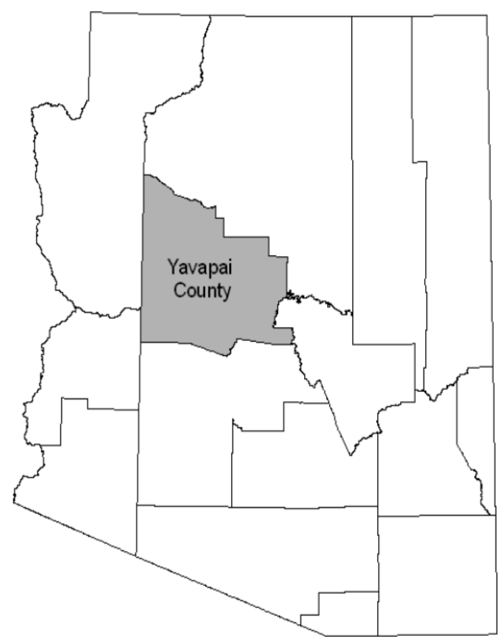
FLOOD INSURANCE STUDY

YAVAPAI COUNTY, ARIZONA
AND INCORPORATED AREAS
VOLUME 1 OF 5



COMMUNITY NAME	COMMUNITY NUMBER
CAMP VERDE, TOWN OF	040131
CHINO VALLEY, TOWN OF	040094
CLARKDALE, TOWN OF	040095
COTTONWOOD, CITY OF	040096
DEWEY-HUMBOLDT, TOWN OF	040061
*JEROME, TOWN OF	040138
PRESCOTT, CITY OF	040098
PRESCOTT VALLEY, TOWN OF	040121
SEDONA, CITY OF	040130
YAVAPAI COUNTY (UNINCORPORATED AREAS)	040093

*No Special Flood Hazard Areas Identified

Revised:
October 16, 2015

Federal Emergency Management Agency

FLOOD INSURANCE STUDY NUMBER
04025CV001D

NOTICE TO
FLOOD INSURANCE STUDY USERS

Communities participating in the National Flood Insurance Program have established repositories of flood hazard data for floodplain management and flood insurance purposes. This Flood Insurance Study (FIS) may not contain all data available within the repository. It is advisable to contact the community repository for any additional data.

Part or all of this FIS may be revised and republished at any time. In addition, part of this FIS may be revised by the Letter of Map Revision process, which does not involve republication or redistribution of the FIS. It is, therefore, the responsibility of the user to consult with community officials and to check the community repository to obtain the most current FIS components.

This FIS report was revised on October 16, 2015. Users should refer to Section 10.0, Revisions Description, for further information. Section 10.0 is intended to present the most up-to-date information for specific portions of this FIS report. Therefore, users of this FIS report should be aware that the information presented in Section 10.0 supersedes information in Sections 1.0 through 9.0 of this FIS report.

Initial Countywide FIS Effective Date:	June 6, 2001	
Revised Countywide FIS Dates:	September 3, 2010	(This revision is described in the text of the FIS report rather than in Section 10)
	October 16, 2014	
	March 2, 2015	
	October 16, 2015	

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FLOOD INSURANCE STUDY
YAVAPAI COUNTY, ARIZONA AND INCORPORATED AREAS

1.0 INTRODUCTION

1.1 Purpose of Study

This Flood Insurance Study (FIS) revises and updates information on the existence and severity of flood hazards in the geographic area of Yavapai County, Arizona, including the Cities of Cottonwood, Prescott, and Sedona; the Towns of Camp Verde, Chino Valley, Clarkdale, Dewey-Humboldt, Jerome, and Prescott Valley; and the unincorporated areas of Yavapai County (referred to collectively herein as Yavapai County). The City of Peoria is not included in this FIS report. See the separately published FIS report and Flood Insurance Rate Map (FIRM) for Maricopa County and Incorporated Areas, Arizona, for flood hazard information.

This FIS aids in the administration of the National Flood Insurance Act of 1968 and the Flood disaster Protection Act of 1973. This study has developed flood-risk data for various areas of the community that will be used to establish actuarial flood insurance rates and to assist the community in its efforts to promote sound floodplain management. Minimum floodplain management requirements for participation in the National Flood Insurance Program (NFIP) are set forth in the Code of Federal Regulations at 44 CFR, 60.3.

Please note that the City of Peoria is geographically located in Yavapai and Maricopa Counties.

Please note that the City of Sedona is geographically located in Yavapai and Coconino Counties. The portion of the City of Sedona shown within Yavapai County is included in this FIS report. See the separately published FIS report and FIRM for flood hazard information for the City of Sedona within Coconino County.

Please note that the Town of Jerome has no special flood hazard areas identified.

In some States or communities, floodplain management criteria or regulations may exist that are more restrictive or comprehensive than the minimum Federal requirements. In such cases, the more restrictive criteria take precedence and the State (or other jurisdictional agency) will be able to explain them.

1.2 Authority and Acknowledgments

The sources of authority for this Flood Insurance Study are the National Flood Insurance Act of 1968 and the Flood Disaster Protection Act of 1973.

This FIS was prepared to show the unincorporated areas of, and incorporated communities within, Yavapai County in a countywide FIS. Information on the authority and acknowledgments for each jurisdiction included in this countywide FIS, as compiled from their previous printed FIS reports, is shown below.

Camp Verde, Town of: the hydrologic and hydraulic analyses of the Verde River and Beaver Creek were taken from the Yavapai County FIS (U.S. Department of Agriculture, 1964) and performed by Henningson, Durham, and Richardson, Inc., for FEMA, under Contract No. H-4644. This work was completed in January 1981.

The study was revised September 27, 1991, to revise the flooding for West Clear Creek. The analyses required under the scope of work for West Clear Creek were performed by AGK Engineers, Inc., for FEMA, under Contract No. EMW-89-C-02839. This work was completed in May 1990.

This study was revised September 20, 1996, to incorporate the effects of a revised hydraulic analysis along the Verde River and new hydrologic and hydraulic analyses for Lucky Canyon Wash, Copper Canyon Wash, and Cherry Creek. This work was performed by Wood, Patel & Associates, Inc., for FEMA, under Contract No. EMW 93-C-4156, and was completed in July 1994.

Flooding of Cherry Creek was studied by detailed methods from the confluence with the Verde River upstream for approximately 1.5 miles. Lucky Canyon Wash was studied from the Verde River upstream approximately 0.5 mile; Copper Canyon Wash was studied from the Verde River upstream approximately one mile; and the Verde River was studied from Cross Section L upstream to the Town of Camp Verde corporate limits. Flooding sources studied by approximate methods included portions of Cherry Creek, Lucky Canyon Wash, Verde River, Beaver Creek, and West Clear Creek.

The study was revised again on December 19, 1997, to add road names and correct errors in the description of ERM

218. The Yavapai County Flood Control District requested these changes. No changes to flood-hazard information were made as part of this revision.

Chino Valley, Town of: the hydrologic and hydraulic analyses for the original study were performed by the U.S. Army Corps of Engineers (USACE), Los Angeles District, for FEMA, under Interagency Agreement No. EMW-87-E-2549. This work was completed in 1989.

Clarkdale, Town of: the hydrologic and hydraulic analyses for the original study were performed by Cella, Barr, Evans, & Associates, for FEMA, under Contract No. H-4607. This work was completed in November 1979.

Cottonwood, City of: Cella, Barr, Evans & Associates, performed the hydrologic and hydraulic analyses for the original study for FEMA, under Contract No. H-4607. This work was completed in November 1979.

The hydrologic and hydraulic analyses for the November 19, 1987 revision of the City of Cottonwood study were performed by Cella, Barr, Evans and Associates, for FEMA, under Contract No. EMW-85-C-1909. This work was completed in March 1986.

Dewey-Humboldt, Town of: the September 20, 1996 revision of Yavapai County (unincorporated areas) incorporated the effects of new hydrologic and hydraulic analyses for Texas Wash near the Town of Dewey-Humboldt. Sections of Texas Gulch were studied by approximate methods. This work was performed by Wood, Patel, & Associates, Inc., for FEMA, under Contract No. EMW-93-C-4156 and was completed in July 1994.

Prescott, City of: the hydrologic and hydraulic analyses for the original study were performed by the USACE, Los Angeles District, for FEMA, under Interagency Agreement No. IAA-H-2-73, Project Order No. 4. This work was completed in 1973.

In the March 29, 1983 revision, updated hydrologic and hydraulic analyses for Willow, Aspen, and Manzanita Creeks were completed in 1982. A revised hydraulic analysis for Willow Creek, between Willow Creek Road and Lorraine Drive, was completed in 1984 and published on September 4, 1985.

In the March 16, 1986 revision, updated analyses for Willow Creek from Willow Creek Road to the City of Prescott corporate limits were performed by Cella, Barr, Evans & Associates, for FEMA, under Contract No. EMW-85-C-1909. Detailed studies of Willow Creek Tributary and Willow Creek Reservoir Tributary were incorporated into the third revision in 1986, as was a revised hydraulic analysis of Willow Creek. This work was completed in December 1986.

In the August 19, 1991 revision, a detailed analysis was conducted for a portion of Granite Creek from its confluence with Watson Lake to Highway 89. The USACE, Los Angeles District, performed the hydrologic and hydraulic analyses, for FEMA, under Interagency Agreement No. EMW-88-E-2768, Project Order No. 8, EMW-89-2994, and EMW-87-E-2549. This work was completed in December 1989.

Prescott Valley, Town of: Henningson, Durham & Richardson, Inc. performed the hydrologic and hydraulic analyses for the Agua Fria River and Navajo Drive Wash for FEMA under Contract No. H-4644. This work was completed in April 1981.

The analyses for North Navajo Drive Wash were performed by the USACE, Los Angeles District, for FEMA, under Interagency Agreement No. EMW-87-E-2549, Project Order No. 8. This work was completed in March 1988.

Sedona, City of: the hydrologic and hydraulic analyses for Oak Creek was performed by Henningson, Durham & Richardson, Inc., for FEMA, under Contract No. H-4644. This study was completed in January 1981.

Yavapai County (Unincorporated Areas): the hydrologic and hydraulic analyses for the original study of the unincorporated areas of Yavapai County were performed by Henningson, Durham & Richardson, Inc., for the Federal Emergency Management Agency (FEMA), under Contract No. H-4644. This study was completed in January 1981, and covered all significant flooding sources affecting the unincorporated areas of Yavapai County, with the exception of the Verde River in the Town of Clarkdale. The hydrologic and hydraulic analyses for this area were performed by Cella, Barr, Evans & Associates, as determined for the Flood Insurance Study for the Town of Clarkdale (FEMA, 1982).

In the May 18, 1992 revision, hydraulic analyses for South Rocky Boy Wash were prepared by AGK Engineers, Inc., for FEMA, under Contract No. EMW-89-C02839. This work was completed in August 1990.

The September 20, 1996 revision incorporated the effects of a revised hydraulic analysis along Miller Creek and new hydrologic and hydraulic analyses for the East Tributary of Chino Valley Stream, several tributaries of Big Chino Wash, Texas Wash near the Town of Dewey-Humboldt, and Zalesky Wash near the community of Bridgeport. In addition the West Tributary of Chino Valley Stream, sections of Texas Gulch, and sections of Zalesky Wash were studied by approximate methods. This work was performed by Wood, Patel & Associates, Inc., for FEMA, under Contract No. EMW-93-C-4156 and was completed in July 1994.

The September 20, 1996 revision also incorporated the effects of updated topographic information and an improved hydraulic analysis along Miller Creek and Model Creek. Miller Creek was studied from its confluence with Model Creek to approximately 6,500 feet upstream of U.S. Route 89. Model Creek was studied from its confluence with Miller Creek to approximately 3,500 feet upstream of U.S. Route 89. This work, performed by Erie & Associates, was completed in July 1995.

The December 19, 1997 revision incorporated the effects of a detailed hydraulic analysis along Big Chino Wash, Santa Cruz Wash, and Chino Valley Stream. Big Chino Wash was studied from the Sullivan Lake Spillway to approximately 700 feet upstream of U.S. Route 89. Santa Cruz Wash was studied from its confluence with Big Chino Wash to just downstream of Road 5 North. Chino Valley Stream was studied from its confluence with Santa Cruz Wash to approximately 7,800 feet upstream of U.S. Route 89. The revision of this study also added flood hazards along Tributaries 100, 200, 300, and Santa Cruz Wash upstream of Road 5 North. This revision also incorporated additional road names and corrected errors in descriptions of Elevation Reference Marks (ERMs). The Yavapai County Flood Control District requested these corrections.

