 SHEETS

© THOMAS & Dib ASSOCIATES & INC.

VALUE ENGINEERING PAYS



SAFETY PAYS

RIO DE FLAG FLOOD CONTROL
FLAGSTAFF, ARIZONA
PLAN
RIO DE FLAG-CLAY AVENUE WASH CHANNELIZATION

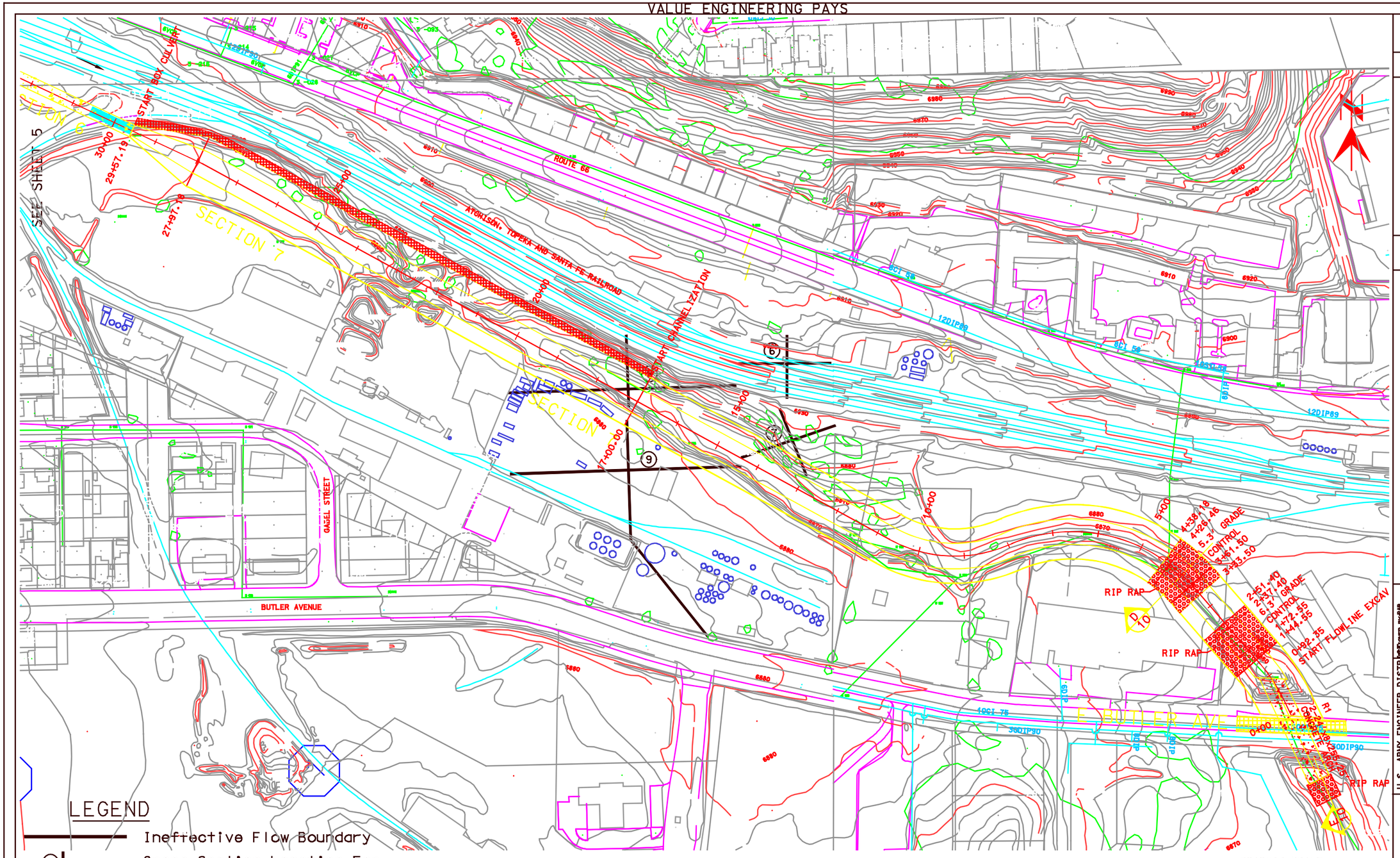
U.S. ARMY ENGINEER DISTRICT
LOS ANGELES
CORPS OF ENGINEERS

PREPARED UNDER THE DIRECTION OF:
JOHN P. CARROLL
COL., CORPS OF ENGINEERS

REVISIONS

SHEET 5 OF 16 SHEETS

VALUE ENGINEERING PAYS



LEGEND

Ineffective Flow Boundary

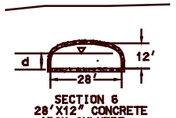
Cross Section Location For Determining Adjustment to Roughness Coefficient

X.XXX Cross Section and River Milepost

PROJECT LIMITS

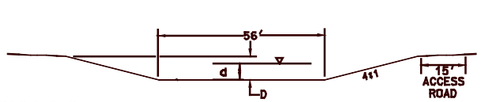
ACCESS ROAD

PARCEL BOUNDARY



SECTION 6
28'X12" CONCRETE
ARCH CULVERT

TYPICAL SECTIONS
SEE PROFILES FOR "d" AND "D"



SECTION 7
GREENBELT CHANNEL

GRAPHIC SCALE

100 0 50 100 200

(IN FEET)

Contour Interval = 2 Feet

Mapped by the City of Flagstaff

Topography from aerial photographs taken 1988-1996

REVISIONS

SYMBOL	DESCRIPTIONS	DATE	APPROVAL

RIO DE FLAG FLOOD CONTROL
FLAGSTAFF, ARIZONA
PLAN

RIO DE FLAG CHANNELIZATION

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

DESIGNED BY: DRAWN BY: CHECKED BY: SUBMITTED BY: APPROVED: DATE:

CHIEF, ENGINEERING DIVISION

CADD FILE NAME: PLAN7.dwg

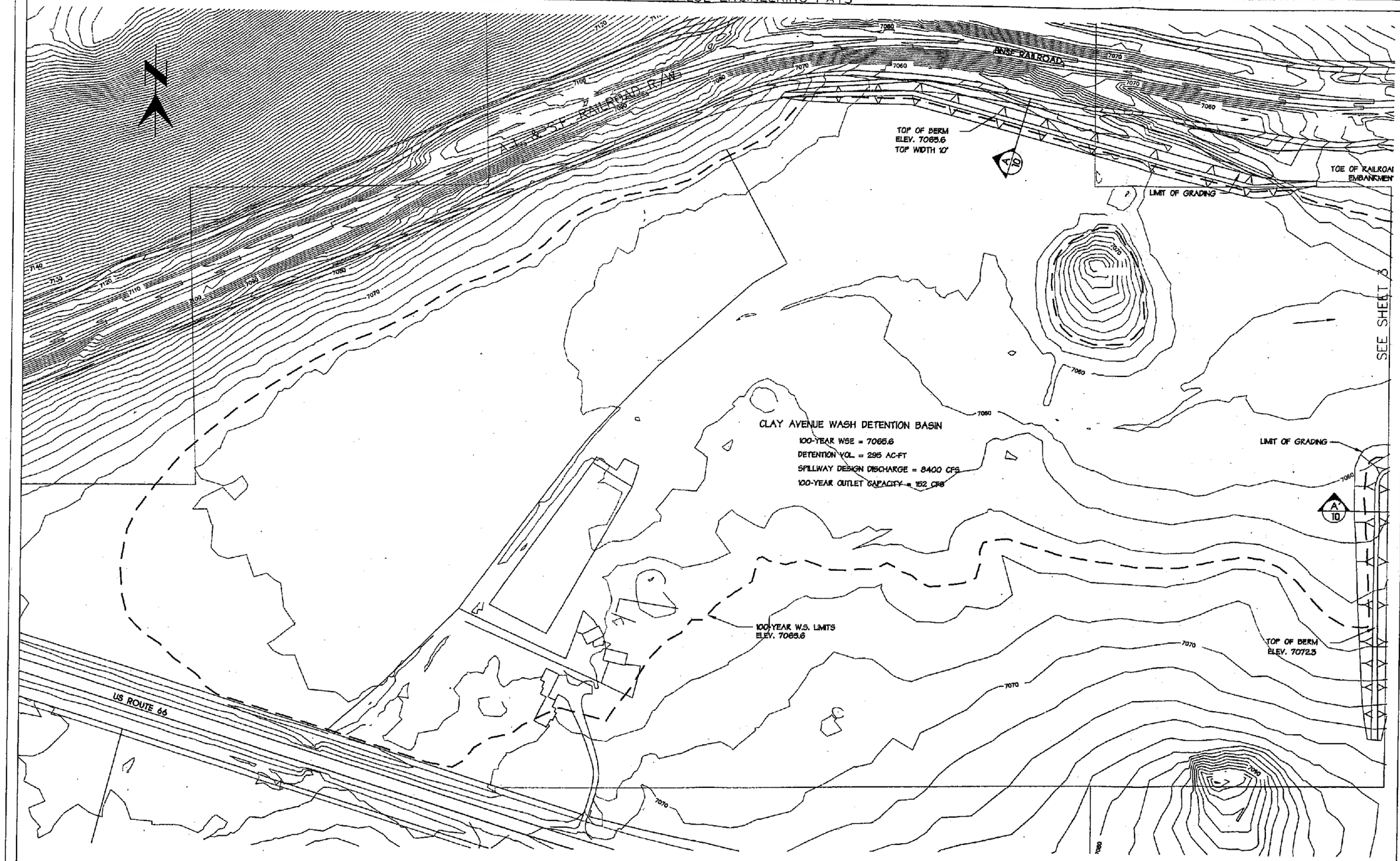
SPEC. NO.

PREPARED UNDER THE DIRECTION OF:
JOHN P. CARROLL
COL., CORPS OF ENGINEERS
DISTRICT ENGINEER

SHEET 7 OF 16 SHEETS

SAFETY PAYS

VALUE ENGINEERING PAYS



LEGEND

PROJECT

PARCEL BOUNDARY

GRAPHIC SCALE

100 0 50 100 200

(IN FEET)

Contour Interval = 2 Feet

Mapped by the City of Flagstaff
Topography from aerial photographs
taken 1988–1996

SYMBOL	DESCRIPTIONS REVISIONS	DATE	APPROVAL

RIO DE FLAG FLOOD CONTROL
FLAGSTAFF, ARIZONA
PLAN
CLAY AVENUE WASH DETENTION BASIN

DESIGNED BY: RAM
DRAWN BY: CRT/RAB
CHECKED BY: RAB/JRS

CADD FILE NAME: PLAN2.dwg

SPEC. NO.

Shaws, Li & Associates, Inc.

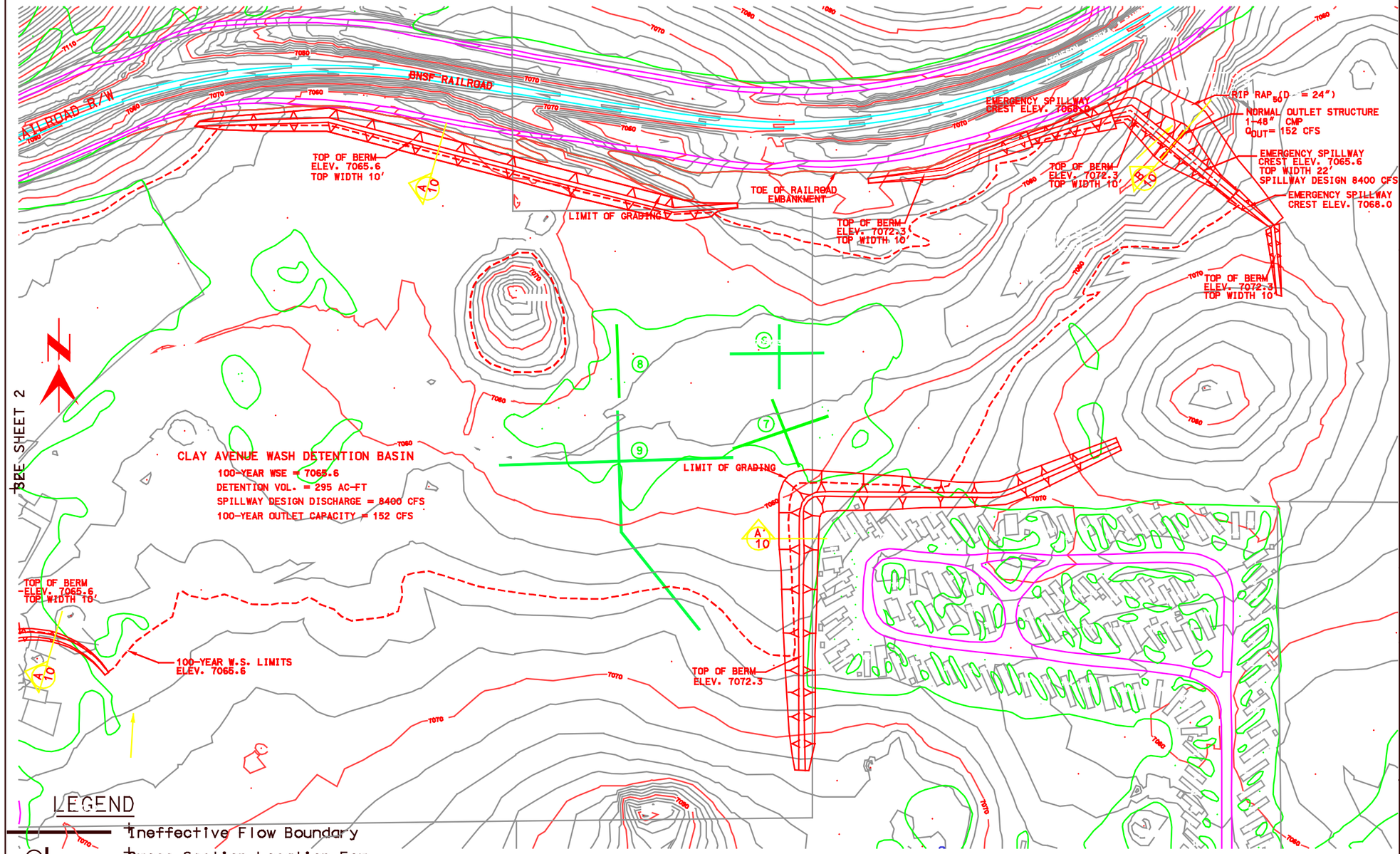
JOHN P. CARROLL
COL., CORPS OF ENGINEERS L.A. DISTRICT COMMANDER

DISTRICT FILE NO.