The June 8, 1998 revision incorporated updated topographic information for Wet Beaver Creek and Russell Wash. Modifications were made to the floodplain and floodway boundary delineation and 1-percent annual chance (100-year) flood elevations along Wet Beaver Creek and Russell Wash. The changes to Wet Beaver Creek were made from approximately 8,800 feet downstream to approximately 2,350 feet downstream of Montezuma Avenue. Changes were made along Russell Wash from its confluence with Wet Beaver Creek to approximately 1,600 feet upstream of Montezuma Avenue.

The March 9, 1999 revision incorporated the effects of detailed hydrologic and hydraulic analyses along Dry Creek from approximately 1,500 feet downstream to approximately 2,000 feet upstream of Sunset Hills Drive. The revision also included information about the construction of a levee along the left bank (looking downstream) from approximately 100 feet upstream to approximately 1,600 feet upstream of Sunset Hills Drive.

The hydrologic and hydraulic study for Blue Tank Wash, Powder House Wash Tributaries 1 and 2, and Wash P, was developed by Black & Veatch, Inc., and Coe & Van Loo Consultants, Inc., for the Maricopa County Flood Control District. The results of the study are presented in the technical report entitled, "Wickenburg Area Drainage Master Study: Technical Documentation Report and Appendices 1.1 through 6.20," dated May 1994, updated January 4, 1995, and shown on the topographic maps entitled, "Flood Control District of Maricopa County - Floodplain Delineation for Wickenburg Area Master Drainage Study, Contract FCD 89-79," dated June 1994. Since study reaches for these four streams extended into Yavapai County from Maricopa County, the results of the above referenced study were included in the revision of Yavapai County.

Revised hydrologic and hydraulic analyses were performed for Sols Wash, which passes through the Town of Wickenburg in Maricopa County and extends into Yavapai County for a reach of approximately 8,800 feet. This work was done by Cella, Barr, Evans & Associates for FEMA under Contract No. EMW-85-C-1909 and was completed in December 1986.

The revised analyses for the September 3, 2010, revision was completed by MAPIX-Mainland for FEMA under contract number EMF-2003-CO-0047 to update corporate limits, to change Special Flood Hazard Areas, to update roads and road names, and to incorporate previously issued Letters of Map Revision.

1.3 Coordination

The dates of the initial, intermediate, and final Consultation Coordination Officer (CCO) meetings held for Yavapai County and the incorporated communities are shown in Table 1, "CCO Meeting Dates for Precountywide FISs."

TABLE 1 – CCO MEETING DATES FOR PRECOUNTYWIDE FIS

Community Name	For FIS Dated	Initial CCO Date	Intermediate CCO Date	Final CCO Date
Camp Verde, Town of	August 19, 1985	[1]	[1]	[1]
	September 27, 1991	August 10, 1988	June 13, 1989	December 10, 1990
	September 20, 1996	[1]	[1]	[1]
	December 19, 1997	[1]	[1]	[1]
	June 6, 2001	[1]	[1]	[1]
Chino Valley, Town of	September 1, 1981	[1]	[1]	[1]
	May 4, 1992	August 10, 1988	[1]	June 27, 1991
	June 6, 2001	[1]	[1]	[1]
Clarkdale, Town of	December 1, 1982	August 8, 1977	[1]	January 24, 1980
	June 6, 2001	[1]	[1]	[1]
Cottonwood, City of	September 16, 1981	August 8, 1977	January 24, 1980	[1]
	November 19, 1987	[1]	December 11, 1984	May 5, 1986
	June 6, 2001	[1]	[1]	[1]
Dewey-Humboldt, Town of	August 19, 1985[2]	May 5, 1978[2]	December 22, 1980[2]	January 12-13, 1982[2]
	September 20, 1996[2]	[1]	[1]	[1]
	December 19, 1997[2]	[1]	[1]	[1]
	June 6, 2001[2]	[1]	[1]	[1]
Prescott, City of	February 2, 1977	[1]	[1]	[1]
	March 29, 1983	[1]	[1]	[1]
	September 4, 1985	[1]	[1]	[1]
	March 16, 1988	December 11, 1984	[1]	May 5, 1986
	August 19, 1991	August 10, 1988	[1]	[1]
	June 6, 2001	[1]	[1]	[1]
Prescott Valley, Town of	August 16, 1982	May 5, 1978	November 6, 1980	[1]
	July 16, 1990	[1]	[1]	October 5, 1987
	June 6, 2001	[1]	[1]	[1]

[1]Data not available

[2]Information for the CCO meeting dates for the Town of Dewey-Humboldt is taken from Yavapai County.

TABLE 1 – CCO MEETING DATES FOR PRECOUNTYWIDE FIS - continued

Community Name	For FIS Dated	Initial CCO Date	Intermediate CCO Date	Final CCO Date
Prescott Valley, Town of	August 16, 1982	May 5, 1978	November 6, 1980	[1]
	July 16, 1990	[1]	[1]	October 5, 1987
	June 6, 2001	[1]	[1]	[1]
Sedona, City of	August 19, 1975[3]	[1]	[1]	[1]
	March 9, 1999[3]	[1]	[1]	[1]
	June 6, 2001[3]	[1]	[1]	[1]
Yavapai County (Unincorporated Areas)	August 19, 1985	May 5, 1978	December 22, 1980	January 12-13, 1982
	May 18, 1992	August 10, 1988	June 13, 1989 April 18, 1980	June 27, 1991
	September 20, 1996	[1]	[1]	[1]
	December 19, 1997	[1]	[1]	[1]
	June 8, 1998	[1]	[1]	[1]
	March 9, 1999	[1]	[1]	[1]
	June 6, 2001	[1]	[1]	[1]

[1]Data not available
[3]Information for the CCO meeting dates for the City of Sedona is taken from Yavapai County.

For the countywide FIS, final CCO meetings were held January 7, 2008. These meetings were attended by representatives of the study contractors, the communities, the State of Arizona, FEMA, and MAPIX-Mainland.

Contact was maintained during the course of the studies with the USACE, the NRCS, the Arizona Department of Transportation, and the Town Manager of Prescott Valley. Tile Arizona Water Commission served as the State Coordinating agency for this study. Information for the North Navajo Drive Wash study was obtained from the Town of Prescott Valley Planning and Zoning Department. A pre-contract meeting was held on July 1, 1987, to determine the areas of the community to be included in this restudy. Representatives of the Town of Prescott Valley and FEMA were present at this meeting.

2.0 AREA STUDIED

2.1 Scope of Study

This FIS covers the geographic area of Yavapai County, Arizona, including the incorporated communities listed in Section 1.1. The areas studied by detailed methods were selected with priority given to all known flood hazards and areas of projected development or proposed construction. Streams studied by detailed methods are shown in Table 2, "Streams Studied by Detailed Methods".

TABLE 2 – STREAMS STUDIED BY DETAILED METHODS

Agua Fria River
American Wash
Ash Fork Draw Wash
Ash Fork Draw Wash
Aspen Creek
Beaver Creek
Big Bug Creek
Big Chino Wash
Big Chino Wash Irrigation Split
Big Chino Wash Overflow
Big Chino Wash Spill #1
Big Chino Wash U.S. Route 89 Overflow
Bitter Creek
Bitter Creek South Fork
Black Canyon Creek
Blue Tank Wash
Boynton Canyon
Butte Creek
Cougar Creek
Cherry Creek
Chino Valley Stream
Chino Valley Stream East
Chino Valley Stream (Tributary)
Chino Valley Stream (with Levee)
Clayton Canyon Wash
Clipper Wash
Copper Canyon Wash
Dead Mule Canyon Wash
Deception Wash
Del Monte Wash
Dry Creek
Dry Beaver Creek
Dry Well Wash
Granite Creek
Green Wash
Hassayampa River
Jacks Canyon
J.W. Draw
Lonesome Valley Wash
Lonesome Valley Wash Tributary Reach 100
Lonesome Valley Wash Tributary Reach 200
Lonesome Valley Wash Tributary Reach 330
Lonesome Valley Wash Tributary Reach 350
Lonesome Valley Wash Tributary Reach 360
Lonesome Valley Wash Tributary Reach 405
Lonesome Valley Wash Tributary Reach 500
Lower Kelly Wash
Lucky Canyon Wash
Lynx Creek
Manzanita Creek
Martinez Wash
Miller Creek
Mint Wash
Model Creek
Mud Springs Wash
Navajo Drive Wash
North Fork Granite Creek
North Fork Miller Creek
North Navajo Drive Wash
North Tributary to South Branch Agua Fria River
Oak Creek
Oak Wash
Powder House Wash Tributary 1
Powder House Wash Tributary 2
Railroad Wash
Ramsgate Wash
Robert Wash
Russell Wash
Santa Cruz Wash
Silver Springs Gulch
Skull Valley Wash
Sols Wash
South Branch Agua Fria River
South Rocky Boy Wash
Spring Creek
Squaw Creek
Telephone Tank Wash
Telephone Tank Wash Breakout
Texas Gulch Main Stream
Texas Gulch West Branch
Timon Wash
Verde River
Wash P
West Clear Creek
West Fork Miller Creek
Wet Beaver Creek
Williamson Valley Wash
Williamson Valley Wash North Split
Willow Creek
Willow Creek Reservoir Tributary
Willow Creek Tributary
Zalesky Wash Main Stem

Flooding in the Yavapai, Hualapai, Camp Verde, Lower Camp Verde, and Middle Camp Verde Indian Reservations was included only as it pertained to flooding in surrounding areas. Outlying areas of Tonto National Forest, Coconino National Forest, and Prescott National Forest were not studied due to the lack of development in these areas (FEMA, 1999).

Minguez Wash, originally designated for detailed study; the study of the wash was terminated because the extent of the drainage-basin area contributing to this stream channel was less than one square mile, and the floodplain was less than 200 feet in width (FEMA, 1982).

Approximate analyses were used to study those areas having low development potential or minimal flood hazards. The scope and methods of study were proposed to, and agreed upon, by FEMA and the communities.

The September 3, 2010 revision incorporated the results of mappable LOMCs (i.e., Letters of Map Amendment and LOMRs) issued by FEMA for the projects listed in Table 3, "Letters of Map Change."

TABLE 3 – LETTERS OF MAP CHANGE

Community	Flooding Source(s)/Project Identifier	Date Issued	Type
Town of Chino Valley	Chino Hills Subdivision	February 27, 2007	LOMR
Town of Cottonwood	Tom Pender	July 20, 2009	LOMR
City of Prescott	Timber Creek Villas	December 26, 2008	LOMR
City of Prescott	Centerpointe South	February 21, 2008	LOMR
City of Prescott	The 6th Street Condominium Warehouses	May 21, 2007	LOMR
Town of Prescott Valley	Pronghorn Ranch LOMR	July 30, 2009	LOMR
Town of Prescott Valley	Poquito Valley Flood Hazard Study	June 27, 2008	LOMR
Town of Prescott Valley	Orchard Ranch	May 9, 2008	LOMR
Town of Prescott Valley	Antelope Meadows Subdivision	April 14, 2008	LOMR
Town of Prescott Valley	Prescott Valley Lots 7387, 7388, 7389	December 14, 2007	LOMR
Town of Prescott Valley	Quailwood Meadows	October 25, 2007	LOMR
Town of Prescott Valley	Quailwood Meadows Subdivision	August 31, 2006	LOMR
Town of Prescott Valley	Navajo Wash Channel Improvements	August 25, 2006	LOMR
Town of Prescott Valley	Granville Agua Fria River	October 14, 2004	LOMR

TABLE 3 – LETTERS OF MAP CHANGE – continued

Community	Flooding Source(s)/Project Identifier	Date Issued	Type
Yavapai County (Unincorporated Areas)	APN: 103-01-221V, Stock Tank Removal	October 6, 2008	LOMR
Yavapai County (Unincorporated Areas)	Poquito Valley Flood Hazard Study	June 27, 2008	LOMR
Yavapai County (Unincorporated Areas)	Orchard Ranch	May 9, 2008	LOMR
Yavapai County (Unincorporated Areas)	Antelope Meadows Subdivision	April 14, 2008	LOMR
Yavapai County (Unincorporated Areas)	Wickenburg Ranch	April 17, 2008	LOMR
Yavapai County (Unincorporated Areas)	DBC Floodplain	March 20, 2008	LOMR
Yavapai County (Unincorporated Areas)	Quailwood Meadows	October 25, 2007	LOMR
Yavapai County (Unincorporated Areas)	Mint Wash	September 27, 2007	LOMR
Yavapai County (Unincorporated Areas)	American Wash and Mint Wash	June 27, 2007	LOMR
Yavapai County (Unincorporated Areas)	Floodplain Delineation Study of Wet Beaver Creek	October 28, 2004	LOMR
Yavapai County (Unincorporated Areas)	Red River Road Wash	September 6, 2004	LOMR

2.2 Community Description

Yavapai County encompasses approximately 5.2 million acres in north-central Arizona. It is bounded on the north and east by Coconino County, on the east by Gila Counties, on the south by Maricopa County, and on the west by Mohave and La Paz Counties. The City of Prescott is the county seat and is located approximately 97 miles north of Phoenix (U.S. Department of Agriculture, 1978).

According to the U.S. Census Bureau, in 2012 the population estimate for Yavapai County was 212,637 (U.S. Census Bureau, 2013).

The largest percentage of the work force in the county is employed by the educational services, and health care and social assistance sector. The economy is well diversified from mining of copper, gold, silver, lead, and zinc to the fast-growing manufacturing sector. Livestock grazing is the principal agricultural activity. To support the growth in population, the arts, entertainment, and recreation, and accommodation and food services is the second largest sector (U.S. Census Bureau, 2013).

In general, the topography is moderately steep with steep hills and mountains interspersed with nearly level to strongly sloping valley plains and stream floodplains. The Verde, Agua Fria, Hassayampa, and Santa Maria Rivers and their tributaries are the principal drainages in the county and are in the north and eastern, south central, southwestern, and western portions of the county, respectively (U.S. Department of Agriculture, 1978). Climate, soils, and vegetation all vary with respect to the elevation and latitude.

Elevations range from approximately 2,000 feet in the desert in the southwestern portion of the county to 7,971 feet on top of Mount Union south of the City of Prescott. With this drastic increase in elevation the mean daily maximum temperature for the year ranges from 100 degrees Fahrenheit (°F) to 51°F and the mean daily minimum ranges from 55.9°F to 20°F. Extremes have ranged from 116°F in the deserts to -21°F in Prescott (Sellers and Hill, 1973).

Soils in the county can generally be broken into five groups:

> Arid Uplands with moderately coarse and fine-textured soils with cemented lime layers at moderate to shallow depths;
>
> Arid Mountains with shallow, gravelly, fine or moderately coarse-textured soils on bedrock of andesite, basalt, granite, schist, or limestone. Rock outcrop occurs on steeper slopes;
>
> Semiarid Uplands with a range of soils that are deep, fine- or medium-textured cobbly loam, stony clay or loamy soils with some areas having basalt bedrock or cemented lime layers at moderate to shallow depths;
>
> Semiarid Mountains with shallow, stony, medium and fine-textured gravelly soils on bedrock of basalt, andesite, tuff agglomerate, weathered granite, fractured schist, limestone or sandstone, Rock outcrop occurs on the steeper slopes; and
>
> Subhumid Mountains with moderate to deep and deep, stony, moderately coarse and fine-textured soils on granite, schist, or basalt bedrock.

Vegetation changes from a sparse cover of desert shrubs and cacti at the lower elevations to chaparral, grass, or pinyon-juniper in intermediate areas. On higher mountains the vegetation consists of a mixture of pine, oak, and scattered stands of fir trees. Vegetation changes within short distances due to differences in elevation, rainfall, and temperature (U.S. Department of Agriculture, 1978).

Precipitation in the study area is produced by general winter, general summer, and local storms. General winter storms normally occur over the southwestern United States during the cooler months of November through March as extratropical cyclones move inland from the Pacific Ocean, spreading light to moderate precipitation over large areas for several days. Orographic effects are usually quite pronounced with the mountain receiving greater precipitation than the lower elevations. Much of the precipitation in the higher elevations also falls as snow during this type of storm.

At times, however, warm heavy rain can fall on top of a ripe snow-pack creating conditions favorable for heavy runoff. General summer storms normally occur between July and October and may be associated with a tropical storm. These storms usually consist of general steady or intermittent rain over large areas, with moderate to heavy thunderstorms often embedded. Local storms are defined as rainstorms of high to very high intensity, occurring over small areas for short durations. They are most common during the summer months, but can occur at any time of the year (USACE, 1976). Mean annual precipitation ranges from approximately 10 inches in the desert to over 27 inches in the mountains. The mean annual snow, sleet, and hail total for the mountains ranges between 40 and 50 inches. Crown King station recorded a monthly extreme of 116.1 inches in January 1941 (Sellers and Hill, 1973).

Development of the floodplain varies. Most of the land along the study streams is either agricultural or undeveloped. However, many areas have mobile homes, houses and/or commercial structures as well as public utilities, roads, and bridges located in the floodplain.

2.3 Principal Flood Problems

Flooding occurs as a result of discharges in excess of channel capacities, and in some cases from backwater from restrictive bridges. The following descriptions contain information on the principal flooding problems and historical flooding.

For the smaller drainage area streams, local storms, predominately during the late summer months, cause the most severe flooding. With the exception of Pacific Tropical Storm Norma in September 1970, major flooding in the larger basins occurs from the general winter storms with snowmelt.

Flooding records date back to 1890 for the Hassayampa River and 1891 for the Verde River. Six of the detailed study streams were correlated with information obtained from the USGS stream gages.

The stream name, date, discharge, and estimated recurrence interval for some of the larger peak discharges recorded are shown in Table 4, "Historic Recorded Discharges".

TABLE 4 – HISTORIC RECORDED DISCHARGES

GAGING STATION	SQUARE MILES	DATE	DISCHARGE	RECURRENCE INTERVAL
Agua Fria River At Rock Springs	1,130	September 5, 1970	40,100	– –[1]
		March 2, 1978	39,500	
		December 18, 1978	52,800	
		February 19, 1980	59,500	
Dry Beaver Creek	142	November 23, 1965	9,670	– –[1]
		January 25, 1969	10,600	
		September 5, 1970	26,600	
		December 18, 1978	24,200	
		February 14, 1980	18,600	
Granite Creek At the City of Prescott	– –[1]	September, 1983	8,300	– –[2]
Hassayampa River At Box Canyon	417	August 29, 1951	27,000	– –[1]
		September 5, 1970	58,000	
		March 2, 1978	16,000	
		February 19, 1980	24,900	
Oak Creek Near Cornville	357	December 30, 1951	17,200	7
		November 25, 1965	17,600	10
		December 6, 1966	19,200	13
		September 5, 1970	24,700	17
		March 1, 1978	17,400	5
		December 19, 1978	25,100	28
		February 19, 1980	26,400	75
Oak Creek At the City of Sedona	– –[1]	February 15, 1980	18,000	– –[2]
		February 19, 1980	25,000	
		1993	23,200	
		1995	17,100	
		2004	19,000	
Verde River At the Town of Camp Verde[3]	4,220	February 21, 1920	60,000	– –[1]

[1]Data not available
[2]Recurrence intervals are included in Section 2.3
[3]Non-concurrent records from three separate gaging stations

TABLE 4 – HISTORIC RECORDED DISCHARGES - continued

GAGING STATION	SQUARE MILES	DATE	DISCHARGE	RECURRENCE INTERVAL
Verde River				
Downstream of	4,670	September 5 ,1970	43,000	– –[1]
the Town of		October 20, 1972	40,600	
Camp Verde[3]		March 1, 1978	41,000	
		December 19, 1978	55,000	
		February 15, 1980	50,900	
Verde River				
Near the Town of	5,024	February 7, 1937	41,700	– –[1]
Camp Verde[1]		March 3, 1938	97,000	
		March 14, 1941	30,000	
Verde River			22,500	
At the Town of	– –[1]	December 6, 1967	35,500	– –[2]
Clarkdale		March 8, 1918	50,600	
		February 20, 1920	25,000	
		February 7, 1980		
Verde River				
Near the Town of	3,520	March 8, 1918	35,500	50
Clarkdale		February 21, 1920	50,600	133
		December 6, 1966	22,500	7
		March 1, 1978	25,000	11
		December 18, 1978	19,900	6
		February 15, 1980	30,100	21
West Clear Creek				
At the Town of	– –[1]	October 19, 1972	11,300	– –[2]
Camp Verde		February 9, 1976	8,130	
		March 1, 1978	13,800	
		December 18, 1978	22,400	
		February 19, 1980	15,100	
		March 12, 1982	9,890	
		November 30, 1982	6,700	

[1]Data not available
[2]Recurrence intervals are included in Section 2.3
[3]Non-concurrent records from three separate gaging stations

TABLE 4 – HISTORIC RECORDED DISCHARGES - continued

GAGING STATION	SQUARE MILES	DATE	DISCHARGE	RECURRENCE INTERVAL
West Clear Creek At the Town of Camp Verde	– –[1]	October 19, 1972	11,300	– –[2]
		February 9, 1976	8,130	
		March 1, 1978	13,800	
		December 18, 1978	22,400	
		February 19, 1980	15,100	
		March 12, 1982	9,890	
		November 30, 1982	6,700	
Wet Beaver Creek	111	November 25, 1965	6,150	– –[1]
		September 5, 1970	7,670	
		October 19, 1972	5,490	
		March 1, 1978	4,360	
		December 18, 1978	7,560	
		February 19, 1980	10,900	
		November 30, 1982	5,480	

[1]Data not available
[2]Recurrence intervals are included in Section 2.3
[3]Non-concurrent records from three separate gaging stations

Due to the uncontrolled building next to low flow channels, even minor flooding has destroyed public and private property. Millions of dollars in damage has added up through the years.

Aggravation of flooding problems varies with the location of the stream within the county. In the southern portion of the county, extremely sandy overbanks are highly vulnerable to erosion and shifting of the channel. In the gradually sloping grass valleys, low flow channels usually cannot contain the smaller events, leading to an overbank, shallow flooding condition. The mountainous regions have higher ground slopes that increase flooding velocities to extremely dangerous conditions. Except for the gradually sloping valleys, stream velocities throughout the county are capable of causing severe erosion to streambeds, streambanks, bridge piers and abutments, and culverts, and carry heavy debris.

Natural obstructions to floodflows in many areas of the county include brush, large trees, and/or other vegetation growing along the stream banks. Uncontrolled building adjacent to the low flow channels and in the floodplain, mobile homes, campers, trailers, lumber, and other common items create additional problems. The natural and manmade debris can collect on bridges, culverts, pipelines, buildings, and fences, increasing the water-surface elevation and creating additional pressure on the structure that could destroy it.

The Verde Lakes Estates in the Town of Camp Verde experienced severe flooding from West Clear Creek in September 1970, December 1971, October 1972, February 1976, and February 1980 (Sellers, W.D., Hill, R.H., and Sanderson-Raw, M., 1986; USACE, 1975; FEMA, 1985, Preliminary 1991). The peak discharges are shown in Table 4. The 1980 flood was so severe that channel alignment and grade were significantly altered. This alteration occurred after the mapping used for the 1985 Flood Insurance Study was completed in 1978 (FEMA, 1985, Preliminary 1991).

Historic peak discharges at the USGS West Clear Creek gaging station, near the Town of Camp Verde, are shown chronologically for the seven historic ranked annual discharges in 23 years of record (see Table 4).

No significant flood-related losses, either in lives or property, have been recorded since the Town of Chino Valley was founded in 1971. The heaviest rainfall of the year usually occurs between July and September, but there are also secondary storms that come in from the Pacific Coast during the later winter months. The winter snows dissipate rapidly due to the dry air. Both thunderstorms and rapid snowmelt conditions are potential flood problems. The Town of Chino Valley is subject to hazards produced by rainfall in the nearby City of Prescott.

Historic records of major floodflow events in the Town of Clarkdale area indicate that many of these flows have resulted in relatively little damage to property.

Historic floodflow events recorded on the Verde River are shown in Table 4, “Historic Recorded Discharges”. The discharge values have return periods between 10- and 2-percent annual chance events as determined from gage records (1916 through 1920 and 1966 through 1979) compiled by the USGS and subsequent log-Pearson Type III analysis. The February 21, 1920, event is the maximum flood of record and has an estimated recurrence interval of a 2-percent annual chance flood event. The February 7, 1980, flood event had a 20-year recurrence interval.

Historical records of major floodflow events in the City of Cottonwood area indicate that many of these flows resulted in relatively little damage to property and were mostly inconvenient in nature. The extensive development in the City of Cottonwood which has occurred since these events increases the likelihood that the resulting property damage would be much more significant. Significant flooding problems have occurred as a result of high magnitude floodflows on Del Monte Wash. This problem has occurred as a result of floodwaters breaking out of the channel at the East Main Street crossing and flowing downstream on the adjacent overbanks through the most highly developed portion of the City of Cottonwood. This breakout resulted from insufficient culvert capacity beneath the East Main Street crossing and from debris blockage of the culverts. On August 26, 1964, a high intensity rainfall event occurred over the Del Monte Wash drainage basin and resulted in a relatively large magnitude flood event. An excerpt from the "Verde Independent" on September 3, 1964, stated, "...this storm of August 26, alone dumped more than the 8-year average of 2.18 inches, falling in a 2-hour period. The day before the big storm 0.88 inch was reported in

Cottonwood." The 2.18-inch rainfall in a 2-hour period translates to approximately a 25-year event as determined by the hydrologic information for the City of Cottonwood presented by the study contractor.