SHEET 2 OF 16 SHEETS

SAFETY PAYS

VALUE ENGINEERING PAYS



RIO DE FLAG FLOOD CONTROL
FLAGSTAFF, ARIZONA
PLAN
CLAY AVENUE WASH DEETENTION BASIN

SYMBOL	DESCRIPTIONS	DATE	APPROVAL
	REVISIONS		

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

PREPARED UNDER THE DIRECTION OF:
JOHN P. CARROLL
CHIEF, ENGINEERING DIVISION

SUBMITTED BY: DATE:
APPROVED: DATE:
CHIEF, ENGINEERING DIVISION

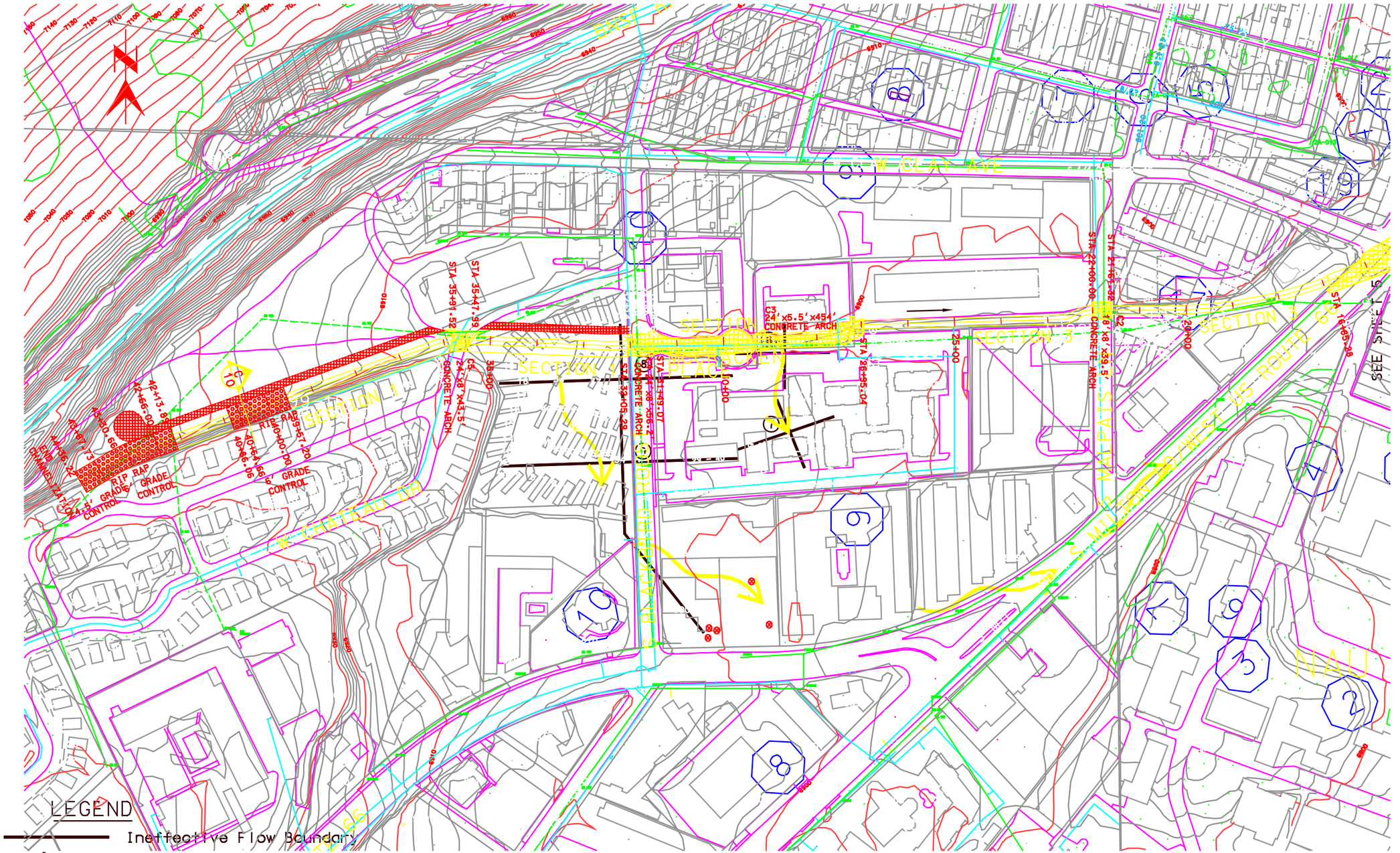
DESIGNED BY:
DRAWN BY:
CHECKED BY:
CADD FILE NAME:

SPEC. NO.
DISTRICT FILE NO.

SHEET 3 OF 16 SHEETS

SAFETY PAYS

VALUE ENGINEERING PAYS



LEGEND

Ineffective Flow Boundary

Cross Section Location For Determining Adjustment to Roughness Coefficient

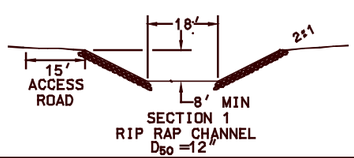
X.XXX Cross Section and River Milepost

GRAVEL ACCESS ROAD

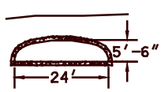
PROJECT

PARCEL BOUNDARY

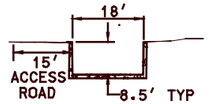
TYPICAL SECTIONS



SECTION 1
RIP RAP CHANNEL
D_{50} =12"



SECTION 2
24'X5'-6" CONCRETE ARCH CULVERT



SECTION 3
OPEN CONCRETE CHANNEL

GRAPHIC SCALE

100 0 50 100 200

(IN FEET)

Contour Interval = 2 Feet

Mapped by the City of Flagstaff

Topography from aerial photographs taken 1988-1996

REVISIONS

SYMBOL	DESCRIPTIONS	DATE	APPROVAL

RIO DE FLAG FLOOD CONTROL
FLAGSTAFF, ARIZONA

PLAN

CLAY AVENUE WASH CHANNELIZATION

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

DESIGNED BY&AB | DRAWN BY: CRT-RAB | CHECKED BY:RAB-RLS | DATE:
SUBMITTED BY: | DATE: | APPROVED: | CHIEF, ENGINEERING DIV:SIGN
CADD FILE NAME:Plan4.dwg

PREPARED UNDER THE DIRECTION OF:
JOHN P. CARROLL
COL., CORPS OF ENGINEERS
L.A. DISTRICT COMMANDER
CHIEF, DESIGN BRANCH

SPEC. NO.

DISTRICT FILE NO.

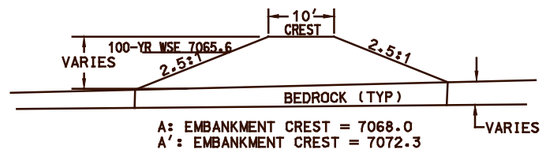
SHEET 4 OF 16 SHEETS

SAFETY PAYS

D50 =24"		D50 =18"	
% PASSING		% PASSING	
100-90	48"	100-90	36"
85-70	36"	85-70	27"
50-30	24"	50-30	18"
15-5	16"	15-5	12"
5-0	8"	5-0	6"

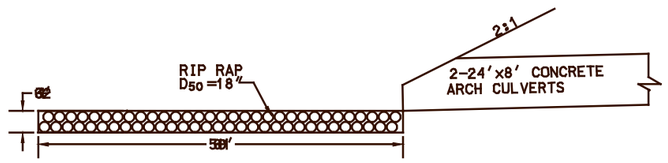
D50 =12"		D50 =6"	
% PASSING		% PASSING	
100-90	24"	100-90	12"
85-70	18"	85-70	9"
50-30	12"	50-30	6"
15-5	8"	15-5	4"
5-0	4"	5-0	2"

RIPRAP GRADIATION SPECIFICATIONS

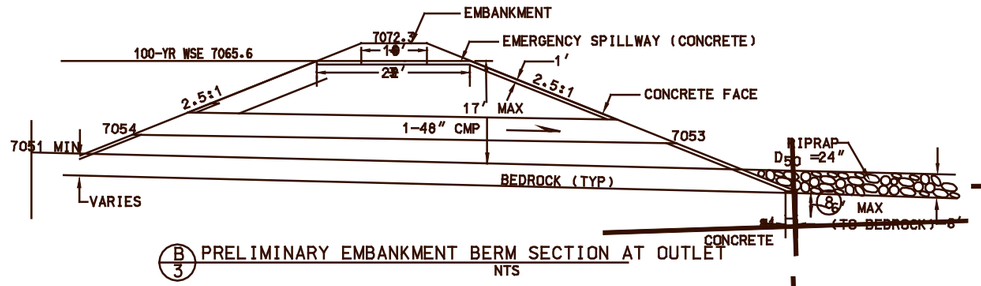


A: EMBANKMENT CREST = 7068.0
A': EMBANKMENT CREST = 7072.3

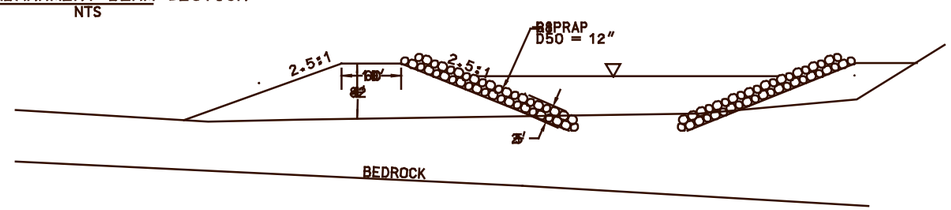
A/2 A/2 A'/3 A/3 PRELIMINARY SOUTHEAST EMBANKMENT BERM SECTION
NTS



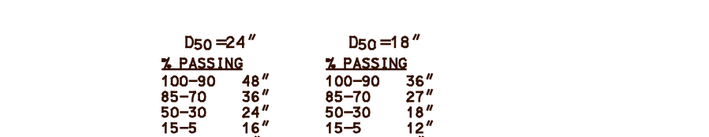
E/7 EAST BUTLER AVENUE CULVERT OUTLET
NTS



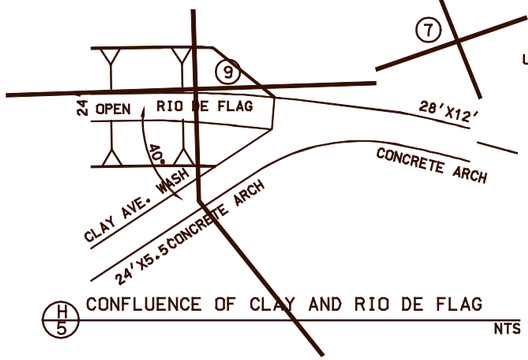
B/3 PRELIMINARY EMBANKMENT BERM SECTION AT OUTLET
NTS



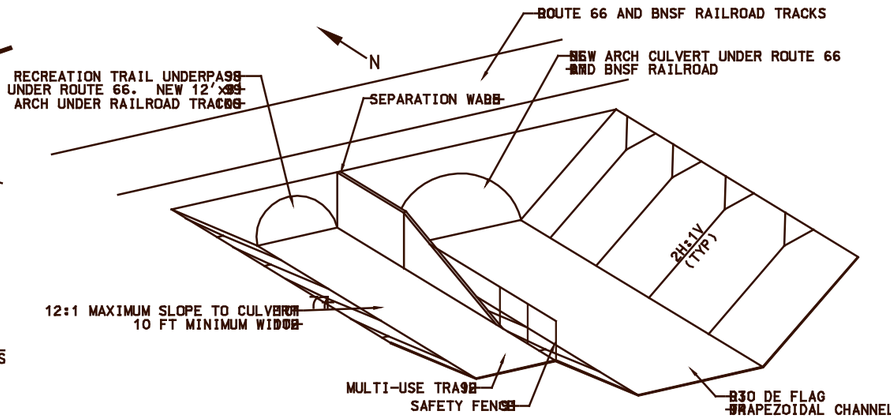
F/8 PRELIMINARY THORPE PARK WING DIKE SECTION
NTS



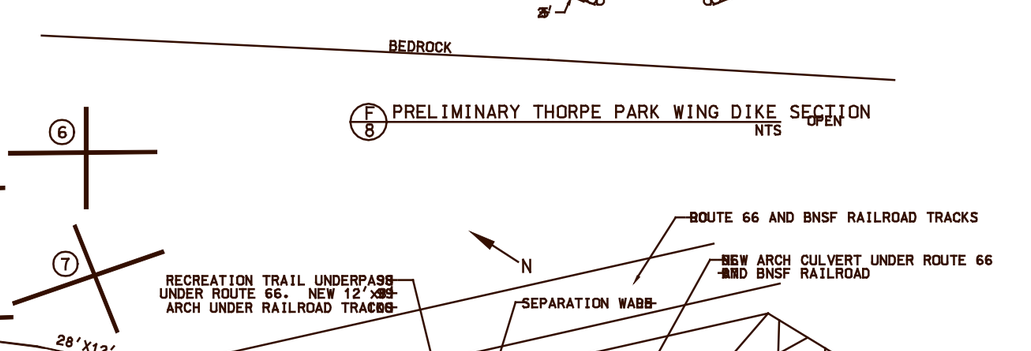
C/4 CLAY AVENUE WASH GRADE CONTROL STRUCTURE SECTION
EXTEND RIP RAP TO BEDROCK
STA 39+57.20 - 40+86.06
STA 42+13.89 - 44+36.22
NTS



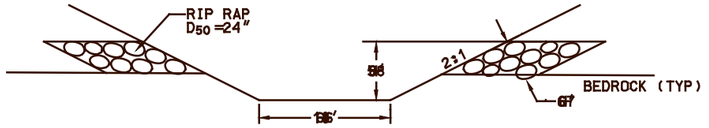
H/5 CONFLUENCE OF CLAY AND RIO DE FLAG
NTS



I/5 I/6 BELOW GRADE CROSSING - ISOMETRIC VIEW
HWY 66 AND BNSF RR NTS



I/5 I/6 BELOW GRADE CROSSING
HWY 66 AND BNSF RR NTS



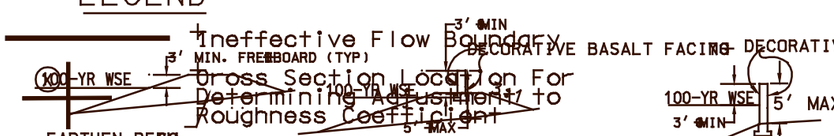
D/7 RIO DE FLAG GRADE CONTROL STRUCTURE SECTION
STA 1+44.55 - 2+51.40
STA 3+33.50 - 4+38.18
NTS

LEGEND

Ineffective Flow Boundary

Cross Section Location For Determining Adjustment to Roughness Coefficient

X.XXX Cross Section and River Milepost



G/8 TYPICAL FLOODWALL SECTIONS
NTS

NOTE:
DETAILS FOR ADDITION OF ADOT STANDARD B-04.20 AND B-04.40 WINGWALLS TO NEW BRIDGES AT N. BEAL ROAD AND W. ANDERSON ROAD AND TO THE EXISTING DRAINAGE STRUCTURE AT W. MEADE LANE ARE NOT PROVIDED.
45° STANDARD B-04.20 WINGWALLS SERVE AS TRANSITION BETWEEN CONCRETE ARCH CULVERTS AND RIPRAP CHANNELS.