Except for the flooding problems generated by significant development adjacent to Del Monte Wash, there have been relatively few historic floodflow events which have resulted in significant damage to life and property. Historically, there have been large magnitude floodflow events on the Verde River, which passes adjacent to the northern corporate limits of the City of Cottonwood. These events were recorded by the Town of Clarkdale (see Table 4, "Historic Recorded Discharges").

Principal flood damage in Prescott occurs along Granite and Miller Creeks (see Table 4, "Historic Recorded Discharges"). The worst flood in Prescott occurred in August 1963. Ten inches of rain was recorded and damage was estimated at $400,000.

In September 1983, flooding of Willow Creek in the City of Prescott caused significant bank erosion, although minimal property damage was sustained. According to the City of Prescott Department of Public Works (Robert Hardy, 1984), between 4.5 and 7.5 inches of rain fell in six hours, along with 10 inches of hail. The record gives an estimated storm frequency of between 150 and 300 years for what was assumed to be a 6-hour duration.

Principal flooding in the Town of Prescott Valley occurs along the Agua Fria River and its tributaries. As the Town of Prescott Valley lies in the extreme upper end of the Agua Fria River watershed, flooding problems are minimal. There have been no significant losses recorded, either in lives or property, due to flooding since the Town of Prescott Valley was founded. Both thunderstorms and rapid snowmelt conditions may cause potential flood problems in extreme situations (Sellers and Hill, 1973).

Significant flooding of Oak Creek occurred in the following years as recorded at the USGS gaging station at Cornville: 1885, 1938, 1952, 1956, 1964, 1967, 1969, 1970, 1976, 1978, 1979, 1980, 1993, 1995, and 2004. The 1980 floods (see Table 4) were estimated to have had approximately a 2-percent annual chance recurrence interval in the vicinity of the City of Sedona. Damage due to flooding has been mostly in the form of erosion and the resulting loss of land (FEMA, 1995).

2.4 Flood Protection Measures

All mappable flood protection structures or flood control devices existing within Yavapai County and for the Towns of Camp Verde, Chino Valley, Clarkdale, and Prescott Valley, and for the City of Cottonwood, have been incorporated onto the Flood Insurance Rate Map.

The large stock tanks located within several of the watersheds in the unincorporated areas of Yavapai County have an insignificant effect during major flooding events. There are floodplain management measures in effect for Yavapai County (FEMA, 1999).

Problems created by large magnitude floodflow events on Del Monte Wash in the City of Cottonwood are a result of inadequate culvert capacity at the main stream crossing.

An earthen levee exists on the north bank of Willow Creek between Willow Creek Road and Lorraine Drive in the City of Prescott. This levee was reconstructed at several sections in 1987, in order to provide protection from 1-percent annual chance floodflows for the Sandretto Hills Development, which is located along the north side of Willow Creek (FEMA, 1982, revised 1990).

An organization was formed in 1978 in the City of Sedona area to predict flooding of Oak Creek and warn residents living in the vicinity so that evacuation of floodprone areas could be possible. The main purpose of the organization was protect life. Several small dikes and riprapped embankments have been constructed by private landowners along Oak Creek to protect their property from inundation and erosion during floods.

There is a levee on the right bank (looking downstream) of Chino Valley Stream downstream of U.S. Route 89. Because the levee does not meet the requirements of Section 65.10 of the NFIP regulations, two flooding situations were evaluated for the 1-percent annual chance floodplain and floodway: flooding due to the levee failing and holding. Assuming the levee fails during the 1-percent annual chance flood, Chino Valley Stream will converge with Santa Cruz Wash, approximately 4,900 feet upstream of Old U.S. Route 89. Assuming the levee holds during the 1-percent annual chance flood, Chino Valley Stream will continue north along a different path for approximately 5,200 feet and converge with Santa Cruz Wash just upstream of Old U.S. Route 89. The floodway for Chino Valley Stream was determined assuming the levee fails during the 1-percent annual chance flood. Because Chino Valley Stream will follow a different path if the levee holds, a floodway was also determined for that reach.

The Towns of Chino Valley and Prescott Valley, and the Cities of Cottonwood, Prescott and Sedona have passed floodplain regulations or zoning ordinances designed to delineate areas of flood hazards and to guide and regulate development within flood hazard areas so as to restrict future flood damage and flood hazards.

3.0 ENGINEERING METHODS

For the flooding sources studied in detail in the county, standard hydrologic and hydraulic study methods were used to determine the flood hazard data required for this FIS. Flood events of a magnitude which are expected to be equaled or exceeded once on the average during any 10-, 50-, 100-, or 500-year period (recurrence interval) have been selected as having special significance for floodplain management and for flood insurance rates. These events, commonly termed the 10-, 50-, 100-, and 500-year floods, have a 10-, 2-, 1-, and 0.2-percent chance, respectively, of being equaled or exceeded during any year. Although the recurrence interval represents the long term average period between floods of a specific magnitude, rare floods could occur at short intervals or even within the same year. The risk of experiencing a rare flood increases when periods greater than 1 year are considered. For example, the risk of having a flood which equals or exceeds the 100-year flood (1-percent chance of annual exceedence) in any 50-year period is approximately 40 percent (4 in 10), and, for any 90-year period, the risk increases to approximately 60 percent (6 in 10). The analyses reported herein reflect flooding potentials based on conditions existing in the county at the time of completion of this FIS. Maps and flood elevations will be amended periodically to reflect future changes.

3.1 Hydrologic Analyses

Hydrologic analyses were carried out to establish peak discharge-frequency relationships for each flooding source studied by detailed methods affecting the communities.

For the unincorporated areas of Yavapai County, discharge-frequency analyses for all flooding sources studied in detail except the Verde River were developed using the NRCS computer program for Project Formulation- Hydrology (U.S. Department of Agriculture, 1964). This methodology uses basin physical characteristics, soil classification, cover conditions, and precipitation amount as parameters for developing runoff.

Each basin within Yavapai County was divided into subwatersheds with attention given to homogeneity, soil type, and cover conditions. Times of concentration were computed using Manning's equation to develop the velocity component. Drainage areas were measured using USGS topographic maps (U.S. Department of the Interior, 1965, et cetera; U.S. Department of the Interior, 1967 et cetera; U.S. Department of the Interior, 1947 et cetera; U.S. Department of the Interior, 1954 et cetera; USACE, 1978).

Soil classification and cover conditions were determined through field surveys and the following publications: General Soil Map, Yavapai County, Arizona (U.S. Department of Agriculture, May 1972); General Soil Map, Coconino County, Arizona (U.S. Department of Agriculture, 1976); Soil Survey of Yavapai County, Arizona, Western Part (U.S. Department of Agriculture, 1967); Soil Survey, Beaver Creek Area, Arizona (U.S. Department of Agriculture, 1974); and Soil Survey, Long Valley Area, Arizona (U.S. Department of Commerce, 1973). Antecedent moisture condition 2 was used for the soil moisture content. The National Oceanic and Atmospheric Administration Atlas 2 (USACE, February 1977) was used to select rainfall amount for the 10-, 2-, and 1-percent annual chance events. The 0.2-percent annual chance rainfall amount was derived on extreme probability paper from extrapolation of a line through the plotted 10-, 2-, and 1-percent annual chance values.

Discharges for some study streams were modified after reviewing the hydrologic results with the USACE. The difference in discharges for six study streams developed by the USACE and the study contractor were considered negligible and, therefore, the already published USACE values were used. The six study streams are Willow Creek, Manzanita Creek, Clipper Wash, Spring Creek, Dry

Creek, and Russell Wash. For the remaining study streams where results were compared, discharges developed by the study contractor were utilized after justification to the USACE.

All flooding sources were analyzed to determine the peak discharge for the 24-hour rainfall distributions.

The Town of Wickenburg, Maricopa County, requested a restudy for Sols Wash based upon studies performed by the NRCS and PRC Toups Engineering (PRC) (PRC Toups, 1981). These studies yielded peak discharges significantly less than what had been assumed in the previous analysis for the effective Flood Insurance Study for the Town of Wickenburg.

The NRCS computer model TR-20 was selected for use in estimating the 10-, 2-, 1-, and 0.2-percent annual chance peak discharges for various concentration points along Sols Wash. The TR-20 model utilizes the method of analysis described in detail in the NRCS National Engineering Handbook, Section 4, Hydrology, 1972 (U.S. Department of Agriculture, 1972). This method allows for the prediction of surface water runoff for an individual watershed using rainfall duration and intensity data. The TR-20 model provides a convenient means of predicting the results of storm runoff from multiple watersheds. The storm runoff for individual watersheds is computed and an outflow hydrograph simulated. Individual hydrographs may then be routed and combined to obtain the cumulative downstream effects.

The precipitation frequencies for the area were obtained from isopluvial maps prepared by the U.S. Weather Bureau. The NRCS Type II rainfall distribution was used to model the rainfall, which was adjusted using an areal reduction based upon the total drainage area. Such reduction is necessary to convert from the point areal rainfall amount. Using soils maps of the area prepared by the NRCS, as well as site investigations, runoff curve numbers were selected, based upon information developed by the NRCS. Times of concentrations for steep and incised washes were computed using the Kirpich equation. For gently sloping alluvial plains, many of which occur on the upper northwest portion of the drainage basin, travel velocities were estimated assuming broad sheetflow and utilizing Manning's equation.

Because there is no gaging station on Sols Wash, and thus no accurate record of historic flooding, there is no means to provide calibration of the rainfall-runoff model, and therefore only comparison with earlier studies can be made.

The discharge estimates obtained from the TR-20 analysis for the study correspond with the results of both the NRCS and PRC analyses. The discharge-frequency curve developed by the USACE for the 1977 FIS has a steeper slope and results in a much larger 1-percent annual chance peak discharge than in the other studies.

The NRCS, PRC, and Cella, Barr, Evans & Associates each employed the TR-20 model in their studies, which might explain, in part, the consistency of the results, although the model is quite sensitive to changes in time of concentration, and each model employed different input parameters.

The calibration of the TR-20 model by PRC, which used streamflow data from the Hassayampa River, lends further credence to each of the study results. Therefore, results from the TR-20 model utilized in the restudy of Sols Wash have been employed in the hydraulic analysis.

For the Town of Camp Verde, no significant changes in hydrological conditions have been reported in the watershed since the completion of the 1985 Flood Insurance Study for Yavapai County (U.S. Department of Agriculture, 1964). Therefore, during the initial CCO meeting, FEMA and Yavapai County decided that for West Clear Creek the same peak discharges generated in the 1985 FIS would be used for determining flood elevations in the Town of Camp Verde study.

Because no stream gage records exist for the Chino Wash basin, a regional analysis was used to determine the 1-percent annual chance peak discharge for the Town of Chino Valley. This regional analysis included 13 gages with over 10 years of record. Results of that analysis were used with procedures contained in U.S. Water Resources Council Bulletin 17B (Arizona Department of Transportation, 1968) to compute the 1-percent annual chance peak flows for the drainage areas of concern.

For the Town of Clarkdale, peak discharge values for drainage channels in the State of Arizona that have insufficient streamflow records available to allow for floodflow frequency computations, were analyzed utilizing a method presented in the Arizona Department of Transportation publication entitled, "Hydrologic Design: for Highway Drainage in Arizona" (Arizona Highway Department, 1968, revised 1969) for the Town of Clarkdale. This method is referred to as the NRCS Method and consists of two different approaches which are a function of the drainage-area size. This method pertains to areas where existing and projected urbanization has a negligible influence on expected basin discharges. The streams studied by detailed methods in the Town of Clarkdale area fall under this criteria, with the exception of the Verde River where sufficient streamflow data are available to allow for a more sophisticated approach.

Peak discharge values for streams studied by approximate methods were developed on the basis of an average expected discharge per acre from the contributing basin areas. Floodplain boundaries were developed from aerial photography (USACE, October 1973) and field surveys with specific reference for defining geologic boundaries with consideration of expected flows.

In the City of Cottonwood, the peak discharges for Railroad Wash are significantly reduced downstream of the Cottonwood Airport by the detention/retention basins located near the Cottonwood Airport. The first basin, located immediately upstream of the airport, was formed by obstruction of the wash and installation of an undersized culvert when the airport runway was constructed. These characteristics created a substantial runoff storage capacity to the west of the runway.

The other basin in the City of Cottonwood is a ponding area located behind an old railroad bed which simulates a dam-like structure. This basin is located approximately 1,600 feet downstream of the former basin and has a 1-percent annual chance stillwater elevation of 3,492.1 feet (Cooper Arial Surveys, 1978).

For some of the studies in the City of Prescott, flood-frequency data were developed from discharge-frequency relationships of historic floods and hydrologic study analyses performed by tile USACE (USACE, October 1973). Various modifying factors were applied in developing the discharge frequency curves to allow for the effects of existing floodplain developments.

Flood hydrographs were developed using unit hydrograph procedures. The unit hydrograph was derived from synthetic S graphs as determined from reconstitution in the basin or a similar graph.