SAFETY PAYS

REVISIONS

SYMBOL	DESCRIPTIONS	DATE	APPROVAL

RIO DE FLAG FLOOD CONTROL
FLAGSTAFF, ARIZONA

DETAILS

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

DESIGNED BY:
DRAWN BY:
CHECKED BY:
SUBMITTED BY:
APPROVED:
CHIEF, ENGINEERING DIVISION
CHIEF, DESIGN BRANCH
CHIEF, DESIGN SECTION
DATE:
CADD FILE NAME: SHEET10.dwg

PREPARED UNDER THE DIRECTION OF:
JOHN P. CARROLL
COL., CORPS OF ENGINEERS
DISTRICT ENGINEER
THOMAS H. SAGE, P.E.
DISTRICT FILE NO.

SHEET
10 OF 16
SHEETS

Discussion of Covered Channels

It was determined that covered channels would be required for certain sections of the Rio de Flag project due to cost savings, rights-of-way constraints, and access issues. Covered channels were therefore evaluated due to their ability to meet planning objectives and contribute to National Economic Development. The project alignment would require covered channels in four primary locations: under an existing street right-of-way (Mike's Pike), under the cul-de-sac at McCracken Place, along Rio de Flag downstream of Thorpe Park, and along the railroad tracks. In all cases a covered channel is less costly than an open channel due primarily to real estate considerations. The project is located in a densely developed and highly urbanized area. Covered channels involve acquisition of easements, whereas an open channel configuration necessitate a permanent loss of usable property, which requires higher compensation. The covered channels are the NED plan for the proposed reaches. A discussion and cost comparison and the results of the NED eligibility evaluation follow.

Under Existing Street Rights -of-Way (Mike's Pike)

Due to the highly urbanized nature of Flagstaff, Mike's Pike was determined to be the most cost effective alignment to place a channel to convey Clay Avenue Wash flows to the Rio de Flag. The alignment is the shortest, resulting in the least construction cost, and since it is under an existing street impacting no adjacent properties, real estate costs are eliminated. The proposed channel would be placed under the existing roadway, allowing for the preservation of the buildings and businesses along the street. Alternative channel alignments would have resulted in costly right-of-way acquisition and the destruction of homes and businesses, many of which have historical significance.

Under the Cul-de-Sac at McCracken Place

This covered channel would be constructed along Clay Avenue Wash from Blackbird Roost east to the edge of the parking lot at McCracken Place. This segment of the wash currently follows a cul-de-sac and driveway which extend east from Blackbird Roost into an adjacent apartment building complex. The covered channel in this location is more economically efficient due to the constrained real estate available within the apartment complex parking lot. Further, an open channel would create the need for at least two bridges to replace the ingress and egress currently provided by the driveway.

Along Rio de Flag Downstream of Thorpe Park

It was determined that the arch culvert section that extends from the intersection of Sitgreaves Street and West Dale Avenue downstream to West Birch Avenue provides the most cost effective channel improvements due to real estate constraints. As was indicated by **Table 5.5**, *"Cost and Benefit Summary - Alternatives 6A, 6B, and 7,"* the difference between an open trapezoidal channel and an arch culvert section through this reach is approximately $1,300,000.

Along the Railroad Tracks

The alternative plans involve rerouting Rio de Flag into its historic alignment, generally along the south side of the BNSF railroad tracks. The construction of a channel large enough to contain the combined flows from Rio de Flag and Clay Avenue Wash in this area presented many constraints. The properties in this segment of the project are some of the highest value commercial property in Flagstaff. Fee title for an open channel configuration is approximately $12 per square foot, whereas an appropriate easement would be approximately $2 per square foot. The area also has several railroad spurs and road crossings over the proposed channel alignment requiring either several bridges or a significant length of covered channel even if an open channel were possible in this reach. These factors led to a detailed analysis of covered versus open channel options in this reach.

Channel Configurations along the Railroad

Four channel types were investigated: two types of open channel and two types of covered channel. The open channels investigated were earthen-bottom with rip-rap side-slopes and concrete channels with vertical walls. The earthen bottom channel was generally less expensive to construct than the concrete channel, but required more rights-of way due to the sloping sides. . The types of covered channels examined included traditional box culverts, and Con-Arch culverts. Con-Arch is a reinforced concrete buried arch system that has been used extensively in Arizona, Nevada, and southeastern California by private developers and public works agencies.

The primary benefit of the covered channels along Mike's Pike and the railroad was the reduced real estate required. The covered channel does not require a maintenance road, or the fee purchase of the land through which it passes. Because the land above the culvert is still available to be used by the landowner, only an easement is required.

Detailed cost estimates showed that a covered channel was more cost effective than the best open channel alternative due primarily to the reduced right-of way requirements. Additional construction cost savings were also obtained due to the unique design of the Arch culverts.

The Arch Culvert

The Arch system's arches are formed with stock reusable steel forms, over which a steel reinforcing mat is placed. Structural shotcrete is then applied. The forms can be removed quickly due to the strength of the arch geometry, and backfilling with light construction equipment then takes place. The process involves much less time than typically required for box culvert construction in which the excavation can remain open for anywhere from 7 to 28 days. For this reason, traffic detours during construction can sometimes be avoided or reduced. Because Con-Arch is a cast-in-place system, a great deal of design flexibility is available. Skewed ends, radius sections, and drop or side inlets are all easily accommodated in a Con-Arch system.

Since the arch is a very efficient shape for a culvert, significant cost savings can be realized by replacing conventional reinforced concrete box culverts with arch culverts. The Con-Arch system can span up to 48' in standard form sections. This allows multiple cell box culverts to be reduced to fewer cells with a comparable Con-Arch culvert. The result is a reduction in cost and an improvement in the efficiency of the hydraulic performance. Cost savings can range from 10% to 20% or more over competitive construction technologies. The flat invert in the Con-Arch system can also provide a maintenance advantage compared to multiple pipe culverts.

In addition, the flat slope in the areas in which the covered channels are proposed will also require a significant amount of excavation to achieve enough grade to convey flow. By placing a covered channel in this area, it is not required to protect this increased distance from the invert to the top of bank. This represents another significant material savings.

Due to the efficiencies in the design and construction of the Con-Arch culvert, plus savings in real estate that would otherwise be required with an open channel design, significant cost savings were achieved compared with the use of an open channel configuration. For the reach along the railroad tracks for the Con-Arch channel, the construction plus real estate costs along the Rio de Flag is approximately $4.8 million. A comparable concrete open channel with vertical sides would cost approximately $5.2 million primarily due to an increase in real estate costs. A trapezoidal rip rap channel, by comparison, would have a lower construction cost but require even more real estate due to the wider channel section necessary. Covered channels, whether they be Con-Arch or covered rectangular box channels, result in lower overall costs for construction plus real estate. A cost comparison of the channel options investigated, as shown in

Table 6.1, shows that the arch design covered channel as proposed for the selected plan for the proposed reach is the NED plan due to least cost.

Table 6.1 Channel Options Cost Comparison

	Construction	Real Estate	Total
Open Channel - Trapezoidal	$2,300,000	$2,902,000	$5,202,000
Open Channel - Rectangular	$4,100,000	$1,090,000	$5,190,000
Covered Channel - Rectangular	$5,100,000	$118,000	$5,218,000
Covered Channel - Arch	$4,700,000	$118,000	$4,818,000

Engineering Considerations of Covered Channels

In accordance with Corps of Engineers regulation ER 1165-2-118, the following discussion of the Engineering considerations of the proposed covered channel reaches for the project is provided.

Submerged Channel Entrance : The covered channels proposed in the selected plan are sized to convey the 100-year design discharge. Flows in excess of the design discharge would overtop the channel and flow into the surrounding streets. The residual, with-project, overflow maps presented as **Figures 6.2 and 6.3** show the results of the 500-year event on the selected plan. These residual discharges and associated damages are included in the with-project economic evaluation. Residual flood depths are significantly lower than under the without-project condition, and consist primarily of street flooding when the covered channel entrance is submerged.

Danger of Rupture from Pressurization : The proposed channel is a reinforced concrete structure more than adequate to resist typical forces from pressurization. Detailed design during PED will include an analysis of pressure flow forces.

Features to Prevent Human Ingress : Recent experience with grates or other types of barriers which are placed at inlet/outlet points of covered channels has indicated that the placement of such features may create liability in the event that such features fail, for whatever reason (such as vandalism), to perform that intended function; also such features could become traps for people who have managed to breach the barrier. In addition, such grates often are utilized as trash racks or debris collectors. In the case of the Rio de Flag project, the function as a trash rack or debris collector is unnecessary since the size of the covered channels is more than adequate to convey the expected debris. To address safety concerns, fencing and other types of barriers will be constructed along the open channels leading into and out of the covered channels, as well as in all other reaches, to limit or prevent public access to the channels themselves. Additional vehicular barriers and pedestrian barriers will be placed as warranted to limit or prevent public access to the channels. The City of Flagstaff will continue to conduct their public safety and education program consisting of public information notices, school programs, warning signs, periodic maintenance inspections, and police patrols for vagrants/campers within the channels and covered portions of the channels. These types of channel access limitations, methods, and procedures are as effective as physical grates with less associated liability.

Effect of Cover on Inspection and Maintenance Costs : Large access ports would be located in streets for access to the covered channels. The covered channels are relatively large, permitting equipment to be lowered down if necessary. However, as discussed, no significant build up of debris is anticipated within the covered portion of the channels. The effect of providing cover over the channel is insignificant in terms of increased inspection and maintenance costs.

Features Provided for Pressure Release and Venting : Although the structure will be designed to withstand any hydrostatic pressures associated with flow in excess of the design flow, additional safety features (e.g., venting) will be employed as deemed appropriate during PED.

Need for a Flood Warning System : A flood warning system was evaluated as part of the plan formulation process and eliminated from additional consideration as a project feature. It was determined that a flood warning system would not result in a significant change in either lead times or preparatory behaviors, and therefore, would not affect associated damage reductions.

Facilities Provided to Divert Flows Exceeding the Design Flow : No additional facilities are provided for this purpose since flows exceeding the design flow would not result in significant flood damages and residual flooding would be less than would occur under the without-project condition as shown by the 500-year residual overflow maps, **Figure 6.2** and **6.3**. Localized flooding and ponding would occur, and streets would be flooded. These areas would eventually be drained (within 12 hours) under the with-project condition by local drainage and stormwater facilities.

Project Performance

Table 6.2 shows that for the Recommended Plan, there is less than a one percent chance that the capacity of the reaches along the upper Rio de Flag except the most upstream reach will be exceeded. This table also shows that all reaches except two along Clay Avenue Wash have an annual exceedance probability of less than one percent. One of these two reaches C1A, is located upstream of the proposed channel improvements. The other, C2S, is the split flow reach.

Furthermore, as shown on the table, the long-term risk over the 50-year period of analysis ranges from less than one percent to about 20 percent for the improved reaches along the Upper Rio de Flag (R2 - R9). The long-term risk over ten years for these reaches ranges from less than one percent to nearly 4.5 percent. Additional evaluation of project performance may be performed, as necessary, after detailed project design is completed during the Preconstruction Engineering and Design phase following approval of this feasibility study report.

Table 6.2 Risk and Uncertainty - Future Conditions (2052)

	Risk & Uncertainty Results -- Alternative 6B Future Conditions (205 2)										
	Target Stage Exp. Annual Exceedance Probability		Long-Term Risk			Conditional Non -Exceedance Probability by Event					
	Alt 6B	Without Proj.	10 Yrs	25 Yrs	50 Yrs	10%	4%	2%	1.0%	0.4%	0.2%
Upper Rio de Flg											
R1	3.7%	3.7%	31.4%	61.1%	84.8%	95%	68%	31%	13.0%	2.0%	0.6%
R2	0.1%	18.0%	0.1%	0.3%	0.6%	100%	100%	100%	99.9%	99.2%	98.4%
R5	0.5%	29.8%	4.5%	10.9%	20.6%	100%	100%	98%	91.1%	58.1%	34.4%
R6E	0.4%	58.1%	3.7%	9.0%	17.1%	100%	100%	98%	92.3%	68.0%	49.0%
R7	0.1%	18.9%	1.0%	2.4%	4.8%	100%	100%	95%	85.8%	64.7%	49.3%
R8N	0.1%	25.8%	1.5%	3.6%	7.2%	100%	100%	100%	99.9%	90.8%	53.7%
R8S	0.1%	7.2%	0.4%	1.1%	2.1%	100%	100%	100%	99.9%	97.2%	82.7%
R9	0.1%	3.4%	0.1%	0.3%	0.7%	100%	100%	100%	99.9%	99.9%	99.2%
Clay Avenue Wash											
C1A	2.7%	4.8%	24.0%	49.7%	74.7%	98%	83%	35%	29.0%	17.0%	11.2%
C1B	0.5%	5.0%	5.2%	12.5%	23.5%	100%	100%	94%	64.8%	62.5%	60.9%
C1C	0.4%	3.3%	3.9%	9.5%	18.1%	100%	100%	96%	73.2%	70.3%	68.3%
CW	0.4%	3.2%	3.7%	8.9%	16.0%	100%	98%	94%	86.2%	71.1%	61.3%
CWS	0.1%	5.1%	0.5%	1.3%	2.6%	100%	100%	100%	99.8%	99.8%	99.8%
C1	0.1%	9.1%	0.1%	0.3%	0.6%	100%	100%	100%	99.9%	99.9%	99.9%
C2N	0.1%	25.0%	0.8%	2.0%	4.0%	100%	100%	98%	97.7%	97.6%	97.6%
C2S	1.1%	53.5%	9.9%	23.0%	40.7%	100%	100%	98%	52.0%	3.5%	0.3%
C3N	0.3%	33.0%	2.9%	7.0%	13.6%	100%	100%	100%	100.0%	84.6%	24.6%
C3S	0.2%	9.7%	1.6%	4.0%	7.8%	100%	100%	100%	100.0%	95.4%	62.5%
Historical Channe											
H1	0.1%	2.3%	0.1%	0.3%	0.5%	100%	100%	100%	99.9%	99.9%	99.3%
H2	0.1%	9.7%	0.1%	0.3%	0.5%	100%	100%	100%	99.9%	99.9%	99.3%
Lower Rio de Fla;											
RL1	3.8%	3.5%	32.2%	62.2%	85.7%	98%	55%	31%	20.9%	9.3%	5.2%
RL3	5.2%	4.7%	41.3%	73.7%	93.1%	96%	31%	15%	9.6%	4.3%	2.5%
RL4	9.4%	6.8%	62.6%	91.5%	99.3%	69%	6%	2%	1.2%	0.5%	0.3%

C. Benefits

The Recommended Plan provides average annual NED benefits attributable to flood control in the amount of $2,387,000. The Recommended plan additionally provides average annual recreation benefits in the amount of $65,450.

D. Summarized Cost Estimate

Appendix E, Cost Estimates, provides a detailed cost estimate for the selected plan based upon the Corps of Engineers MCACES-level cost estimates. The total first cost of the flood control component of the Recommended Plan is $23,598,000 which includes mitigation costs. The total first cost of the recreation component is $474,000. Total project costs are estimated to be $24,072,000. There are no requested betterments or other associated non-Federal costs. The Total project cost will be cost shared in accordance with Corps regulations. **Table 6.3** shows the cost estimate summary.

Table 6.3 Recommended Plan - Summary Cost Estimate

Item	Cost
Construction Cost*	$13,444,607
Contingency	$2,688,921
PED/EDC	$1,854,000
S&A	$873,899
Real Estate**	$4,737,000
Total First Cost	**$23,598,428**
Recreation	$474,000
Total Cost	**$24,072,428**

* Includes $177,300 in Environmental Mitigation Costs

** Includes credits of $14,000 in addition to the REP (Appendix G)

Including the additional advanced bridge replacement benefits (see **Appendix F, Economics** for details) the Recommended Plan has net NED benefits of $594,000, and a benefit/cost ratio of 1.33

E. Maintenance Considerations

The detention basin would be designed and constructed to operate with minimal operational requirements. That is, based on the design, the basin would detain peak flows and then discharge them over a period of up to 60 hours without human intervention (e.g., opening or closing valves and spillway gates). Periodic inspection, maintenance, and repair would be conducted by the City of Flagstaff. The level of effort required to inspect, maintain, and repair the detention basin would not be extensive and would include tasks such as ensuring that the embankments do not erode following storms and removing debris and sediment buildup in the outlet structures.

The channel modifications would require additional inspection, maintenance, and repair. These scope of these activities would be expanded to include the modified sections of the Rio de Flag and Clay Avenue Wash channels. Additionally, the City of Flagstaff would need to implement a long-term public information program regarding the hazards associated with drainages, especially the previously described covered concrete channels.

F. Associated Non-Federal Considerations

There are no specific identified associated non-Federal features required for the Recommended Plan.

G. Recreation Plan

This section presents the plan for development of recreation features along a portion of the Rio de Flag that conforms with and reflects the requirements of the City of Flagstaff and the U.S. Army Corps of Engineers (Corps), as a component of the Rio de Flag Feasibility Study. This plan will accommodate the needs of the local population while remaining compatible with the flood control purpose of the Rio de Flag channel improvements.

Through the Flagstaff 2020 visioning process, the people of the greater Flagstaff area expressed their desire to direct the development of their community. In particular, they expressed a desire to orient neighborhoods to pedestrians and bicycles by expanding the Flagstaff Urban Trails System (FUTS). There was also interest in overcoming the barriers to non-automobile travel created by Route 66 and the Burlington, Northern & Santa Fe Railroad (BNSFRR) by providing links to downtown with Northern Arizona University (NAU) and the Southside neighborhood.

The proposed trail will help accomplish both of these goals by linking segments of the FUTS and providing safe, below-grade crossings of Route 66 and the BNSFRR. The resulting trail system will provide a complete FUTS link from Observatory Mesa in the west, across town to the Mount Elden Conference Grounds in the east.

Route 66 and the Burlington, Northern, and Santa Fe Railroad (BNSFRR) bisect the southern half of the project area. The proposed trail will cross Cherry Avenue, Birch Avenue, Aspen Avenue, Beaver Street, and San Francisco Street. It will be accessible at all these points. Additionally, the proposed trail will be located on the west side of Wheeler Park.

The recreation component of the recommended plan is located in downtown Flagstaff. Existing land uses in the project vicinity are primarily residential mixed with commercial and some city services. The proposed trail begins in a residential area and continues through an area occupied by the City Hall and the Flagstaff Public Library. Once under Route 66 and the railroad, the proposed trail continues through an area that is currently used by the railroad, but is transitioning to commercial/light industrial uses.

The Recreation Plan:

- Addresses the need for recreation facilities in the project area,
- Addresses the potential for recreation development of project lands, and
- Evaluates the economic feasibility of recreation development.

Recreation Plan Objectives:

- Provide recreation opportunities for the general public that will meet expressed needs of local and regional users;
- Develop recreation facilities and resources that will complement, and not conflict with, the primary project purpose of flood control;
- Provide a trail along the channel that will link existing segments of the Flagstaff Urban Trails System (FUTS); and
- Protect and enhance aesthetic qualities of the project area by incorporating landscaping and aesthetic design features.

Due to lack of space, recreation trail uses will be restricted to one side of the channel. The trail will also serve as an operation and maintenance (O&M) road. Observation of other trails with similar dual functions indicates that there should be no significant conflict.

Physical Plan for Recreation Development

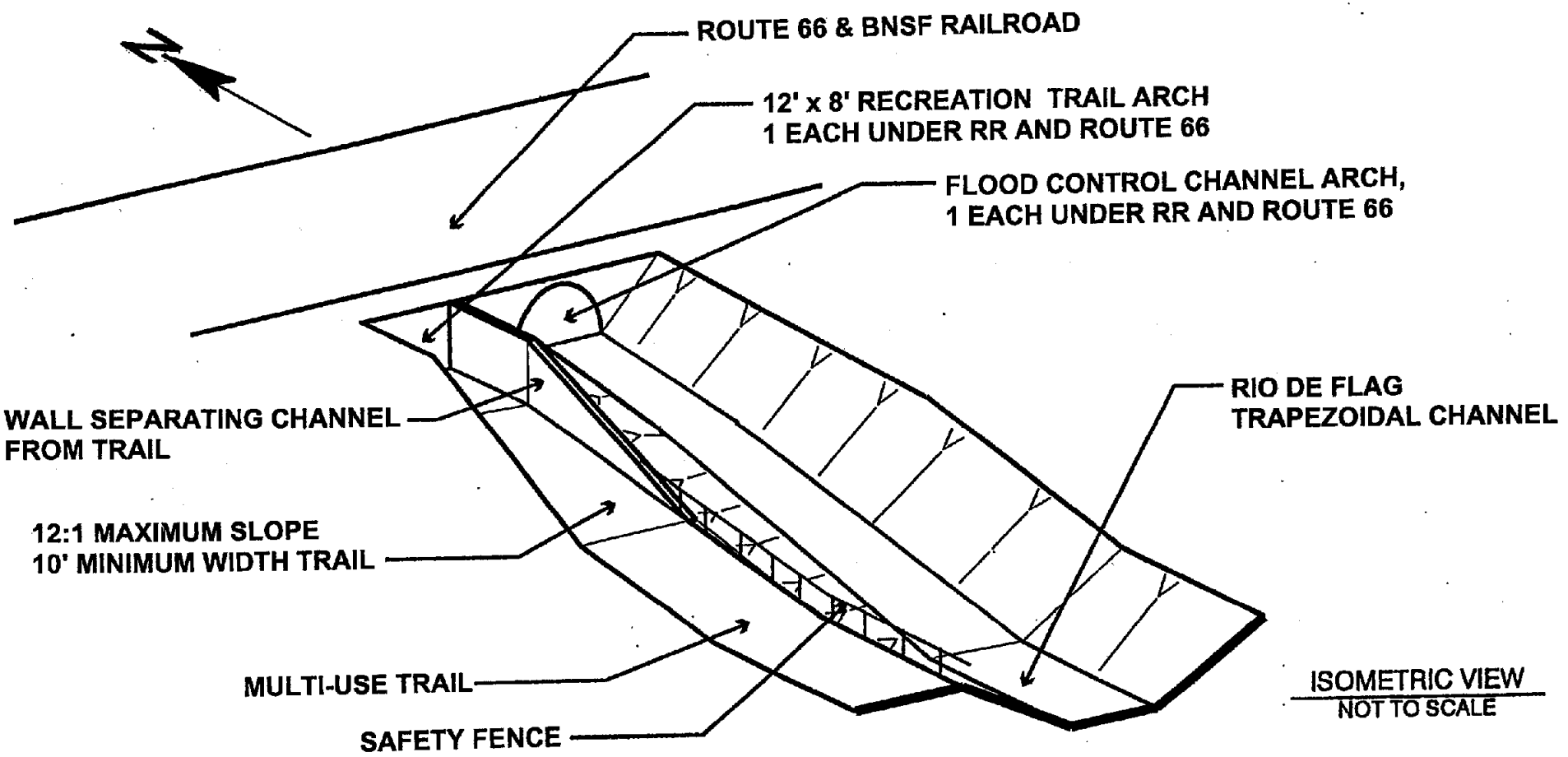
Multi-Use Trail

The Flagstaff Vision 2020 report has identified the Rio de Flag as an important area for development of recreation features that link FUTS and provide for neighborhood uses. The proposed multi-use trail will support bicycle, pedestrian, and related uses. The trail expansion will link existing segments of the FUTS, including those currently separated by Route 66 and the BNSF Railroad. The result will allow trail travel from Observatory Mesa to the west across town to the Mount Elden Conference Grounds to the east. The trail will use the maintenance access road in its travel along the Rio de Flag channel. Interpretive and directional signs will be provided along the proposed trail. Interpretive signs will present information on the unique historical features and biological habitats of the area.

Bicycle Underpass

Below-grade crossings for recreation users will be required in two places: under Route 66 and under the BNSFRR tracks. Below grade crossings are required due to high traffic volumes on both Route 66 and the railroad, making at-grade crossings impractical and potentially unsafe. The trail will descend adjacent to the channel improvements to pass under Route 66 and the railroad through a new arch culvert under each thoroughfare (see **Figure 6.13**). Due to the closeness of Route 66 and the railroad, the trail will be connected between these two crossings. The ramps into and out of the channel must be a minimum of 10 feet wide with a slope not to exceed 12:1. At-grade crossings for the trail will be used at other roads. It is not expected that traffic volume on these roads will increase to a point precluding at-grade crossings**.**

RECREATION TRAIL UNDERPASS SCHEMATIC



SEE PLAN SHEETS 5, 6, AND 10, DESIGN APPENDIX, FOR ADDITIONAL DETAILS. THESE SHEETS ARE SHOWN AS FIGURES 6.6, 6.9, AND 6.10 IN THE FEASIBILITY REPORT

RIO DE FLAG
FLAGSTAFF, ARIZONA

FIGURE 6.13
RECREATION TRAIL
UNDERPASS

Interpretive Elements

The Rio de Flag trail will travel through several areas of environmental significance. Interpretive elements may be used to inform and educate visitors about plant and animal species, habitat preservation and restoration, historic uses of the stream, and other cultural resources. Information about the river's early role as a transportation mode, in agricultural irrigation and mill works, and as a food source may also be offered. The interpretive elements may include small signs with graphics or photographs and brief written narratives.

The Rio de Flag trail will also travel through several areas of historic/cultural prominence in the City of Flagstaff. Historic Downtown Flagstaff is the most prominent historic/cultural site, along with the Spanish/Basque settlement area. Several small local streets from these areas bisect the proposed trail and offer opportunities for bicyclists or pedestrians to leave the trail and enter the historic districts. Signs at key areas would inform the user of the important early links between these settlements and the river.

All interpretive signage should use natural materials as much as possible. Entry signs at trail entrances or exits should be made of materials consistent with those used in other parts of the FUTS. All signage should be uniform in size and shape and be displayed for easy observation by both bicyclists and pedestrians.

Aesthetic Treatments

The Rio de Flag trail improvements will connect to the existing river trail at Birch Avenue and continue to San Francisco Street. The existing trail is eight (8) feet wide and composed of a treated gravel surface. The trail composition will remain consistent throughout the project site, except at areas where the trail is part of an existing or proposed roadway or where it travels under existing structures (such as Route 66 or the railroad). Trail surfaces at these locations will be consistent with the existing improvements. Excess graded areas along the trail should be revegetated with species consistent with the habitat mitigation measures used downstream of the railroad tracks.

There are several areas of sufficient size along the trail to allow opportunities for additional facilities such as a drinking fountain or bench. Interpretive or scenic overlooks are encouraged at wide spots along the trail. Clearing an area along the trail may develop the opportunity for an interpretive viewing area. These areas/interpretive nodes may be appropriate for interpretive signage describing wildlife habitats or other significant features in the area. Additional amenities such as protective fencing, seating, trash receptacles and drinking fountains may also be included.

Fencing Requirements

Fencing and safety rails will be utilized along the river trail to define the trail boundary and restrict public access to particular areas. Fencing will be necessary between the channel and the edge of the trail. Treated wood posts with safety chains or coated steel wire may utilized. Overlook areas will require tubular steel or wood 'split-rail' fencing. Utility fencing should be unobtrusive and blend into the surrounding landscape. If chain link is needed to protect areas, plant material may be used to screen it. Any color coating of materials will be done with colors that are compatible with the surrounding environment. All fencing or safety rails will meet ADA requirements and City of Flagstaff development standards.

Planting

All planting installed under the recreation plan will occur upstream of the railroad tracks. Planting of downstream sections is covered under the mitigation requirements. Landscape plantings should be used to add shade, variety, and interest to the trail. Plantings should also be used as a screen to block undesirable views and enhance trail entrances and interpretive areas.

Irrigation will be required for plant establishment. After plant establishment, irrigation may be necessary to maintain healthy and attractive plantings.

The mix density and types of vegetation will be determined in consultation with the Flagstaff Arboretum.