Peak discharge values for Willow Creek Tributary and Willow Creek Reservoir Tributary were determined utilizing the NRCS Method. This method is recommended for drainage basin parameters such as drainage basin area, slope, vegetation type and cover density, and hydrologic soil groups to determine the rainfall-runoff relationship and the peak discharge for each recurrence interval.

On Willow Creek, the discharges have been reduced at several points upstream of the mouth in accordance with the NRCS TR-20 model prepared by Henningson, Durham & Richardson, Inc.

Discharges for the Agua Fria River, Navajo Drive Wash, and Lynx Creek in the Town of Prescott Valley were developed using the computer program Project Formulation Hydrology (FEMA, 1964). This NRCS methodology uses basin physical characteristics, soil classification, cover conditions, and precipitation amount as parameters for developing runoff.

A hydrologic analysis for North Navajo Drive Wash was done by adjusting the discharge values of previously studied Navajo Drive Wash (FEMA, 1982, revised 1990), by applying the drainage area ratio. The peak 1-percent annual chance discharge varies from 190 cubic feet per second (cfs) upstream to 740 cfs downstream. For this study only the 1-percent annual chance flood was calculated.

The upper Agua Fria River watershed basin was divided into subwatersheds, with attention given to homogeneity of soil type and cover conditions. Times of concentrations were computed using Manning's equation to develop the velocity component. Drainage areas were measured using USGS topographic maps (U.S. Department of the Interior, 1965, et cetera; U.S. Department of the Interior, 1947 et cetera; U.S. Department of the Interior, 1970).

Soil classification and cover conditions were determined through field surveys and through the General Soil Map for Yavapai County (U.S. Department of Agriculture, 1978). Antecedent moisture condition 2 was used for the soil moisture content.

Tile National Oceanic and Atmospheric Administration Atlas 2 (USACE, February 1977) was used to select rainfall amounts for the 10-, 2-, and 1-percent annual chance floods. The 0.2-percent annual chance rainfall amount was derived on extreme probability paper from extrapolation of a line through the plotted 10-, 2-, and 1-percent annual chance values.

All flooding sources in the Town of Prescott Valley were analyzed to determine the peak discharge for the 1- and 24-hour rainfall distributions.

The hydrologic analysis of the watershed affecting the Oak Creek area in the City of Sedona was performed using the NRCS TR-20 computer program (FEMA, 1985, Preliminary 1991). Input data for the TR-20 computer program were prepared for the Yavapai County FIS as part of the hydrology report on Oak Creek in Yavapai County (U.S. Department of the Interior, 1973). To obtain peak floodflows at the required concentration points of Oak Creek, it was necessary to modify the TR-20 model by adding additional concentration points. Further modification, in the form of higher area reduction factors applied to the precipitation data, was necessary to model the relatively higher peak flood flows occurring from the smaller drainage areas. Therefore, peak discharges for the upper reaches of Oak Creek are higher than peak discharges obtained at the same location when the lower Oak Creek peak discharges were being investigated.

A summary of the drainage area-peak discharge relationships for the streams studied by detailed methods is shown in Table 5, “Summary of Discharges.”

TABLE 5 – SUMMARY OF DISCHARGES

FLOODING SOURCE AND LOCATION	DRAINAGE AREA (sq. miles)	PEAK DISCHARGES (cfs)			
		10-PERCENT	2-PERCENT	1-PERCENT	0.2-PERCENT
AGUA FRIA RIVER (At Black Canyon City)					
At downstream limit of detailed study	1,055.00	28,500	56,700	70,200	124,800
Upstream of confluence with Black Canyon Creek	808.00	19,300	38,900	48,600	86,400
AGUA FRIA RIVER (At the Town of Dewey-Humboldt)					
At downstream limit of detailed study	164.00	19,300	38,900	48,600	86,400
Upstream of confluence with Clipper Wash	81.00	6,800	17,250	23,200	50,200
AGUA FRIA RIVER (At Town of Prescott Valley)					
At downstream limit of detailed study	19.00	2,440	6,490	8,250	14,200
AMERICAN WASH					
At confluence with Mint Wash	3.00	550	1,230	1,680	2,950
ASH FORK DRAW WASH					
At Atchison, Topeka and Santa Fe Railway	113.00	4,160	9,490	12,800	22,800
Upstream of confluence with Johnson Creek	61.00	3,000	6,450	8,750	14,100
ASPEN CREEK (At City of Prescott)	5.06	780	2,500	4,000	10,000
BEAVER CREEK (At Town of Camp Verde)					
At confluence with Verde River	423.00	27,600	59,200	74,000	129,200
BEAVER CREEK (At Lake Montezuma)					
At Montezuma Castle National Monument	415.00	27,500	59,600	74,600	131,300

TABLE 5 – SUMMARY OF DISCHARGES – continued

FLOODING SOURCE AND LOCATION	DRAINAGE AREA (sq. miles)	PEAK DISCHARGES (cfs) 10-PERCENT	2-PERCENT	1-PERCENT	0.2-PERCENT
BIG BUG CREEK (At Interstate Highway 17)					
At Cordes Junction	51.00	3,800	11,700	13,000	17,350
At downstream limit of detailed study (At Mayer), approximately 0.80 mile downstream of Rolling Ridge Drive	30.00	2,560	8,290	9,180	12,000
BIG CHINO VALLEY, EAST					
Green Wash					
At confluence with Big Chino Wash	14.36	--[1]	--[1]	4,831	--[1]
Upstream of Atchison, Topeka & Santa Fe Railway	14.14	--[1]	--[1]	9,631	--[1]
Upstream of J. W. Draw confluence	4.45	--[1]	--[1]	3,908	--[1]
BIG CHINO VALLEY, WEST					
Clayton Canyon Wash					
At confluence with Big Chino Wash	4.11	--[1]	--[1]	44,045	--[1]
Upstream of confluence with Dry Well Wash	1.81	--[1]	--[1]	2,028	--[1]
At upstream limit of detailed study	1.12	--[1]	--[1]	1,430	--[1]
BIG CHINO WASH					
At U.S. Route 89	695.00	15,080	31,000	43,180	92,770
Upstream of confluence of Williamson Valley Wash	349.00	8,660	17,875	24,915	48,630
BIG CHINO WASH, IRRIGATION SPLIT					
At convergence with Big Chino Wash	--[2]	--[3]	--[3]	11,278	--[2]
At divergence from Big Chino Wash	--[2]	--[3]	--[3]	6,415	--[2]

[1]Data not available
[2]Data not applicable
[3]Data not computed

TABLE 5 - SUMMARY OF DISCHARGES - continued

FLOODING SOURCE AND LOCATION	DRAINAGE AREA (sq. miles)	PEAK DISCHARGES (cfs) 10-PERCENT	2-PERCENT	1-PERCENT	0.2-PERCENT
BIG CHINO WASH-OVERFLOW AREA					
At confluence with Big Chino Wash	--[2]	--[3]	--[3]	20,615	--[2]
BIG CHINO WASH-SPILL # 1					
At convergence with Big Chino Wash	--[2]	--[3]	--[3]	12,618	--[2]
BIG CHINO WASH-U.S. ROUTE 89 OVERFLOW					
At confluence with Big Chino Wash	--[2]	--[3]	--[3]	25,178	--[2]
BITTER CREEK					
At confluence with Verde River	14.90	6,793	8,688	11,600	31,000
At confluence of Bitter Creek-South Fork	16.96	6,793	8,688	11,600	31,000
BITTER CREEK-SOUTH FORK					
At confluence with Bitter Creek	1.10	1,156	1,733	2,167	5,800
BLACK CANYON CREEK					
At confluence with Agua Fria River	242.00	14,200	30,100	38,000	56,600
BLUE TANK WASH					
At Hassayampa River	10.83	--[1]	--[1]	4,071	--[1]
BOYNTON CANYON					
At confluence with Dry Creek	6.00	2,350	4,115	4,875	6,860
CHERRY CREEK					
Above confluence with Verde River	25.02	--[1]	--[1]	14,497	--[1]

[1]Data not available
[2]Data not applicable
[3]Data not computed

TABLE 5 - SUMMARY OF DISCHARGES - continued

FLOODING SOURCE AND LOCATION	DRAINAGE AREA (sq. miles)	PEAK DISCHARGES (cfs) 10-PERCENT	2-PERCENT	1-PERCENT	0.2-PERCENT
CHINO VALLEY STREAM					
Approximately 8,000 feet upstream of U.S. Route 89	33.00	1,950	5,355	7,800	22,500
Upstream of confluence with Chino Valley Stream (Tributary)	19.00	1,440	3,985	5,700	14,389
CHINO VALLEY STREAM EAST	11.40	--[1]	--[1]	5,115	--[1]
CHINO VALLEY STREAM (Tributary)	10.00	1,610	2,940	3,850	10,715
At confluence with Chino Valley Stream	4.00	1,050	2,320	3,030	5,850
At upstream limit of detailed study					
CLIPPER WASH	8.00	1,300	4,200	6,400	11,000
At confluence with Agua Fria River					
COPPER CANYON WASH					
Above confluence with Verde River	7.80	--[1]	--[1]	7,600	--[1]
DEAD MULE CANYON WASH					
At confluence with Ramsgate Wash	8.00	1,050	2,625	3,660	5,790
DECEPTION WASH					
At confluence with Verde River	6.17	2,513	3,696	4,583	12,000
DEL MONTE WASH					
Upstream of East Main Street	5.70	3,086	4,537	5,627	15,000
DRY BEAVER CREEK					
Approximately 2,900 feet upstream of U.S. Highway 17	202.00	--[1]	--[1]	32,750	--[1]

[1]Data not available
[2]Data not applicable
[3]Data not computed

TABLE 5 - SUMMARY OF DISCHARGES - continued

FLOODING SOURCE AND LOCATION	DRAINAGE AREA (sq. miles)	PEAK DISCHARGES (cfs) 10-PERCENT	2-PERCENT	1-PERCENT	0.2-PERCENT
DRY CREEK					
Approximately 2,000 feet upstream of Sunset Hills Drive	56.20	--[1]	--[1]	29,176	--[1]
Upstream of confluence of Boynton Canyon	40.00	7,500	16,100	22,000	30,000
Upstream of confluence of Long Canyon Creek	36.00	5,818	13,330	16,500	25,370
DRY WELL WASH					
Upstream of confluence with Clayton Canyon Wash	1.96	--[1]	--[1]	--[1]	2,155
Approximately 500 feet upstream of Barbara Road	1.27	--[1]	--[1]	--[1]	1,622
GARDNER WASH					
Above confluence with Ramsgate Wash	--[1]	--[1]	--[1]	6,460	--[1]
GRANITE CREEK					
Approximately 4,900 feet upstream of U.S. Highway 89/89A	81	--[1]	--[1]	15,500	--[1]
Upstream of Manzanita Creek	11.87	1,700	5,500	8,200	22,000
Upstream of Aspen Creek	17.79	2,450	7,100	12,500	29,700
At confluence with North Fork Granite Creek	29.10	3,400	10,500	16,800	44,400
At U.S. Route 89 Bridge (former Gage Station)	36.00	3,600	11,000	18,500	47,000
Downstream of Slaughterhouse Gulch	40.00	--[1]	--[1]	20,600	--[1]
At Watson Lake	41.00	--[1]	--[1]	20,600	--[1]
HASSAYAMPA RIVER					
At Yavapai/Maricopa County line	524.00	16,500	42,300	72,200	125,700
Upstream of confluence with Martinez Wash	422.00	14,700	37,200	53,600	102,500
Upstream of Walnut Grove	78.00	4,650	11,200	13,000	19,500
JACKS CANYON					
Near State Route 179	17.00	2,720	7,640	8,350	10,500

[1]Data not available

TABLE 5 - SUMMARY OF DISCHARGES - continued

FLOODING SOURCE AND LOCATION	DRAINAGE AREA (sq. miles)	PEAK DISCHARGES (cfs) 10-PERCENT	2-PERCENT	1-PERCENT	0.2-PERCENT
J. W. DRAW					
Upstream of confluence with Green Wash	2.32	--[1]	--[1]	1,609	--[1]
Approximately 400 feet upstream of Ahonen Road	0.67	--[1]	--[1]	--[1]	750
LONESOME VALLEY WASH					
Downstream of confluence with Lonesome Valley Wash Tributary Reach 200	34.82	--[1]	--[1]	11,208	--[1]
Downstream of confluence with Lonesome Valley Wash Tributary Reach 500	20.82	--[1]	--[1]	8,973	--[1]
Downstream of confluence with Lonesome Valley Wash Tributary Reach 360	14.87	--[1]	--[1]	7,364	--[1]
Downstream of confluence with Lonesome Valley Wash Tributary Reach 405	4.13	--[1]	--[1]	3,320	--[1]
Approximately 0.402 mile upstream of Slash Arrow Drive	2.26	--[1]	--[1]	2,170	--[1]
LONESOME VALLEY WASH TRIBUTARY REACH 100					
Upstream of confluence with Lonesome Valley Wash	2.75	--[1]	--[1]	2,448	--[1]
At upstream limit of detailed study	1.55	--[1]	--[1]	1,578	--[1]