Participation Rates for Multi-use Trail

The City of Flagstaff does not currently collect usage data on the FUTS, therefor usage information was determined by application of information from a similar project. Usage data was taken from the Rillito River Park, Tucson Arizona. This park is a multi-use bike path along the Rillito River. It is located adjacent to residential areas for much of the length where the usage data was collected. It connects neighborhood parks and has links to on-street bicycle routes. Hence, the Rillito project is very similar to the proposed project for the Rio de Flag since it incorporates similar features (connecting existing trail systems) in a comparable environmental setting. Therefore, per capita usage rates for the proposed trail improvements are expected to be similar to those applied in the Rillito study. Based upon the per capita usage rates applied in the Rillito study and the differences in the relative study area populations, the proposed improvements at Rio de Flag are projected to result in an additional 11,729 annual user days.

Bicycling/walking is defined as general recreation and 47 points have been allocated to the proposed trail. General Recreation Points and conversion of points to dollars were determined per *ER 1105-2-100, Chapter 6, Section VII, Tables 6 -28 and 6-29*.

Annual Recreation Value:	11,729 [user days] x $5.58	= $	65,450
Net Annual Benefit:	$66,450 - $0	= $	65,450

(w/project condition – w/o project condition)

Recreation Plan Costs

The costs for the Rio de Flag Recreation Plan are detailed in **Table 6.4**.

Table 6.4 Rio De Flag Recreation Plan

	Cost
Estimated Construction Cost	$336,250
Contingency (20%)	$67,250
PED/EDC[1]	$48,026
S&A[2]	$21,856
LERRDs[3]	$0
Sub-Total Construction	**$473,382**
Interest During Construction[4]	$3,800
Gross Investment	**$477,182**
Average Annual Cost (50 yrs, 6.625%)	$32,946
Annual O&M	$1,000
Total Average Annual Cost	$33,946
Average Annual Benefits	$65,450
Net Benefits	$31,504
Benefit/Cost Ratio	1.93

[1] Planning, Engineering & Design/Engineering During Construction
[2] Supervision and Administration
[3] Lands, Easements, Rights-of-way, Relocations, and Disposal costs
[4] Three-month Construction Period

Corps policy specifies that the level of financial participation in recreation development by the Corps at an otherwise justifiable project may not increase the Federal cost of the project by more than ten percent. The total first cost for the selected flood control project is about $23,584,000. The total first cost of the Recreation plan is about $474,000 which amounts to two percent.

The Recreation plan for the Rio de Flag Flood Control Project falls within the ten percent requirement and in addition is incrementally justified as required by regulation. Recreation costs

are cost shared on a 50%/50% basis between the Corps and the non-Federal sponsor. Fifty percent of the first cost of the recreation plan is $237,000 which would increase the level of Federal financial participation by about one percent.

The recreation analysis is presented in Recreation Appendix of the **EIS**. This appendix includes the recreation demand and visitation analysis, description of the formulated recreation features and a summary of the estimated recreation costs. Additional evaluation of the recreation plan is presented in the **Appendix F, Economics**.

H. Mitigation

ER 1105-2-100 requires that District commanders ensure that project-caused adverse impacts to fish and wildlife resources be avoided or minimized to the extent practicable and that remaining unavoidable impacts be compensated to the extent justified. The following mitigation plan has been developed for the Rio de Flag Feasibility Study to comply with this regulation. As specified in the regulation, both the recommended plan and the NED plan must contain sufficient mitigation to ensure that either plan selected will not have more than negligible adverse impacts on fish and wildlife resources. Since, for the Rio de Flag Feasibility study, the recommended plan and the NED plan are one in the same, only one evaluation is contained herein (from this point on only the NED plan will be referred to although "NED plan" and "recommended plan" are synonymous).

The formulation of mitigation measures for the Rio de Flag Feasibility Study involved a series of steps to evaluate the biological effects (beneficial and adverse) resulting from the implementation and maintenance of the NED plan. The basis for the evaluation was a modified functional habitat assessment of the Rio de Flag and Clay Avenue Wash throughout the project area. The modified approach is based on the framework of the Corps of Engineers Hydro-Geomorphic Method (HGM) for wetland functional assessment (Smith et al. 1995). In general, engineering designs and project footprint maps were used in conjunction with results of hydraulic modeling, the Rio de Flag Fish and Wildlife Coordination Act Report, and site visits to estimate direct impacts from the NED plan.

Biological Impact Mitigation

Significant Mitigable Impact

Significant project impacts were identified by estimating the net loss of wetlands (in acres) resulting from the construction and maintenance of the Rio de Flag Flood Control Project. Engineering drawings depicting the project footprint along with temporary construction easements, right-of-ways, ingress/egress points, construction duration, and maintenance requirements were used to estimate the areal extent of impacts resulting from implementation of the NED Plan.

The NED plan as determined during the Feasibility Study is Alternative 6B. This alternative would provide increased flood protection along the Rio de Flag's Downtown Reach and would also reduce flooding along the Clay Avenue Wash. This alternative would include the Clay Avenue Wash detention basin in addition to channel modifications on Clay Avenue Wash and the Rio de Flag.

Significant mitigable impacts to biological resources from the implementation of the NED plan are summarized in the following paragraphs.

Rio de Flag Channel Modifications : Under the NED Plan, modifications to the Rio de Flag would begin at upstream of Thorpe Park and would continue downstream until the channel reached Butler Avenue. This includes the reestablishment of the historic channel from approximately Beaver Street to Butler Avenue. Although the Rio de Flag is in an urbanized area and has very limited function throughout most of the downtown reaches, there are three areas of significant mitigable impacts to biological resources.

- Construction of the floodwall along the Rio de Flag from downstream of Beale Street to Thorpe Road and the elevation of Thorpe Road would result in a significant but temporary impact to approximately 0.3 acre mixed riparian vegetation.

- Construction of the open trapezoidal channel between Bonito Street and Dale Street would result in a significant but temporary impact to 0.6 acre of mixed riparian and wetland vegetation.

- The construction of a covered concrete arch channel from Dale Street to Birch Street would result in the permanent loss of 0.40 acre of wetland habitat. The habitat in this reach (Reach 6) was evaluated as low and is characterized as highly disturbed riparian vegetation dominated by exotic and ornamental species.

- The realignment of the Rio de Flag from the Route 66 crossing of the Rio de Flag downstream to Beaver Street. In this section, the existing channel will be abandoned and the channel realigned to receive flows from Clay Avenue Wash (via the culvert underneath Mike's Pike) and reestablish the hydrologic connection with the historic Rio de Flag channel. The abandoned section is approximately 590 feet long and 25 feet wide totaling 0.3 acre. It is classified as providing medium functional value.

Additional consideration also was given to the realignment of the channel and the direct impact on the higher value riparian systems downstream of the diversion. It was determined through field observations and additional review of stream gage data that, despite the change in hydrology under the NED Plan, there would not be a significant impact on the riparian systems of these reaches for two reasons. First, flows from local drainage and Sinclair Wash would continue to provide periodic flushing flows to the system during storm events. Second, vegetation in this section of the Rio de Flag has become adapted to low or no flow conditions prevalent during the dry season and should not be affected by the diversion of flows upstream.

Impacts from the Rio de Flag Channel Modifications are summarized in **Table 6.5**.

Table 6.5 Rio de Flag Channel Modifications Mitigable Impacts

Project Feature	Functional Reach	Impacted Area (acres)	Vegetation Type	Qualitative Assessment Rating
Thorpe Park Floodwall	3	0.3	Mixed Riparian	Medium/High
Bonito Street to Dale Street Channel Enlargement	6	0.6	Mixed Riparian and Wetland	Medium
Covered Arch Culvert	6	0.4	Disturbed Riparian	Low
Route 66 to Beaver Street Re-alignment	8	0.3	Mixed Riparian	Medium

Clay Avenue Wash Detention Basin : The features proposed for the Clay Avenue Wash Detention Basin will not result in any significant impacts to biological resources in the project area. Although a formal wetland delineation was not performed as part of the study, the impacted areas do not exhibit characteristics of "waters of the United States" pursuant to Section 404 of the Clean Water Act using the three parameter evaluation of soils, hydrology, and vegetation (Corps, 1987). As such, impacts were not considered significant and there is no mitigation proposed for the Clay Avenue Wash Detention Basin.

Clay Avenue Wash Channel Modifications : Channel modifications to Clay Avenue Wash would extend from north of the Chateau Royal Trailer Park downstream to Milton Road. Impacts from the modifications proposed for the portion extending from the Chateau Royal Trailer Park to Blackbird Roost Road were not considered significant and would not require mitigation since the wash through this section is highly degraded and, in some places, has no defined channel. This modification will most likely result in a net benefit to the system through the establishment of a vegetated channel and the removal of debris and structures that currently reduce the functionality of the system.

Modifications completed between Blackbird Roost and Milton Road would result in the loss of 0.40 acre of highly disturbed riparian habitat. Approximately 0.1 acre (230 feet in length by 15 feet wide) would be permanently lost during the construction of the underground arched culvert from Blackbird Roost to the western edge of the McCracken Place parking lot. An additional 0.30 (860 feet in length and 15 feet wide) acre would be lost to the construction of an open concrete boxed culvert from the western edge of McCracken Place to Milton Road. Both of these sections are considered to have low functional value and are characterized as highly disturbed riparian corridors dominated by ruderal grasses and herbs. Impacts from the Clay Avenue Wash Channel Modifications are summarized below.

Table 6.6 Clay Avenue Wash Channel Modifications Mitigable Impacts

Project Feature	Functional Reach	Impacted Area (acres)	Vegetation Type	Qualitative Assessment Rating
Underground Arched Culvert	Clay Wash	0.1	Disturbed Riparian	Low
Open Concrete Channel	Clay Wash	0.3	Disturbed Riparian	Low

Mitigation Planning Objectives

Based on coordination with Federal, State, and local resource agencies, along with input from the general public during the scoping process, biological resources occurring in the project area have been deemed to have both public and technical significance. Public significance is afforded certain resources when it is clear that the public has strong concern for that resource as reflected in the public scoping process or during public review of the Draft EIS. Private citizens and local planning/community groups have e xpressed an interest in preserving the natural features of the Rio de Flag. To the extent practicable, this entails the avoidance of concrete and the preservation of native vegetation and landscapes along the creek, including the aesthetic qualities associated with a natural greenbelt channel through the City of Flagstaff. Also of public concern is the integration of recreation opportunities along or adjacent to the channel with the recognition of the need to sustain the integrity of the existing business es, industries and associated infrastructure. Appendix C of the **EIS** discusses the conceptual recreation plan associated with this project.

Technical significance is derived from published literature and the professional judgement of experts in the biological sciences field. Both riparian and wetland habitats have sharply declined throughout the arid southwest, making these habitats rare and regionally sensitive. Despite their relatively small expanse, riparian systems provide vital habitat for requisite life cycles for an inordinate number of wildlife species (Briggs, 1996). Although no endangered or threatened species are known to inhabit the Rio de Flag Project area, its native plant communities, primarily wetlands and riparian vegetation, have been afforded local and regional scientific significance.

For these reasons, both public and technical significance was placed on the degradation, disturbance to or removal of riparian and wetland habitats. Accordingly, habitat losses associated with the NED Plan were evaluated for significance and mitigation options established to compensate for unavoidable significant adverse impacts.

The mitigation planning objective for the Rio de Flag Feasibility Study is to compensate for the loss of wetland function resulting from construction and maintenance of the NED Plan. This was used to guide the formulation of mitigation alternatives. The unit of measurement selected to describe the losses being addressed in each mitigation alternative is acres of wetland habitat. The functional assessment was used as a tool in defining the features and components of each mitigation alternative to ensure that lost wetland functions are compensated for at an appropriate functional level. In this manner, both the number of acres (size) and the estimated functional value of the system are accounted for in the mitigation planning process.

Mitigation Requirements

Mitigation requirements were established by assessing the significant impacts of the NED plan relative to the benefits the project may accrue through habitat restoration, preservation, or enhancement. Features of the NED Plan that will, over the life of the project, improve the functional value of the Rio de Flag riverine system include the acquisition of lands at Clay Avenue Wash detention basin and the reestablishment of seasonal flows to the historic Rio de Flag Channel. While the acquisition of lands for the detention basin on Clay Wash will serve as a net benefit to wildlife in the project area, the lands are not considered wetlands. As such, this land acquisition is not considered an acceptable form of mitigation for the significant impacts resulting from the NED Plan. The hydrologic "restoration" of the historic Rio de Flag channel potentially increases the extent of riverine wetlands in the project area by reestablishing a portion of the historic channel. However, in the absence of any targeted revegetation and/or restoration the functional value of this area was questioned by representatives of the resource agencies and was not viewed as an acceptable offset for project impacts in upstream areas. The Corps concurred with this conclusion and agreed to consider the area as a potential mitigation site.

Since the estimated benefits from implementation of th e NED Plan do not adequately offset the significant impacts identified in Section 4 of the **EIS**, mitigation is required. A total of 2.0 acres of project impacts would need to be mitigated for, including 1.2 acres of temporary impacts to medium and high v alue riparian habitats and 0.8 acre of permanent impacts to low value habitats. Total mitigation for these 2 acres of project impacts will consist of 3 acres. Significant impacts requiring mitigation are presented in **Table 6.7.**

Table 6.7 Mitigation Requirements for the NED Plan

Project Feature	Area of Impact (acres)	Qualitative Assessment Rating	Type of Impact
Rio de Flag Modifications			
Thorpe Park Floodwall	0.3	Medium/High	Temporary

Covered Arch	0.4	Low	Permanent
Open Trapezoidal Channel	0.6	Medium	Temporary
Route 66 to Beaver Street Realignment	0.3	Medium	Temporary
Clay Wash Modifications			
Underground Arched Culvert	0.10	Low	Permanent
Open Concrete Channel	0.30	Low	Permanent
Total Mitigation Requirement (acres) (Includes additional Mitigation identified in the EIS)		**3.00**	

Mitigation Alternatives

Mitigation alternatives were developed to compensate for losses attributable to the implementation of the NED Plan. Temporal and permanent losses are addressed separately to take advantage of opportunities to compensate for temporal losses at the impact location. Full consideration was given to utilization of both public and private lands during the formulation process.

Mitigation for Temporal Losses : Temporal losses were identified along the Rio de Flag at three locations (total of 1.2 acres). At each location, implementation of the NED Plan will result in the temporary loss of riparian wetland habitat during construction activities. Mitigation at these sites will consist of restoring the impacted area to a condition that is at least equal in function to the preconstruction condition. The mitigation plan for each site will utilize a rigorous planting palate, with plants of multiple age classes, to facilitate the development of structural diversity from the onset of the mitigation project. The planting design will utilize the same native species that exist in the project area. A species palette is currently being developed by the Arboretum at Flagstaff for each area impacted by the project. Revegetation would involve the use of pole cuttings, containerized plant material, and native seed mix as described below.

Pole Cuttings: To the maximum extent practicable, pole will be harvested from the project area and planted within the designated side slope areas. Pole cuttings shall be collected during the winter dormant season and properly stored and handled prior to installation. The pole cuttings will be planted 15 feet on center and within 3 to 10 feet of existing groundwater. The detailed planting design and mosaic will be prepared during the Planning, Engineering and Design (PED) phase of this project and will include the list of plant species developed by the Flagstaff Arboretum.

Hydroseeding: A herbaceous seedmix shall be applied to the interstitial areas of the restoration site (i.e., in between pole cuttings and containerized plants). The seedmix will be from a local source and conform to industry standards. Application of the seedmix will occur during the Fall and/or Winter months to promote seed establishment and germination.

Containerized Plantings: As part of the revegetaion program, nursery grown containerized native plants (1- and 5-gallon) will be installed 8-foot on center. The detailed planting design and mosaic will be prepared during PED, and is dependent on further groundwater and soil agricultural suitability testing. To limit plant stress and encourage successful plant establishment, planting will occur during the dormant season, preferably November through February. Table 5-2 of Appendix E, Mitigation Planning, of the **EIS** displays a sample of species and quantities of containerized plants and pole cuttings per acre typically used on Corps' projects in Southern California. This list is for cot estimating purposes only and will be revised upon receipt of the recommended list of plant species.

Irrigation: A temporary irrigation system will be installed at the detention basin mitigation site to provide supplemental watering to reduce the chance of plant stress and to encourage downward growth of the roots. Irrigation will be applied and maintained for a minimum of two years from

the date of plant installation being complete. A detailed irrigation plan would be designed during PED, including identification of potential water sources.

Permanent Loss Mitigation : Permanent losses of wetland habitat were identified at three locations in the project area. As displayed in **Table 6.7**, these areas include: 1) Rio de Flag channel modifications; 2) Clay Avenue Wash underground culvert at McCracken Place; and 3) Clay Avenue Wash open concrete channel from McCracken Place to Milton. In sum, the loss of wetlands from these areas totals 0.80 acre with a mitigation requirement of 1.2 acres. The following alternatives was selected to meet this mitigation requirement.

Recommended Mitigation Measure B: Historic Rio de Flag Channel : This mitigation measure compensates for the loss in wetland habitat through creation of riparian habitat in the historic Rio de Flag channel. Following implementation of the NED Plan, a hydrologic link between the upper Rio de Flag watershed and the historic channel alignment will be reestablished creating an opportunity to restore habitat in the previously abandoned channel. The mitigation site will be located downstream of the terminus of the underground arched culvert just downstream of South Elden Street. The current design in this reach calls for a natural channel with an invert width of 56 feet and 4:1 side slopes. Riparian restoration in this channel would consist of creation of a low flow meandering channel with high diversity micro topographic features and reestablishment of native riparian species across the 56 foot invert for a distance of 1,000 feet. Revegetation would involve the use of pole plantings, containerized plant material, and native seedmix, as described below. Soil amendments will be added if analysis indicates the substrate is not suitable for riparian species establishment. Additional components of the mitigation project are discussed in the following paragraphs.

Site Recontouring/Grading: Site grading would be performed to create a meandering low flow channel. Additional site work would be performed to "roughen" the invert which increases micro- and macro topographic diversity and more closely mimics a natural stream corridor.

Pole Cuttings: To the maximum extent practicable, pole cuttings will be harvested from the project area and planted within the mitigation area. Additional investigations conducted during the Planning, Engineering and Design (PED) phase of the project will determine what species are bested suited for the site.

Hydroseeding: A herbaceous seedmix shall be applied to the interstitial areas of the restoration site (i.e., in between pole cuttings and containerized plants). The seedmix will be from a local source and conform to industry standards. Application of the seedmix will occur during the Fall and/or Winter months to promote seed establishment and germination.
Containerized Plantings: As part of the revegetaion program, nursery grown containerized native plants (1- and 5-gallon) will be installed 8-foot on centers. The detailed planting design and mosaic will be prepared during PED, and is dependent on further groundwater and soil agricultural suitability testing. To limit plant stress and encourage successful plant establishment, planting will occur during the dormant season, preferably November through February.

Irrigation: A temporary irrigation system will be installed at the detention basin mitigation site to provide supplemental watering to reduce the chance of plant stress and to encourage downward growth of the roots. Irrigation will be applied and maintained for a minimum of two years from the date of plant installation being complete. A detailed irrigation plan would be designed during PED, including identification of potential water sources.

Incremental Analysis of Mitigation Alternatives

Corps of Engineers' regulations require that all recommended mitigation measures be incrementally justified. The purpose of incremental cost analysis is to discover and display variation in costs, and to identify and describe the least cost plan. This involves an examination of the cost efficiency of each mitigation alternative presented in terms of environmental benefits gained per dollar expended. The goal of the process is to select the option or combination of options that best meets the mitigation goals for the lowest overall cost.

Policy also requires that the Corps seek to minimize acquisition of private land and maximize mitigation opportunities on project lands first and adjacent or nearby public lands second in order to optimize the cost effectiveness of mitigation. For the Rio de Flag project, there is ample area for mitigation within the project boundaries should it be determined that compensatory mitigation is required.

Incremental analysis of mitigation alternatives requires that resource losses expected from the implementation and maintenance of the project and resource gains expected from the mitigation measures be specified in quantitative terms by resource category. For this study, a Functional Assessment was used to characterize biological resource values for the habitat within the study area and aid in the development of mitigation ratios. Specific losses to wetland habitat were addressed using acres of habitat as the standard unit of measurement. Mitigation for temporal losses was developed independent of mitigation for permanent losses since there was sufficient opportunity to mitigation on-site following construction activities.

Based on the analysis, mitigation Alternative B is incrementally justified as maximizing the environmental outputs for the least cost. Selection of the least cost mitigation alternative for permanent losses combined with the mitigation proposed for temporal losses results in a total estimated mitigation cost for the project of $177,260.

Cultural Resource Mitigation

Thorpe Park

The proposed Thorpe Park site has been completely developed for recreation. Three artifacts (mano, biface frag, and groundstone axe) found in the area of the northernmost softball field suggest a prehistoric archeology site that may have been graded away during its construction.

Two small historic buildings are located on the western side of the access road/City Park Dam. One is a log cabin and the other is small building constructed from river cobbles. Boy Scouts moved the log cabin, built in 1895, to that location in 1978 from the Veit Ranch on the San Francisco Peaks. The cabin was moved in pieces for educational use by the Flagstaff Middle School. The cobble stone building was built by the city when City Park was completed in 1923. It is now used for storage of maintenance equipment. These structures have not been evaluated for Section 106 (National Register) eligibility. Both buildings fall within the pool line for a projected 100-year event. Periods of induced inundations will be brief but potentially destructive to the log cabin.

Clay Avenue Wash Detention Basin

The existing ranch house complex at the southwestern side of the detention basin will need to be evaluated for its eligibility for inclusion in the National Register of Historic Places (NRHP). Three of the buildings were built in 1935, 1944, and 1954 respectively. Current project design indicated potential inundation of the ranch complex during a hundred-year event. Within the location for the proposed detention basin are six unevaluated resources. At the point where the channel opens into the easternmost end of the detention basin lies the former Atlantic and Pacific railroad alignment with abandoned railroad bridge abutments. The bridge, built in 1883 from the local Coconino Sandstone, was abandoned in 1937 when the Atchison, Topeka, and Santa Fe Railroad purchased the tracks and realigned them 150 feet north. Continuing west there are two historic trash scatters composed primarily of cans, barrels, and miscellaneous rusted automobile parts. Between the two trash scatters is a historic trail remnant with a trail marker comprised of a rock pile. There are two additional historic resources on the private property portion of the detention basin. One is the obliterated remains of a small 1930-1940s-era cabin, and another small trash scatter.

A request for a determination of eligibility for the railroad bridge was submitted to the Arizona State Historic Officer in a letter dated July 23, 1999. With the exception of the Railroad Bridge, no other resources have been evaluated for National Register eligibility. They probably will not be eligible for the NRHP. Impacts to these historic features will be minor if they are determined to NRHP eligible. Short term inundation will not greatly degrade them anymore than natural weathering all ready has.

Impacts to the bridge from floodwaters will be less serious than when it was built in 1883. From its placement on the natural drainage, it will allow the passage of floodwater. It will thereby continue to function as originally intended. However, because an outlet structure is proposed west of the bridge, water flows will be significantly reduced below historic levels. Scheduled release rates will be at lower levels than the without project condition. The outlet structure is designed to be anchored to the railroad bed approximately 225 feet west of the bridge abutments. The railroad bed was recorded in 1996 as part of the remaining Atlantic and Pacific Railroad Bridge system (AZ:I:14:334). Anchoring the outlet structure into it will constitute an impact, albeit minor. Mitigation would be expected to be limited to Historic American Engineering Record (HAER) recordation of the bridge.

Clay Avenue Wash from the Detention Basin to Mike's Pike

This reach along Clay Avenue Wash was surveyed by the Corps of Engineers for cultural resources and was found to be negative. There will be no impacts to historic properties along the channel alignment between Mikes Pike and the historic Railroad Bridge at the channel's terminus on the western end.

Thorpe Park to Upstream of Beaver Street

This alignment has been surveyed twice, once for the historic building surveys in the 1970s and again in 1998 by the Corps of Engineers. The project alignment has been designed to avoid all structures. There will be no impacts in this reach.

Mike's Pike Alignment

No impacts are expected due to the alignment being comprised of a covered channel within the footprint of the roadway. However, eight National Register listed properties are on the periphery of the Mikes Pike right-of-way. They are: C&M (Double circle) Garage - 204 Mikes Pike, E. T. McGonigle house/B&M auto Camp - 100 S. Mikes Pike, Gavin/Hensing rental house - 37. S. Mikes Pike, Mary A. Gavin's rental houses at 31 - 35 S. Mikes Pike, and an unnamed house at 17 S. Mikes Pike. An additional building, the Flagstaff Steam Laundry is at the southwest corner of Mikes' Pike and Phoenix Ave at 210 W. Phoenix Ave. These historic buildings are all listed as contributors to the Southside/Oldtown Historic District. If construction remains within the specified corridor, these historic properties will not be effected.

Upstream of Beaver Street to Butler Avenue

No impacts are expected in the reach. However, two historic resources within the southern extent of the Railroad Addition Historic District Extension are very close to the proposed alignment. The proposed underground realignment of the historic river channel will narrowly avoid affecting the historic Flagstaff Lumber Company Warehouse at 23 S. San Francisco, and the Northern Motor Company building on the corner of San Francisco and Phoenix.

Continental Area

There will be no expected impacts in this reach. This conclusion is derived from the fact that the area is recently developed, and the potential for structural work is very small. However, if structural work is proposed, a cultural resources survey of the affected area will be conducted.

Cultural Resource Mitigation Plan

Mitigation of cultural resources is confined to those properties that have been evaluated for their eligibility for inclusion in the National Register of Historic Places. At that time they become known as "historic properties." Following determinations of eligibility, historic properties are assessed for the criteria of effect and adverse effect. If the project will adversely affect a historic property mitigation measures will be required to reduce the impacts to a level of no adverse effect. This entire procedure will be followed as specified in a Programmatic Agreement (PA). The PA is a document detailing how Section 106 will be implemented. It is an agreement between the Corps of Engineers, the SHPO, and the Advisory Council on Historic Preservation (Council). The Hopi Tribe, The Haulipai Tribe, and the Pueblo of Zuni will be invited to participate as concurring parties. The PA will contain stipulations that may involve requiring additional surveys and historic building inventories, determinations of eligibility, assessing effects, and mitigation. When the PA is executed by the Council, the project as planned will be in compliance with Section 106 of the National Historic Preservation Act.

Mitigation can be achieved through a variety of methods. The optimal form of mitigation is avoidance or preservation in place. Barring that preferred method the primary mode of mitigation for historic properties may be limited to, but will probably include Historic American Building survey (HABS) recordation for any historic property that will be adversely affected by the preferred alternative. For the structural element; the Atlantic and Pacific Railroad Bridge, the two buildings in Thorpe Park, the City Park Dam, and the ranch complex, Historic American Building Survey/Historic American Engineering Record (HABS/HAER) recordation may be used. The most likely scenario for mitigation of adverse effects to the two buildings in Thorpe Park is to develop floodproofing measures to protect them in addition to the HABS/HAER documentation. If possible, a protective berm should be place around the ranch buildings to protect their integrity. The National Parks Service dictates the level of recordation in both cases. The National Parks Service may not be interested in overseeing mitigation of these historic features. In that case, the State of Arizona has their own approved documentation standards that are outlined in A.R.E. 41-861, et seq. Mitigation measures will be specified in a PA.

In summary mitigation requirements will include HABS/HAER recordation of the Atlantic and Pacific Railroad Bridge, and the ranch complex on Route 66. The historic trash scatters and the house remains probably will not be eligible for the NRHP. Current project design of the buried channel segments indicates that the project will not affect historic properties along Mikes Pike and the historic alignment north of Phoenix Avenue. However, this does not negate the possibility that construction equipment may not have adequate space to be able to maneuver properly in restricted locations. Should this occur, all activity needs to stop until the impacts can be assessed, and mitigation measures can be implemented.

A possibility exists that ground-disturbing activities may uncover subsurface deposits. A qualified archeological monitor will be in place during all ground disturbing activities and he/she will be empowered to halt construction until the situation is resolved. If archeological mitigation is required under this scenario, it will be guided through a stipulation in the PA.

Compliance with Section 106 : A draft Programmatic Agreement has been submitted to the State Historic Preservation Officer in July 23, 1999. With the exception of a request for a determination of National Register eligibility for the Atlantic and Pacific Railroad Bridge included in that letter none of the cultural resources in the area of potential effects (APE) have been evaluated for National Register eligibility. Compliance with Section 106 will be achieved through the PA. The PA will stipulate the required actions, to evaluate all affected properties in the APE, and mitigate adverse affects that will occur as a result of the project. The PA will also contain a stipulation specifying what measures are to be taken if prehistoric archeological materials are encountered during ground disturbing activities. If prehistoric archeological materials are found during ground disturbing activities, all work will cease in the area until the appropriate provisions of 36 CFR 800.13, *Post Review Discoveries*, are completed.