[1]Data not available

TABLE 5 - SUMMARY OF DISCHARGES - continued

FLOODING SOURCE AND LOCATION	DRAINAGE AREA (sq. miles)	PEAK DISCHARGES (cfs) 10-PERCENT	2-PERCENT	1-PERCENT	0.2-PERCENT
LONESOME VALLEY WASH TRIBUTARY REACH 200					
Upstream of confluence with Lonesome Valley Wash	13.17	--[1]	--[1]	6,413	--[1]
At upstream limit of detailed study	10.69	--[1]	--[1]	5,590	--[1]
LONESOME VALLEY WASH TRIBUTARY REACH 330					
Upstream of confluence with Lonesome Valley Wash Tributary Reach 350	2.25	--[1]	--[1]	2,102	--[1]
LONESOME VALLEY WASH TRIBUTARY REACH 350					
Upstream of confluence with Lonesome Valley Wash Tributary Reach 360	2.66	--[1]	--[1]	2,379	--[1]
At upstream limit of detailed study	0.28	--[1]	--[1]	389	--[1]
LONESOME VALLEY WASH TRIBUTARY REACH 360					
Upstream of confluence with Lonesome Valley Wash	7.39	--[1]	--[1]	4,770	--[1]
At upstream limit of detailed study	3.71	--[1]	--[1]	3,002	--[1]
LONESOME VALLEY WASH TRIBUTARY REACH 405					
Upstream of confluence with Lonesome Valley Wash	0.92	--[1]	--[1]	1,084	--[1]

[1]Data not available

TABLE 5 - SUMMARY OF DISCHARGES - continued

FLOODING SOURCE AND LOCATION	DRAINAGE AREA (sq. miles)	PEAK DISCHARGES (cfs) 10-PERCENT	2-PERCENT	1-PERCENT	0.2-PERCENT
LONESOME VALLEY WASH TRIBUTARY REACH 500					
Upstream of confluence with Lonesome Valley Wash	5.39	--[1]	--[1]	3,969	--[1]
LOWER KELLY WASH	4.56	--[1]	--[1]	887	--[1]
LUCKY CANYON WASH					
Upstream of confluence with Verde River	2.38	--[1]	--[1]	3,170	--[1]
LYNX CREEK					
At Fain Road	40.87	--[1]	--[1]	11,392	--[1]
Approximately 12,300 feet downstream of Lynx Creek Road	33.00	3,400	7,000	9,300	18,500
MANZANITA CREEK	2.41	550	1,700	2,700	7,000
MARTINEZ WASH					
At confluence with Hassayampa River	103.00	9,200	27,400	32,000	45,000
Upstream of confluence of Antelope Creek	36.52	2,223	5,174	6,562	10,108
MILLER CREEK					
At U.S. Route 89	20.00	--[1]	--[1]	1,520[2]	--[1]
Approximately 900 feet upstream of U.S. Route 89	20.00	3,635	8,990	10,610	14,600
At upstream limit of detailed study	7.40	--[1]	--[1]	3,200	--[1]
MILLER CREEK (At City of Prescott)	6.02	820	2,600	4,100	10,080
MINT WASH					
At Williamson Valley Road	37.29	--[1]	--[1]	13,985	--[1]
At confluence with American Wash	15.93	--[1]	--[1]	9,500	--[1]

[1]Data not available
[2]9,090 cubic feet per second of flow is lost to West Fork Miller Creek

TABLE 5 - SUMMARY OF DISCHARGES - continued

FLOODING SOURCE AND LOCATION	DRAINAGE AREA (sq. miles)	PEAK DISCHARGES (cfs) 10-PERCENT	2-PERCENT	1-PERCENT	0.2-PERCENT
MODEL CREEK					
At U.S. Route 89	13.00	4,745	14,050	16,820	23,500
Upstream of confluence of South Rocky Boy Wash	7.00	1,510	4,140	4,860	6,900
NAVAJO DRIVE WASH					
At confluence with Agua Fria River	2.00	406	829	1,068	1,857
NAVAJO DRIVE WASH					
At Town of Prescott Valley	2.00	410	830	1,070	1,860
NORTH FORK GRANITE CREEK	79.00	220	800	1,300	3,400
NORTH FORK MILLER CREEK	1.30	370	1,170	1,180	4,700
NORTH NAVAJO DRIVE WASH[1]					
At Ranger Road	1.15	--[2]	--[2]	740	--[2]
At Long Look Drive	0.03	--[2]	--[2]	103	--[2]
NORTH TRIBUTARY TO SOUTH BRANCH AGUA FRIA RIVER					
Approximately 700 feet upstream of Glassford Hill Road	--[4]	--[3]	--[3]	249	--[3]
OAK CREEK					
At confluence with Verde River	460.00	188,100	39,900	51,200	86,700
Upstream of confluence of Spring Creek	358.00	15,700	33,700	43,350	71,550
Upstream of confluence of Dry Creek	269.00	10,300	21,650	28,700	48,650
At Yavapai/Coconino County line	241.00	9,450	20,300	26,900	45,650
OAK WASH					
At confluence with Verde River	5.30	2,320	3,411	4,230	11,500

[1]Discharges for North Navajo Drive Wash were obtained by adjusting discharge values of Navajo Drive Wash
[2]Data not applicable
[3]Data not computed
[4]Flow affected by upstream overflows, diversions, or obstructions; drainage area does not apply

TABLE 5 - SUMMARY OF DISCHARGES - continued

FLOODING SOURCE AND LOCATION	DRAINAGE AREA (sq. miles)	PEAK DISCHARGES (cfs) 10-PERCENT	2-PERCENT	1-PERCENT	0.2-PERCENT
POWDER HOUSE WASH TRIBUTARY 1					
At Powder House Wash	--[1]	--[1]	--[1]	222	--[1]
POWDER HOUSE WASH TRIBUTARY 2 At Powder House Wash	--[1]	--[1]	--[1]	133	--[1]
RAILROAD WASH					
At confluence with Cottonwood Ditch	1.20	397	506	570	680
At East Mingus Culvert	1.10	398	507	572	685
At East Mingus Avenue and 10th Street	0.90	245	312	353	420
At East Mingus Avenue and Paula Street	0.80	245	310	345	410
At bypass Highway U.S. Route 89A	0.50	46[2]	59[2]	66[2]	80[2]
At Cottonwood Airport Runway	0.50	172	297	347	518
RAMSGATE WASH					
Approximately 1,500 feet downstream of Iron Springs Road	34.00	2,390	6,500	8,700	14,650
Above confluence with Dead Mule Canyon Wash	25.00	1,670	4,870	6,460	11,360
ROBERT WASH	3.10	--[3]	--[3]	1,624	--[3]
RUSSELL WASH					
At confluence with Wet Beaver Creek	15.00	2,000	8,000	12,000	16,000
SANTA CRUZ WASH					
At Old U.S. Route 89	--[2]	4,950	13,600	19,800	57,100
At Road 5 North	28.60	3,000	8,240	12,000	34,600
Approximately 600 feet downstream of Colorado Way	25.43	--[3]	--[3]	11,000	--[3]
At Perkins Ville Road	20.54	--[3]	--[3]	9,200	--[3]
At Road 2 North	13.33	--[4]	--[4]	6,400	--[4]
At Palo Verde and Lake Shore Drive	10.81	--[4]	--[4]	5,400	--[4]

[1]Data not computed
[2]Discharge is comparatively less because of the existence of the Detention Basin
[3]Discharges for 10-, 2-, and 0.2-percent annual chance floods
[4]Data not available

TABLE 5 - SUMMARY OF DISCHARGES - continued

FLOODING SOURCE AND LOCATION	DRAINAGE AREA (sq. miles)	PEAK DISCHARGES (cfs) 10-PERCENT	2-PERCENT	1-PERCENT	0.2-PERCENT
SANTA CRUZ WASH					
Just North of Grasshopper Lane	10.12	--[1]	--[1]	5,100	--[1]
Approximately 300 feet South of Road 1 South, downstream of confluence of Autumn Wash	7.88	--[1]	--[1]	4,100	--[1]
At Road 4 South	3.77	--[1]	--[1]	2,200	--[1]
SILVER SPRINGS GULCH					
At confluence with Verde River	5.30	2,541	3,737	4,634	12,500
SKULL VALLEY WASH					
At Kirkland	147.00	8,000	23,300	31,500	54,900
SOLS WASH					
At Maricopa/Yavapai County Boundary	86.70	3,696	7,504	9,419	13,760
SOUTH BRANCH AGUA FRIA RIVER (AT PRESCOTT-VALLEY)					
Approximately 1,650 feet downstream of Glassford Hill Road	--[2]	--[1]	--[1]	4,845	--[1]
Approximately 1,150 feet upstream of Glassford Hill Road	--[2]	--[1]	--[1]	4,660	--[1]
SOUTH ROCKY BOY WASH					
Upstream of confluence with Model Creek	3.36	880	2,340	2,740	3,900
SPRING CREEK					
At confluence with Oak Creek	72.00	6,000	19,000	29,000	42,300
TELEPHONE TANK WASH					
Upstream of confluence with Green Wash	4.43	--[1]	--[1]	3,128	--[1]

[1]Data not available

[2]Flow affected by upstream overflows, diversions, or obstructions; drainage area does not apply

TABLE 5 - SUMMARY OF DISCHARGES - continued

FLOODING SOURCE AND LOCATION	DRAINAGE AREA (sq. miles)	PEAK DISCHARGES (cfs) 10-PERCENT	2-PERCENT	1-PERCENT	0.2-PERCENT
TELEPHONE TANK WASH BREAKOUT					
Upstream of confluence with Green Wash	6.98	--[1]	--[1]	4,500	--[1]
Upstream of confluence of Robert Wash	3.88	--[1]	--[1]	2,900	--[1]
TEXAS GULCH MAIN STREAM					
Upstream of confluence with Agua Fria River	10.22	--[1]	--[1]	3,973	--[1]
At State Route 169	7.38	--[1]	--[1]	3,091	--[1]
Above confluence of West Branch	4.83	--[1]	--[1]	1,893	--[1]
TEXAS GULCH WEST BRANCH					
Upstream of State Route 169	2.55	--[1]	--[1]	1,380	--[1]
Upstream of South Tributary	0.92	--[1]	--[1]	620	--[1]
Upstream of North Tributary	0.61	--[1]	--[1]	400	--[1]
TIMON WASH					
Above confluence with Big Chino Wash	2.51	--[2]	--[2]	2,225	--[2]
At upper limit of detailed study	1.65	--[2]	--[2]	1,798	--[2]
VERDE RIVER					
At USGS Gage no. 09504000	3,124	22,750	55,100	75,100	136,700
At U.S. Route 89 Bridge	3,247	23,900	58,200	79,600	149,700
Below confluence with Oak Creek	3,776	28,700	72,100	100,000	193,900
Below confluence with West Beaver Creek	4,287	33,500	86,300	121,200	241,000
Below confluence with West Clear Creek	4,619	36,800	96,000	135,600	273,900
At USGS Gage no. 09506000	4,645	37,000	96,800	136,700	276,500
WASH P					
At Hassayampa River	0.87	--[2]	--[2]	898	--[2]

[1]Data not available
[2]Data not computed

TABLE 5 - SUMMARY OF DISCHARGES - continued

FLOODING SOURCE AND LOCATION	DRAINAGE AREA (sq. miles)	PEAK DISCHARGES (cfs) 10-PERCENT	2-PERCENT	1-PERCENT	0.2-PERCENT
WEST CLEAR CREEK					
Upstream of confluence with Verde River	293.00	10,600	23,600	35,400	62,500
WEST FORK MILLER CREEK					
At Hays Ranch Road	20.00	--[2]	--[2]	9,090[4]	--[2]
WET BEAVER CREEK					
At USGS Gage near Rimrock	111.00	--[2]	--[2]	19,330	--[2]
Upstream of Red Tank Draw confluence	135.00	--[2]	--[2]	21,930	--[2]
Downstream of Red Tank Draw confluence	189.00	--[2]	--[2]	25,850	--[2]
Upstream of Russell Wash confluence	199.00	--[2]	--[2]	27,200	--[2]
Upstream of Dry Beaver Creek confluence	220.00	--[2]	--[2]	28,330	--[2]
WILLIAMSON VALLEY WASH					
Upstream of confluence with Big Chino Wash	--[1]	6,420	13,130	18,265	44,140
WILLIAMSON VALLEY WASH-North Split	--[1]	--[2]	--[2]	11,510	--[2]
WILLOW CREEK					
At Willow Creek Reservoir	21.00	2,500	8,700	13,000	24,100
ZALESKY WASH					
Upstream of confluence with Verde River	5.91	--[3]	--[3]	2,887	--[3]

[1]Data not applicable
[2]Data not computed
[3]Data not available
[4]West Fork Miller Creek is created from divided flow from Miller Creek

3.2 Hydraulic Analyses

Analyses of the hydraulic characteristics of flooding from the sources studied were carried out to provide estimates of the elevations of floods of the selected recurrence intervals. Users should be aware that flood elevations shown on the FIRM represent rounded whole-foot elevations and may not exactly reflect the elevations shown on the Flood Profiles or in the Floodway Data tables in the FIS report. Flood elevations shown on the FIRM are primarily intended for flood insurance rating purposes. For construction and/or floodplain management purposes, users are encouraged to use the flood elevation data presented in this FIS in conjunction with the data shown on the FIRM.

For most streams, the USACE standard HEC-2 step-backwater computer program was used to compute water-surface elevations for the selected recurrence intervals (USACE, 1976; USACE, 1989).

Cross-section data for the Sols Wash backwater analyses were obtained from topographic maps prepared specifically for this project by Cooper Aerial Surveys in March 1986 (Cooper Aerial Surveys, 1986).

Cross-section data for all other study areas except the Verde River were obtained from digitized sections using photogrammetric methods. Cross-section data for the Verde River at the Town of Clarkdale were compiled using topographic maps (see Table 6, "Topographic Mapping").

Cross sections in detailed study were located at close intervals above and below bridges and culverts in order to compute head losses and backwater effect of these structures. All bridges and culverts were surveyed to obtain elevation data and structural geometry.

Generally, the distances on the flood profiles correspond to distances measured along the centerline of the designated watercourses. In several areas, however, the meandering nature of the low flow streambeds necessitated use of distances measured along the centerline of the 1-percent annual chance flow paths. On the maps, these flow lines, used to establish the respective profile distances, are delineated and labeled as Profile Base Lines.

Flood profiles were not developed for areas of shallow flooding along Gardener Wash. Local topography made computing all four recurrence interval flood elevations impractical. Depths and elevations in shallow flooding areas were obtained using normal-depth calculations and field investigation.

For the segment of Big Bug Creek studied by approximate methods, flood levels were estimated using field investigation and engineering judgment. For the many tributaries to detailed study streams, approximate flood elevations were estimated by using the elevations at the confluences and extending them upstream using engineering judgment.

Cross-section data for the backwater analysis of South Rocky Boy Wash were obtained as digitized cross sections from Cooper Aerial of Phoenix, Inc. (Cooper Aerial Surveys, 1989). The starting water-surface elevation for South Rocky Boy Wash was adopted from the Model Creek floodplain information as included in the previous FIS (U.S. Department of Agriculture, 1964).

In the Town of Camp Verde, a hydraulic analysis of the 1-percent annual chance flow in West Clear Creek was performed by AGK Engineers, Inc. The mapping generated for the Yavapai County Flood Control District by Kenney Aerial

Mapping, Inc. (Kenney Aerial Mapping, Inc., 1986), and the HEC-2 computer data generated by AGK Engineers, Inc., were used to delineate the flood hazard area presented in the study. Cross section data for the backwater analysis of West Clear Creek were determined by obtaining digitized cross sections from Kenney Aerial Mapping, Inc. (Kenny Aerial Mapping, Inc., 1986). The starting water-surface elevation for West Clear Creek was adopted from the Verde River floodplain information as included is the previous FIS for Yavapai County (U.S. Department of Agriculture, 1964).

Cross-section data for the first restudy in the Town of Camp Verde were obtained using digitized cross sections from Aerial Mapping Company, Inc. (Aerial Mapping Company, Inc., Topographic Maps for Portions of Verde River, Scale 1:4,800, Contour Interval 4 feet, October 1993; Aerial Mapping Company, Inc., Topographic Maps for Lucky Canyon Wash and Copper Canyon Wash, Scale 1:2,400, Contour Interval 4 feet, October 1993; Aerial Mapping Company, Inc., Topographic Maps for Cherry Creek, Scale 1:4,800, Contour Interval 4 feet, October 1993).

Data for the selected cross sections in the Town of Chino Valley for the HEC-2 model (USACE, November 1976) were taken directly from the topographic maps, provided by Yavapai County. Bridge and culvert data were obtained from field measurements.

Starting water-surface elevations for Santa Cruz Wash were developed using the slope-area method.

A small area in the northwest portion of the Town of Chino Valley is affected by flooding from Chino Valley Stream. The flood boundaries, base flood elevations and floodway for Chino Valley Stream were taken from the analysis performed by Henningson, Durham, & Richardson, Inc., for FEMA in 1981 and presented in the Yavapai County Flood Insurance Study (U.S. Department of Agriculture, 1964).

In order to simulate the character of stream channels and their adjacent overbanks, cross sections were compiled in the Town of Clarkdale, utilizing a topographic map of the stream channels specified for study by detailed methods (Cooper Aerial Surveys, Topographic Maps, Town of Clarkdale, Yavapai County, Arizona, Scale 1:2,400, Contour Interval 2 feet, Tucson, Arizona, 1978).

Stream channel geometry used in the Town of Clarkdale floodplain analysis was developed specifically for the FIS. Aerial photogrammetric methods were used to compile topographic maps of the stream channel and adjacent floodplain areas for developing the cross sectional geometry (Cooper Aerial Surveys, Topographic Maps, Town of Clarkdale, Yavapai County, Arizona, Scale 1:2,400, Contour Interval 2 feet, Tucson, Arizona, 1978). Stream channel geometry used in the Town of Cottonwood floodplain analysis was developed specifically for the FIS. Aerial photogrammetric methods were used to compile topographic mapping of the stream channel and adjacent floodplain. These topographic maps were used to develop the cross section geometry (Cooper Aerial Surveys, Topographic Maps, Town of Cottonwood, Yavapai County, Arizona, Scale 1:2,400, Contour Interval 2 feet, Tucson, Arizona, 1978; Kenney Aerial Mapping, 1983, 1984). The baselines used for horizontal control on the detailed studied streams were obtained from these same maps.

Much of the overbank areas are covered with extremely dense vegetation. The roughness coefficients for bridges and culverts were assumed to be equivalent to the channel Manning's "n" value.

The dimensions of backwater-producing structures were identified through field investigations and construction plans obtained from the Arizona Department of Transportation. The backwater effects of a structure that was assumed to fail during high-magnitude flow events were not included in the hydraulic analysis. This structure is an earthen flow-diversion dike along the Verde River which was constructed for irrigation purposes.

Starting water-surface elevations for the tributary streams, Deception Wash, Bitter Creek, and Bitter Creek-South Fork, were computed at normal depth at a cross section located within the 1-percent annual chance floodplain limits of the Verde River.

The hydraulic models of tributary streams to the Verde River at the Town of Clarkdale determined that flow is in a supercritical mode within these channels; however, backwater computations (subcritical flow models) were utilized to compute the flow profiles. Critical depth was assumed at nearly every cross section for these tributary studies.

Minguez Wash, Mescal Gulch, and North Fork Mescal Gulch which were studied by approximate methods, utilized the Flood Hazard Boundary Map (U.S. Department of Housing and Urban Development, 1975) aid in delineating flood hazard areas. Additionally, a HEC-2 analysis was used to compute the Minguez Wash floodplain area. These maps were checked in the field to ensure their validity.

In order to simulate the character of stream channels and their adjacent overbanks for the City of Cottonwood, cross sections were compiled utilizing topographic maps of the stream channels specified for study by detailed methods (Cooper Aerial Surveys, Topographic Maps, Town of Cottonwood, Yavapai County, Arizona, Scale 1:2,400, Contour Interval 2 feet, Tucson, Arizona, 1978; Kenny Aerial Mapping, 1983, 1984).

Some discrepancies were noted between portions of the topographic mapping utilized for Silver Springs Gulch in the 1981 FIS of the City of Cottonwood, and the restudy, which is based on current mapping. The mapping was field verified for accuracy and supersedes information presented in the previous study.

An unauthorized excavation of approximately 1,100 feet at Silver Springs Gulch occurred in the summer of 1985, This excavation was brought to the attention of the study contractor by a letter from the Planning and Zoning Administrator for the City of Cottonwood on September 5, 1985, and occurred beginning approximately 1,000 feet west of 6th Street, south of U.S. Highway Bypass 89A. A site visit was subsequently performed by the study contractor on September 27,

1985. It was determined from the site visit that the excavation, although significant, represented only a localized modification and lowering of the channel area and did not contain an effective element to collect runoff at the upstream end or release it at the downstream end. Therefore, the influence of this excavation on floodplain characteristics was ignored, thus yielding more conservative results.

The dimensions of backwater producing structures were identified through field investigation and construction plans obtained from the U.S. Department of the Interior, National Park Service (U.S. Department of the Interior, 1966). The backwater effect of a structure that was assumed to fail during high magnitude flow events was not included in the hydraulic analysis. An example is the Verde River crossing to the Dead Horse Campgrounds. This roadway was constructed by the State Parks Commission in order to provide access to the campgrounds. The roadway is presently impassable as previous floodflows have washed out the roadway surface. Contacts with the State Parks Department have determined that this roadway be reconstructed at channel grade in view of the probability of future flows inundating this structure.

Starting water-surface elevations for Del Monte Wash, Silver Springs Gulch, and Oak Wash were computed at normal depth at a cross section located within the 1-percent annual chance floodplain limits of the Verde River. For Railroad Wash, the starting water-surface elevation was computed at normal depth (using the slope/area method) at a cross section located at the confluence with the Cottonwood Ditch.

The hydraulic models of the streams being studied in the City of Cottonwood determined that flow was in a supercritical mode within these channels; however, backwater computations (subcritical flow models) were utilized to compute the flow profiles. Critical depth was assumed at nearly every cross section for these study streams.

As mentioned in Section 3.1, Railroad Wash has a detention/retention basin which is located approximately 1,600 feet downstream of the runway at Cottonwood Airport. To determine the depth of ponding in the basin during the 1-percent annual chance flood, a flood routing was performed using a modified PULS routing procedure (Arizona Highway Department, 1968, revised 1969). The floodplain upstream of the detention/retention basin was determined using approximate methods.

As described in Section 2.3 of this report, several flooding problems have resulted in the past from the inadequate capacity of the structure at the East Main Street crossing of Del Monte Wash to convey large-magnitude flows and large objects such as trees and cars, from obstructing the flow through the culvert. The results of hydraulic studies have determined that no flow in excess of the 10-percent annual chance event could be passed beneath the roadway under unobstructed flow conditions. The inadequate capacity of this structure has resulted in the most significant flooding problems for the City of Cottonwood, as areas downstream of this structure represent the most highly developed portion of the town. Floodwaters which escape the Del Monte Wash stream channels as a result of backwater effects at East Main Street and flow onto the adjacent floodplains possess entirely different flow profiles from those waters which remain in the well defined channel. An attempt to delineate 1-percent annual chance floodplain limits for these floodplain areas adjacent to Del Monte Wash on the basis of HEC-2 modeling resulted in output which did not correlate with previous floodflow events. These problems rise from the nature of overbank topography, the flow-obstructing effect of numerous buildings and the flow-conveying effects of street systems, and the inability to determine the exact quantity of overbank flow through these areas. In view of the difficulties just described, the method of approach for determining 1-percent annual chance floodprone limits for Del Monte Wash downstream of the East Main Street crossing was to assume that 85 percent of the weir flow discharge would follow a path along each overbank (north overbank and south overbank). Normal depth computations were then undertaken to compute the depth of flow along these overbank areas. A Zone AO was mapped until that point where it was determined that the flow depths were less than one foot. At that point, the floodprone areas were mapped as a Zone X (shaded), or an area of moderate flood hazard (1-percent annual chance shallow flooding less than one foot).

Cross section data for the City of Prescott studies were obtained from topographic maps and field measurements. Starting water-surface elevations for the City of Prescott were determined by the slope/area method or the input elevation method where applicable. Channel roughness coefficients (Manning's "n" values) were assigned on the basis of field inspection.

The hydraulic analysis for Willow Creek was revised by FEMA to incorporate up-to-date survey data, intermediate cross sections, and reduced discharges.

Geometric data for cross sections for Willow Creek were obtained from topographic maps prepared by Kenney Aerial Mapping (Kenney Aerial Mapping, 1988). Two bridges were surveyed to obtain elevation data and structural geometry.

In the Town of Prescott Valley, cross-section data for the hydraulic analyses of the Agua Fria River, Navajo Drive Wash, and Lynx Creek were obtained from digitized sections from photogrammetric methods. Locations of cross sections were provided to the plotter on topographic maps.