CHAPTER VII

PLAN IMPLEMENTATION

This chapter summarizes cost-sharing requirements and procedures necessary to implement the flood control and recreation features of the selected plan.

A. Study Recommendation

The Selected Plan is a flood control project. Because of its positive NED contribution, the selected plan is recommended for implementation.

B. Division of Plan Responsibilities

The Water Resources Development Act (WRDA) of 1986 (P.L. 99-662) and various other administrative policies have established the basis for the division of Federal and non-Federal responsibilities in the construction, maintenance, and operation of Federal water resource projects accomplished under the direction of the Corps of Engineers. This is discussed in detail below.

C. Cost Allocation

Cost sharing for construction of this project would be in accordance with applicable law whereby for flood control projects, the non-Federal sponsor shall provide all lands, easements and rights-of-way and dredged material disposal areas, provide relocations of bridges and roadways; provide alteration of utilities which do not pass under or through the project's structure; and maintain and operate the project after construction. Also, during the construction phase, the non-Federal sponsor shall contribute in cash a minimum of 5% of total project costs and any additional funds as are necessary so that the non-Federal contribution would be at least 35% of those costs assigned to flood control, and 50% of those costs assigned to recreation. Additional studies and analysis of the selected plan will be accomplished during PED. As a result of these studies, additional necessary project features may be identified that could be part of the Federal cost sharing for this project. In this event, Federal project cost sharing would be adjusted accordingly in accordance with the terms that will be included in the Project Cooperation Agreement. **Table 7.1** presents a summary of apportionment of project first costs between Federal and non-Federal interests for the Selected Plan using current (2000) price levels.

Table 7.1 Cost Apportionment Table
Rio de Flag , Flagstaff, Arizona
Flood Control Project
(Costs x$1000)

ITEM	Allocation		
	Federal	**Non-Federal**	**Subtotal**
Construction * (Construction, S&A, PED/EDC, Contingency)	17,352	0	17,352
Construction LERRDs** (lands and credits, easements, rights-of-way, relocations, and disposal sites)	0	6,246	6,246
Total First Cost (percentage of total cost)	**17,352** **74%**	**6,246** **26%**	**23,598**
Mandatory Cash to Provide Minimum 5% Non-Federal Share	(1,180)	1,180	
Additional Cash to Provide Minimum 35% Non-Federal Share	(833)	833	
Total Cost-Shared Amounts for Construction, Lands, and Additional Costs (percentage of total cost)	15,339 *65%*	8,259 *35%*	23,598
Recreation Costs (percentage of recreation costs)	237 *50%*	237 *50%*	474
Total First Costs (percentage of total cost)	**15,576** *65%*	**8,496** *35%*	**24,072**

* Does not include IDC.

D. Current and Future Work Eligible for Credit

There is no current or future work planned or in construction which is part of the Corps' Selected Plans, or which would be eligible for 104 credit.

E. Institutional Requirements

Upon implementation of the cost-shared project, the non-Federal sponsor will prepare the following preliminary financial analysis:

(1) Assess project-related yearly cash flows (both expenditures and receipts where cost recovery is proposed), including provisions for major rehabilitation and operational contingencies and anticipated but uncertain repair costs resulting from damages from natural events;

(2) Demonstrate ability to finance their current and projected-future share of the project cost and to carry out project implementation operation, maintenance, and repair/rehabilitation responsibilities;

(3) Investigate the means for raising additional non-Federal financial resources including but not limited to special assessment districts; and

(4) Complete any other necessary steps to ensure that they are prepared to execute their project-related responsibilities at the time of project implementation.

In addition, as part of any Project Cost Sharing Agreement, the non-Federal sponsor would be required to undertake to hold and save the Federal Government free from damages due to construction, operation, and maintenance of the project, excluding damages due to the fault or negligence of the Federal Government or its contractors.

F. Environmental Requirements

The Selected Plan would result in discharge of fill material into waters of the United States during the period of construction. It also may result in discharges associated with operation and maintenance activities. A Section 404(b)(1) evaluation has been prepared to address practicable alternatives. An NPDES permit will also be required for any water discharged to the river. The Los Angeles District is seeking a Section 404(r) exemption.

An archeological field survey of the proposed project Area of Potential Effects (APE) has been conducted in accordance with the National Historic Preservation Act of 1966 (36 CFR 800).

If cultural resources are discovered during construction and cannot be avoided, work will be suspended in that area until the properties are evaluated for eligibility for listing in the NRHP in consultation with the Arizona State Historic Preservation Officer (SHPO). If the properties are determined to be eligible for the NRHP, the effects of the proposed construction will be taken into consideration in consultation with the SHPO; and the Advisory Council on Historic Preservation will be provided the opportunity to comment in accordance with 36 CFR 800.11.

Other requirements relating to the Arizona Department of Game & Fish and the Arizona Regional Water Quality Control Board, will be addressed by the non-Federal sponsor. The City of Flagstaff is currently involved in pre-application coordination with all appropriate regulatory agencies.

Environmental Commitments are at Section 4.17 of the **EIS**.

G. Non-Federal Responsibilities

The presently estimated non-Federal share of the total first cost of the project is $8,496,000 which includes $6,246,000 in LERRDs credits and $2,250,000 in non-Federal contributions.

In addition, maintenance and operation of the flood control project is estimated to cost the non-Federal sponsor $60,000 annually. Annual operation and maintenance for the recreational component is estimated to cost the non-Federal sponsor $1,000 annually.

Requirements of non-Federal cooperation are specified below:

(1) As required by Public Law 99-663, the Water Resources Development Act of 1986, as amended by Section 202 of Public Law 104-303, the Water Resources Development Act of 1996, provide 35 percent of total project costs assigned to flood control, as further specified below:

a. Provide a minimum 5% cash contribution towards the total estimated project cost;

b. Provide all lands, easements, rights-of-way, and suitable borrow and dredged or excavated material disposal areas, and perform or ensure the performance of all relocations determined by the Federal Government to be necessary for the construction, operation, and maintenance of the project.

c. Provide all improvements required on lands, easements, and rights-of-way to enable the proper disposal of dredged or excavated material associated with the construction, operation, and maintenance of the project. Such improvements may include, but are not necessarily limited to, retaining dikes, waste weirs, bulkheads, embankments, monitoring features, stilling basins, and dewatering pumps and pipes.

d. Provide any additional amounts as are necessary to make its total contribution equal to 35 percent of total project costs.

e. Enter into an agreement which provides, prior to construction, 25 percent of preconstruction engineering and design (PED) costs.

f. Provide, during construction, any additional funds needed to cover the non-Federal share of PED costs.

(2) Provide 50 percent of the costs allocated to recreation, as further specified below:

a. Enter into an agreement which provides 25 percent of preconstruction engineering and design (PED) costs. Any adjustment that may be necessary to bring the non-Federal contribution in line with the project cost sharing will be accomplished in the first year of construction.

b. Provide, during construction, any additional funds needed to cover the non-Federal share of PED costs.

c. Provide all lands, easements, and rights-of-way, including suitable borrow and dredged or excavated material disposal areas, and perform or assure the performance of all relocations determined by the Government to be necessary for the construction, operation, and maintenance of the recreation features of the project.

d. Provide or pay to the Government the cost of providing all retaining dikes, wasteweirs, bulkheads, and embankments, including all monitoring features and stilling basins, that may be required at any dredged or excavated material disposal areas required for the construction, operation, and maintenance of the recreation features of the project.

e. Provide, during construction, any additional cash as necessary to make its total contribution equal to 50 percent of the costs allocated to recreation.

f. Prevent future recreation features from significantly impacting or interfering with the intended functions of the flood control project.

(3) For so long as the project remains authorized, operate, repair, replace, rehabilitate and maintain the completed project and hydraulic integrity of the system, along with any required long-term dredged or excavated material disposal areas, in a manner compatible with the project's authorized purposes, and in accordance with applicable Federal and State laws and regulations and any specific directions prescribed by the Federal Government.

(4) Give the Government a right to enter, at reasonable times and in a reasonable manner, upon property that the non-Federal sponsor owns or controls for the purpose of completing, operating, maintaining, repairing, replacing, or rehabilitating the project.

(5) Assume responsibility for operating, maintaining, replacing, repairing, and rehabilitating (OMRR&R) the project or completed functional portions of the project, including mitigation features without cost to the Government, in a manner compatible with the project's authorized purpose and in accordance with applicable Federal and State laws and specific directions prescribed by the Government in the OMRR&R manual and any subsequent amendments thereto.

(6) Comply with Section 221 of Public Law 91-611, Flood Control Act of 1970, as amended, and Section 103 of the Water Resources Development Act of 1986, Public Law 99-662, as amended, which provides that the Secretary of the Army shall not commence the construction of any water resources project or separable element thereof, until the non-Federal sponsor has entered into a written agreement to furnish its required cooperation for the project or separable element.

(7) Hold and save the United States free from all damages arising from the construction, operation, and maintenance of the project and any betterments, except for damages due to the fault or negligence of the United States or its contractors.

(8) Keep and maintain books, records, documents, and other evidence pertaining to costs and expenses incurred pursuant to the project to the extent and in such detail as will properly reflect total project costs, and in accordance with the standards for financial management systems set forth in the Uniform Administrative Requirements for Grants and Cooperative Agreements to State and Local Governments in 32 CAR Section 33.20.

(9) Perform, or cause to be performed, any investigations for hazardous substances as are determined necessary to identify the existence and extent of any hazardous substances regulated under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), 42 U.S.C. 9601-9675, that may exist in, on, or under lands, easements, or rights-of-way that the Federal Government

determines to be necessary for the construction, operation, and maintenance of the project. However, for lands that the Government determines to be subject to the navigation servitude, only the Government shall perform such investigation unless the Federal Government provides the non-Federal sponsor with prior specific written direction, in which case the non-Federal sponsor shall perform such investigations in accordance with such written direction.

(10) Assume complete financial responsibility, as between the Federal Government and the non-Federal sponsor, for all necessary cleanup and response costs of any CERCLA regulated materials located in, on, or under lands, easements, or rights-of-way that the Federal Government determines to be necessary for the construction, operation, or maintenance of the project.

(11) To the maximum extent practicable, operate, maintain, repair, replace, and rehabilitate the project in a manner that will not cause liability to arise under CERCLA.

(12) Prevent future encroachments on project lands, easements, and rights-of-way which might interfere with the proper functioning of the project.

(13) Comply with the applicable provisions of the Uniform Relocation Assistance and Real Property Acquisition Policies Act of 1970, Public Law 91-646, as amended by Title IV of the Surface Transportation and Uniform Relocation Assistance Act of 1987 (Public Law 100-17), and the Uniform Regulations contained in 49 CAR Part 24, in acquiring lands, easements, and rights-of-way, required for construction, operation, and maintenance of the project, including those necessary for relocations, borrow materials, and dredged or excavated material disposal, and inform all affected persons of applicable benefits, policies, and procedures in connection with said act.

(14) Comply with all applicable Federal and State laws and regulations, including, but not limited to, Section 601 of the Civil Rights Act of 1964, Public Law 88-352 (42 U.S.C. 2000d), and Department of Defense Directive 5500.11 issued pursuant thereto, as well as Army Regulation 600-7, entitled "Nondiscrimination on the Basis of Handicap in Programs and Activities Assisted or Conducted by the Department of the Army."

(15) Provide 35 percent of that portion of total cultural resource preservation mitigation and data recovery costs attributable to flood control that are in excess of 1 percent of the total amount authorized to be appropriated for flood control, and provide 50 percent of that portion of total cultural resource preservation mitigation and data recovery costs attributable to recreation that are in excess of 1 percent of the total amount authorized to be appropriated for recreation.

H. Sponsorship Agreements

The City of Flagstaff has provided a Letter of Intent acknowledging sponsorship requirements for the Rio de Flag Project. Prior to the start of construction, the non-Federal sponsor will be required to enter into an agreement with the Federal Government that it will comply with Section 221 of the Flood Control Act of 1970 (P.L. 91-611), and the Water Resources Development Act of 1986 (P.L. 99-662) as amended.

I. Procedures for Implementation

Future actions necessary for authorization and construction of the selected plans are summarized as follows:

(1) This report will be reviewed by the Headquarters of the U.S. Army Corps of Engineers, Washington D.C.

(2) The Chief of Engineers will seek formal review and comment by the Governor of the State of Arizona and interested Federal agencies.

(3) Following State and Agency review, the report will be sent to the Assistant Secretary of the Army for Civil Works.

(4) Upon approval of the Assistant Secretary, the report will be forwarded to the Office of Management and Budget (OMB) to obtain the relationship of the project to programs of the President.

(5) The final report of the Chief of Engineers will then be forwarded by the Assistant Secretary of the Army for Civil Works to Congress.

(6) Congressional review of the feasibility report and possible authorization of the project would follow.

(7) Pending project authorization for construction, the Chief of Engineers could include funds where appropriate, in his budget requests for preconstruction engineering and design of the project. The objective is to ready each project for a construction start established with the feasibility study.

(8) Following receipt of funds, preconstruction engineering and design would be initiated and surveys and detailed engineering designs would be accomplished.

(9) Following Congressional authorization of the project, plans and specifications would be accomplished by the District Engineer.

(10) Subsequent to appropriation of construction funds by Congress, but prior to construction, formal assurances of local cooperation would be required from non-Federal interests.

(11) Bids for construction would be initiated and contracts awarded.

[This page left intentionally blank.]

CHAPTER VIII

SUMMARY OF COORDINATION AND PUBLIC VIEWS

A. Non-Federal Views and Preferences

The non-Federal views and preferences regarding flood control, with some recreation components, were in general obtained through coordination with the study sponsor and with various local and regional agencies and organizations, neighborhood associations, and the general public. These coordination efforts consisted of a series of public meetings held during the reconnaissance and feasibility study phases, through surveys, through the maintenance of a "point-of-contact" with whom any interest could discuss matters, and a mailing list by which invitations to public meetings were distributed. Announcements for public meetings were made in local newspapers, including date, time, place, and subject matter. Complete details are provide in the Public Involvement Appendix.

B. Views of the Non-Federal Sponsor

The City of Flagstaff has expressed willingness in continuing to be the non-Federal sponsor for project implementation. The City has indicated its support for the project and a willingness to assume cost-shared financial obligations for its implementation. A Letter of Intent is shown as **Figure 8.1**.

The non-Federal sponsor fully supports the results of the feasibility study. The non-Federal sponsor's interest in implementing flood control solutions for Rio de Flag, Clay Avenue Wash, and Continental areas is reflected in the many previous studies and reports prepared by the City, and by their willingness to enter into a cost-shared feasibility study to determine Federal interest. The scope of the potential flood damages in the City of Flagstaff, and the scope of the desired flood control solutions, however, are beyond the non-Federal sponsor's individual means to address and implement.

There currently exists within the community, and with the non-Federal sponsor, significant interest for providing flood damage reduction solutions for the major areas that are subject to such damages. This is demonstrated by their desire to pursue flood control options for the project, and their willingness to accommodate Federal guidance in the selected plan. An Environmental Impact Statement (**EIS**), addressing existing resources and potential impacts to these resources from implementation of the desired flood control solutions recommended in this study, indicates that the selected plan would have mitigable impacts to environmental resources. This is discussed in detail in the **EIS**.

Locally-preferred options within the study area consisted mainly of desires for a greater percentage of the project devoted to recreation. The non-Federal sponsor understands the requirement of developing the selected plans, Federal constraints, and that the selected plan differed somewhat from non-Federal desires. The non-Federal sponsor has related its acceptance of the selected plan and is willing to accept the Corps of Engineers identified NED plan as the Locally Preferred Plan. The City accepts complete responsibility for additional recreational or flood control enhancements in the future that would allow the City to more fully realize the overall objectives of its long term planning efforts, while realizing that the Corps of Engineers Plan was formulated taking into full consideration those long term planning objectives.

C. Financial Analysis

Further project engineering, design, and construction would be conducted in accordance with the cost-sharing principles provided by the Water Resources Development Act of 1986, as amended. The non-Federal sponsor has indicated its ability and willingness to participate in the planning, engineering and design of the selected plan, and to participate in construction of the project.

In accordance with ER 1105-2-100, para. 6-184.b, a preliminary financing plan and statement of financial capability has been prepared by the non-Federal sponsor (**Figure 8.2**). The District has reviewed the information, understands the budgetary issues related to the financing of the proposed project, and finds that the non-Federal sponsor has the capability to fund its portion of implementation responsibilities.

D. Summary of Study Management, Coordination, Public Views and Comments

The study team was a multi-disciplinary group that consisted of several functional elements of the Corps and the non-Federal sponsors. The study team included study and project managers, engineers, hydrologic and hydraulic engineers, groundwater specialists, environmental specialists, cost estimators, designers, appraisers, economists, materials, geotechnical specialists, real estate specialists, and landscape architects.

The study was coordinated with a variety of agencies, interest groups and individuals. Feedback from the public was incorporated in the plan formulation and evaluation process. Additional public views are summarized in the **EIS**. Public views have also been incorporated into the plan formulation and evaluation process. In general, agencies, public interest groups, and individuals have been supportive of the selected plan.

E. Compliance With Executive Order 12898

The primary goal of Executive Order 12898 is to focus Federal attention on the environmental and human health conditions in minority communities and low-income communities with the goal of achieving equity in the siting of Federally-funded facilities that may have adverse environmental impacts.

The Rio de Flag Project will be consistent with all the stated goals for the Arizona Environmental Justice Project. Detailed background research and baseline documentation has identified environmental issues within project boundaries. This information in conjunction with extensive public involvement in the plan formulation process has led to the proposed Rio de Flag Project. The project will not contribute to any health or environmental hazards, while the proposed flood control and recreation features will have far reaching benefits for these areas. The selected plans have also been presented to and approved by the Arizona Department of Environmental Quality (ADEQ) Environmental Justice Committee.

[This page left intentionally blank.]

City of Flagstaff

OFFICE OF THE CITY MANAGER
(520) 779-7604

September 05, 2000

Colonel John P. Carroll
Commander and District Engineer
U.S. Army Corps of Engineers
Los Angeles District
911 Wilshire Boulevard
Los Angeles, CA 90017

Dear Colonel Carroll:

The City of Flagstaff would like to extend its full support of the Rio de Flag, Flagstaff, Arizona Feasibility Study findings and recommendation for the Rio de Flag flood control project. We understand that the study was completed under the authorities given to the Corps of Engineers by Congress and by certification of the report by the Corps of Engineers to move into the implementation phase of this project.

We feel that the plan contained in the Feasibility Report is an appropriate action to overcome the impacts of flooding in the Downtown area, including Northern Arizona University. Flood control is consistent with the City's goals to enhance the economic vitality of the Downtown area by minimizing the impacts of flooding.

We understand that the current estimated cost of the Rio de Flag project is about $24 million and that the non-federal share, including all lands, easements, rights-of-way, relocations, and disposals, is about $8.4 million. We are fully prepared to meet our requirements to ensure completion of the project.

We stand prepared to enter into the next phase of this project and look forward to executing a Pre-construction Engineering and Design Agreement at the earliest opportunity.

Sincerely

DAVID W. WILCOX
City Manager

211 West Aspen Avenue, Flagstaff, Arizona 86001
Main & TDD (520) 774-5281; Fax (520) 779-7696

Figure 8.1

[This page left intentionally blank.]

City of Flagstaff

September 05, 2000

Colonel John P. Carroll
Commander and District Engineer
U.S. Army Corps of Engineers
Los Angeles District
911 Wilshire Boulevard
Los Angeles, CA 90017

Dear Colonel Carroll:

The City of Flagstaff is currently the local sponsor of the U.S. Army Corps of Engineers Rio de Flag Flagstaff, Arizona Feasibility Study to construct a flood control project within the City of Flagstaff.

The City of Flagstaff is prepared to move forward as the local sponsor with the Corps of Engineers to construct this flood control project, anticipating continued congressional support and authorization of the project through WRDA 2000. We are prepared to commit to our local share of 35% of the costs of the Pre-construction Engineering and Design and Project Construction Phases, and 50% local match requirements for recreation features. Upon completion, the project will be operated and maintained by the City of Flagstaff Public Works Department as a public facility.

The City of Flagstaff currently has a population of 60,880 people. The current, Fiscal Year 2000 - 2001 budget is $137,973,636, of which $41,397,417 is General Funds. The total assessed valuation of property within the City is $385,098,813 and our property tax rate is 1.7127 mills. The City also imposes a 1% sales tax and shares in both State income tax receipts and sales taxes. The Moody's / Standard and Poors G.O. bond rating is A-1/A+, respectively, which has been maintained since 1979.

The City currently has $5,022,000 cash on hand in our current fiscal year budget for the Rio de Flag Flood Control Project and has committed an additional $5,808,000 to our Capital Improvement Program Budget over the next five years for this project. This funding has been allocated entirely from cash sources available to the City of Flagstaff on an ongoing basis, and no bond or other form of loan is anticipated to be required for the City to meet the financial obligations for the project. The City of Flagstaff is fully prepared and capable to meet our share of project costs and to meet the ongoing requirements associated with annual operation and maintenance.

Sincerely

DAVID W. WILCOX
City Manager

211 West Aspen Avenue, Flagstaff, Arizona 86001
Main & TDD (520) 774-5281; Fax (520) 779-7696

Figure 8.2

[This page left intentionally blank.]

CHAPTER IX
RECOMMENDATIONS

I recommend that the plan described herein for flood control and recreation be authorized for implementation as a Federal project. The total first cost of the project is currently estimated at $24,072,000 under October 1999 prices ($23,598,000 flood control; $474,000 recreation). The Federal share is currently estimated at $15,576,000 ($15,339,000 flood control; $237,000 recreation).

I recommend that the plans recommended herein be exempt from regulations of the Clean Water Act, pursuant to Section 404(r) of the Act.

My recommendation is subject to cost sharing, financing, and other applicable requirements of Federal and State laws and policies, including Public Law 99-663, the Water Resources Development Act of 1986, as amended by Section 202 of Public Law 104-303, the Water Resources Development Act of 1996, and in accordance with the following requirements which the non-Federal sponsor must agree to prior to project implementation.

(1) As required by Public Law 99-663, the Water Resources Development Act of 1986, as amended by Section 202 of Public Law 104-303, the Water Resources Development Act of 1996, provide 35 percent of total project costs assigned to flood control, as further specified below:

a. Provide a minimum 5% initial cash contribution towards the total estimated project cost;

b. Provide all lands, easements, rights-of-way, and suitable borrow and dredged or excavated material disposal areas, and perform or ensure the performance of all relocations determined by the Federal Government to be necessary for the construction, operation, and maintenance of the project.

c. Provide all improvements required on lands, easements, and rights-of-way to enable the proper disposal of dredged or excavated material associated with the construction, operation, and maintenance of the project. Such

improvements may include, but are not necessarily limited to, retaining dikes, waste weirs, bulkheads, embankments, monitoring features, stilling basins, and dewatering pumps and pipes.

d. Provide any additional amounts as are necessary to make its total contribution equal to 35 percent of total project costs assigned to environmental restoration.

e. Enter into an agreement which provides, prior to construction, 25 percent of preconstruction engineering and design (PED) costs.

f. Provide, during construction, any additional funds needed to cover the non-Federal share of PED costs.

(2) Provide 50 percent of the costs allocated to recreation, as further specified below:

a. Enter into an agreement which provides 25 percent of preconstruction engineering and design (PED) costs. Any adjustment that may be necessary to bring the non-Federal contribution in line with the project cost sharing will be accomplished in the first year of construction.

b. Provide, during construction, any additional funds needed to cover the non-federal share of PED costs.

c. Provide all lands, easements, and rights-of-way, including suitable borrow and dredged or excavated material disposal areas, and perform or assure the performance of all relocations determined by the Government to be necessary for the construction, operation, and maintenance of the recreation features of the project.

d. Provide or pay to the Government the cost of providing all retaining dikes, wasteweirs, bulkheads, and embankments, including all monitoring features and stilling basins, that may be required at any dredged or excavated material disposal areas required for the construction, operation, and maintenance of the recreation features of the project.

e. Provide, during construction, any additional cash as necessary to make its total contribution equal to 50 percent of the costs allocated to recreation.

f. Prevent future recreation features from significantly impacting or interfering with the intended functions of the flood control project.

(3) For so long as the project remains authorized, operate, repair, replace, rehabilitate and maintain the completed project and hydraulic integrity of the system, along with any required long-term dredged or excavated material disposal areas, in a manner compatible with the project's authorized purposes, and in accordance with applicable Federal and State laws and regulations and any specific directions prescribed by the Federal Government.

(4) Give the Government a right to enter, at reasonable times and in a reasonable manner, upon property that the non-Federal sponsor owns or controls for the purpose of completing, operating, maintaining, repairing, replacing, or rehabilitating the project.

(5) Assume responsibility for operating, maintaining, replacing, repairing, and rehabilitating (OMRR&R) the project or completed functional portions of the project, including mitigation features without cost to the Government, in a manner compatible with the project's authorized purpose and in accordance with applicable Federal and State laws and specific directions prescribed by the Government in the OMRR&R manual and any subsequent amendments thereto.

(6) Comply with Section 221 of Public Law 91-611, Flood Control Act of 1970, as amended, and Section 103 of the Water Resources Development Act of 1986, Public Law 99-662, as amended, which provides that the Secretary of the Army shall not commence the construction of any water resources project or separable element thereof, until the non-Federal sponsor has entered into a written agreement to furnish its required cooperation for the project or separable element.

(7) Hold and save the United States free from all damages arising from the construction, operation, and maintenance of the project and any betterments, except for damages due to the fault or negligence of the United States or its contractors.

(8) Keep and maintain books, records, documents, and other evidence pertaining to costs and expenses incurred pursuant to the project to the extent and in such detail as will properly reflect total project costs, and in accordance with the standards for financial management systems set forth in the Uniform Administrative Requirements for Grants and Cooperative Agreements to State and Local Governments in 32 CAR Section 33.20.

(9) Perform, or cause to be performed, any investigations for hazardous substances as are determined necessary to identify the existence and extent of any hazardous substances regulated under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), 42 U.S.C. 9601-9675, that may exist in, on, or under lands, easements, or rights-of-way that the Federal Government determines to be necessary for the construction, operation, and maintenance of the project. However, for lands that the Government determines to be subject to the navigation servitude, only the Government shall perform such investigation unless the Federal Government provides the non-Federal sponsor with prior specific written direction, in which case the non-Federal sponsor shall perform such investigations in accordance with such written direction.

(10) Assume complete financial responsibility, as between the Federal Government and the non-Federal sponsor, for all necessary cleanup and response costs of any CERCLA regulated materials located in, on, or under lands, easements, or rights-of-way that the Federal Government determines to be necessary for the construction, operation, or maintenance of the project.

(11) To the maximum extent practicable, operate, maintain, repair, replace, and rehabilitate the project in a manner that will not cause liability to arise under CERCLA.

(12) Prevent future encroachments on project lands, easements, and rights-of-way which might interfere with the proper functioning of the project.

(13) Comply with the applicable provisions of the Uniform Relocation Assistance and Real Property Acquisition Policies Act of 1970, Public Law 91-646, as amended by Title IV of the Surface Transportation and Uniform Relocation Assistance Act of 1987 (Public Law 100-17), and the Uniform Regulations contained in 49 CAR Part 24, in acquiring lands, easements, and rights-of-way, required for

construction, operation, and maintenance of the project, including those necessary for relocations, borrow materials, and dredged or excavated material disposal, and inform all affected persons of applicable benefits, policies, and procedures in connection with said act.

(14) Comply with all applicable Federal and State laws and regulations, including, but not limited to, Section 601 of the Civil Rights Act of 1964, Public Law 88-352 (42 U.S.C. 2000d), and Department of Defense Directive 5500.11 issued pursuant thereto, as well as Army Regulation 600-7, entitled "Nondiscrimination on the Basis of Handicap in Programs and Activities Assisted or Conducted by the Department of the Army."

(15) Provide 35 percent of that portion of total cultural resource preservation mitigation and data recovery costs attributable to flood control that are in excess of 1 percent of the total amount authorized to be appropriated for flood control, and provide 50 percent of that portion of total cultural resource preservation mitigation and data recovery costs attributable to recreation that are in excess of 1 percent of the total amount authorized to be appropriated for recreation.

The plans presented herein are recommended with such modifications thereof as in the discretion of the Commander, HQUSACE, may be advisable.

The recommendations contained herein reflect the information available at this time and current Departmental policies governing formulation of individual projects. They do not reflect program and budgeting priorities in the formulation of a national Civil Works construction program nor the perspective of higher review levels within the Executive Branch. Consequently, the recommendations may be modified before they are transmitted to the Congress as proposals for authorization and implementation funding. However, prior to transmittal to the Congress, the non-Federal sponsors, the States, interested Federal agencies, and other parties will be advised of any modifications and will be afforded an opportunity to comment further.

John P. Carroll
Colonel
Corps of Engineers
District Engineer

[This page left intentionally blank.]