For some portions of the Agua Fria River, a Profile Base Line was used for horizontal control due to excessive stream meandering and an ill-defined natural channel. The starting water-surface elevations for the Agua Fria River were determined by developing a rating curve for the primary cross section. For Navajo Drive Wash and North Navajo Drive Wash confluence elevations from the Agua Fria River were used as starting elevations.

A hydraulic analysis was performed to determine the channel capacity for North Navajo Drive Wash and the depth of overbank flooding from the 1-percent annual chance flood.

Values for the roughness coefficient "n" for the Manning's equation for North Navajo Drive Wash were determined by the Cowan Method (Chow, Ven T., 1959).

Flow profiles were not compared with historical events. There is little information on flood elevations and historical discharges with which to make this comparison.

For the City of Sedona, cross sections used for the backwater analysis of Oak Creek were hand-coded from topographic maps (U.S. Department of Agriculture, 1971).

For all detailed studies, flood profiles were drawn showing computed water-surface elevations to an accuracy of 0.5 foot for floods of the selected recurrence intervals. The starting water-surface elevations were determined either by developing a rating curve for the primary cross sections, assuming critical depth, or by the slope-area method.

Locations of selected cross sections used in the hydraulic analyses are shown on the Flood Profiles (Exhibit 1). For stream segments for which a floodway was computed (Section 4.2), selected cross section locations are also shown on the Flood Insurance Rate Map (Exhibit 2).

The hydraulic analyses for this study were based on unobstructed flow. The flood elevations shown on the profiles are thus considered valid only if hydraulic structures remain unobstructed, operate properly, and do not fail.

Manning's "n" roughness coefficients used in the hydraulic computations were established using "Roughness Coefficients for Stream Channels in Arizona" (USACE, May 1976) and by field observations of the streams and floodplain areas, and from previous studies by the USACE (USACE, 1989). Table 7, "Manning's "n" Values," shows the values used for each study stream.

TABLE 6 – TOPOGRAPHIC MAPPING

Community	Scale	Contour Interval	Flooding Type
Yavapai County (West Clear Creek, Wet Beaver Creek)	1:2,400	5 feet	Detailed
Yavapai County (All other study areas except Verde River)	1:2,400	4 feet	Detailed
Yavapai County (South Rocky Boy Wash Restudy)	1:4,800	4 feet	Detailed
Yavapai County (Big Chino Wash Tributaries Restudy)	1:2,400	2 feet	Detailed
Yavapai County (East Tributary of Chino Valley Stream, Texas Gulch Restudy)	1:4,800	4 feet	Detailed
Yavapai County (Sols Wash)	1:200	2 feet	Detailed
Town of Camp Verde (1st Restudy)	1:4,800	4 feet	Detailed
Town of Camp Verde (Beaver Creek)	1:2,400	5 feet	Detailed
Town of Camp Verde (1st Restudy)	1:2,400	4 feet	Detailed
Town of Chino Valley	1:1,200	2 feet	Detailed
Town of Clarkdale	1:2,400	2 feet	Detailed
City of Cottonwood	1:2,400	2 feet	Detailed
City of Cottonwood	1:4,800	5 feet	Detailed
City of Cottonwood	1:8,400	(Aerial Photos)	Approximate
City of Prescott (Aspen Creek, Manzanita Creek)	1:4,800	4 feet	Detailed
City of Prescott (Willow Creek, Willow Creek Tributary, Willow Creek Reservoir Tributary)	1:4,800	4 feet	Detailed
City of Prescott (Aspen Creek, Manzanita Creek, Willow Creek, Willow Creek Tributary, Willow Creek Reservoir Tributary)	1:1,200	1 foot	Detailed
City of Prescott (Granite Creek)	1:1,200	2 feet	Detailed
City of Prescott (all other detailed flooding)	1:24,000	10 feet	Detailed
City of Prescott – Willow Creek Tributary	1:4,800	4 feet	Approximate
City of Prescott (all other approximate flooding)	1:24,000	20 feet	Approximate
Town of Prescott Valley (Agua Fria River, Navajo Drive Wash, Lynx Creek)	1:2,400	4 feet	Detailed
Town of Prescott Valley (North Navajo Drive Wash)	1:2,400	2 feet	Detailed
City of Sedona – Oak Creek, Soldier Wash	1:2,400	5 feet	Detailed
City of Sedona – Oak Creek	1:4,800	2 feet	Detailed

TABLE 7 – MANNING'S "n" VALUES

Flooding Source	Channel	Overbanks
Agua Fria River (At Black Canyon City)	0.025-0.055	0.075-0.150
Agua Fria River (At Dewey-Humboldt)	0.020-0.045	0.040-0.065
Agua Fria River (At Prescott Valley)	0.020-0.030	0.040-0.050
American Wash	0.025-0.035	0.035-0.055
Ash Fork Draw Wash	0.030-0.035	0.055-0.0100
Aspen Creek	0.055	0.095
Beaver Creek (At Camp Verde)	0.050-0.060	0.085-0.100
Beaver Creek (At Lake Montezuma)	0.045-0.085	0.040-0.125
Big Bug Creek	0.035-0.060	0.090-0.150
Big Chino Valley East Streams	0.035-0.040	0.035-0.040
Big Chino Valley West Streams	0.035	0.035-0.040
Big Chino Wash	0.025-0.030	0.030-0.040
Bitter Creek	0.040	0.050
Bitter Creek - South Fork	0.040	0.050
Black Canyon Creek	0.025-0.055	0.065-0.150
Boynton Canyon	0.040-0.065	0.065-0.080
Chino Valley Stream	0.030-0.040	0.035-0.045
Chino Valley Stream, East	0.032	0.032
Chino Valley Stream (Tributary)	0.030-0.045	0.035-0.050
Clipper Wash	0.020-0.035	0.050-0.075
Dead Mule Canyon Wash	0.030	0.060
Deception Wash	0.040	0.050
Del Monte Wash	0.040	0.065
Dry Creek	0.030-0.060	0.075-0.100
Granite Creek	0.014-0.035	0.075-0.100
Hassayampa River	0.025-0.060	0.035-0.070
Jacks Canyon	0.035-0.070	0.045-0.125
Lynx Creek	0.035-0.065	0.075-0.150
Manzanita Creek	0.050	0.090-0.125
Martinez Wash	0.025-0.060	0.090
Miller Creek	0.035-0.090	0.060-0.100
Model Creek	0.035	0.050-0.135
Navajo Drive Wash	0.020-0.030	0.050-0.070
North Navajo Drive Wash	0.040-0.050	0.040-0.050
Oak Creek	0.030-0.080	0.040-0.180
Oak Wash	0.035	0.040
Railroad Wash	0.013-0.065	0.045-0.065
Ramsgate Wash	0.035	0.040-0.060
Russell Wash	0.035-0.045	0.045-0.070

TABLE 7 - MANNING'S "n" VALUES - continued

Flooding Source	Channel	Overbanks
Santa Cruz Wash	0.040	0.045
Silver Springs Gulch	0.040-0.050	0.045-0.065
Skull Valley Wash	0.015-0.040	0.060-0.065
Sols Wash	0.018-0.050	0.055-0.090
South Rocky Boy Wash	0.025-0.043	0.025-0.061
Spring Creek	0.040-0.055	0.050-0.125
Texas Gulch Main Stem	0.035-0.045	0.037-0.045
Texas Gulch West Branch	0.035	0.040
West Clear Creek	0.035-0.050	0.050-0.120
Wet Beaver Creek	0.035-0.060	0.060-0.125
Williamson Valley Wash	0.030	0.035-0.040
Willow Creek	0.045	0.060
Zalesky Wash Main Stem	0.028-0.045	0.063-0.140

Behind-Levee Analyses

Some flood hazard information presented in prior FIRMs and in prior FIS reports for Yavapai County and its incorporated communities was based on flood protection provided by levees. Based on the information available and the mapping standards of the NFIP at the time that the prior FISs and FIRMs were prepared, FEMA accredited the levees as providing protection from the flood that has a 1-percent annual chance of being equaled or exceeded in any given year. For FEMA to continue to accredit the identified levees with providing protection from the base flood, the levees must meet the criteria of the Code of Federal Regulations, Title 44, Chapter I, Section 65.10 (44 CFR 65.10), titled “Mapping of Areas Protected by Levee Systems.”

On August 22, 2005, FEMA issued “Procedure Memorandum No. 34 – Interim Guidance for Studies Including Levees.” The purpose of the memorandum was to help clarify the responsibility of community officials or other parties seeking recognition of a levee by providing information identified during a study/mapping project. Often, documentation regarding levee design, accreditation, and the impacts on flood hazard mapping is outdated or missing altogether. To remedy this, Procedure Memorandum No. 34 provides interim guidance on procedures to minimize delays in near-term studies/mapping projects, to help our mapping partners properly assess how to handle levee mapping issues.

While documentation related to 44 CFR 65.10 is being compiled, the release of a more up-to-date FIRM for other parts of a community or county may be delayed. To minimize the impact of the levee recognition and certification process, FEMA issued “Procedure Memorandum No. 43 – Guidelines for Identifying Provisionally Accredited Levees” on March 16, 2007. These guidelines allow issuance of the FIS and FIRM while levee owners or communities compile full documentation required to show compliance with 44 CFR 65.10. The guidelines also explain that a FIRM can be issued while providing the communities and levee owners with a specified timeframe to correct any maintenance deficiencies associated with a levee and to show compliance with 44 CFR 65.10.

FEMA contacted the communities within Yavapai County to obtain data required under 44 CFR 65.10 to continue to show the levees as providing protection from the flood that has a 1-percent annual chance of being equaled or exceeded in any given year.

FEMA understood that it may take time to acquire and/or assemble the documentation necessary to fully comply with 44 CFR 65.10. Therefore, FEMA put forth a process to provide the communities with additional time to submit all the necessary documentation. For a community to avail itself of the additional time, it had to sign an agreement with FEMA. Levees for which such agreements were signed are shown on the final effective FIRM as providing protection from the flood that has a 1-percent annual chance of being equaled or exceeded in any given year and labeled as a Provisionally Accredited Levee (PAL). Communities have two years from the date of FEMA's initial coordination to submit to FEMA final accreditation data for all PALs. Following receipt of final accreditation data, FEMA will revise the FIS and FIRM as warranted.

FEMA coordinated with the local communities, Bureau of Reclamation, and other organizations to compile a list of levees based on information from the FIRM and community provided information.

Approximate analyses of "behind levee" flooding were conducted for all the levees to indicate the extent of the "behind levee" floodplains. The methodology used in these analyses is discussed below.

Levee-like structure ID #3 and levee structure ID #16 are located on Lynx Creek. Based upon topographic information and aerial imagery from the USGS a hydrologic and hydraulic analysis was developed for this portion of Lynx Creek. The watershed to these structures has a drainage area of 40 sq. mi. and using the USGS National Flood Frequency equations for Arizona the discharge was computed to be 12,280 cfs. Using the USACE HEC-RAS hydraulic model an area of flooding in the event of failure of the levees was determined.

Levee-like structures with inventory ID #4, 5 and 6 are located on Cienega Creek. Based on the FIS and topographic information from the USGS (i.e., 10 meter DEMs), there is no depression behind these levee-like structures and they are not providing protection from flood hazards. Therefore no change in the floodplain is recommended at this location.

Levee-like structure with inventory ID #12 is located on Skull Valley Wash. Based on the FIS and topographic information from the USGS (i.e., 10 meter DEMs), the shaded Zone X area to the north was recommended as the approximate area of 1-percent annual chance flooding in the event of failure of the levees.

Levee structure with inventory ID #18 and levee-like structure with inventory ID #60 are located on Dead Mule Canyon Wash. Based on the FIS and topographic information from the USGS (i.e., 10 meter DEMs), the shaded Zone X area to the north was recommended as the approximate area of 1-percent annual chance flooding in the event of failure of the levees. The approximate area was extended to Ramsgate Wash based on engineering judgment and the topographic information.

Levee with inventory ID #19 is located on Willow Creek. Based on the FIS and topographic information from the USGS (i.e., 10 meter DEMs), the shaded Zone X area to the east was recommended as the approximate area of 1-percent annual chance flooding in the event of failure of the levees. The approximate area was extended to tie back in with the detailed flooding downstream based on engineering judgment and topographic information.

Levee with inventory ID #20 is located on Dry Creek. The approximate areas of 1-percent annual chance flooding in the event of failure of the levee were determined based on redelineation of the Dry Creek base flood elevations on the landward side of the levee using topographic information from the USGS (i.e., 10 meter DEMs).

Levee-like structure with inventory ID #27 is located on South Rocky Boy Wash. Based on a review of the effective flood hazards and aerial imagery, it appears that the effective flooding is contained in the channel at this location. As this levee-like structure appears to be a channel not a levee, no change in the floodplain is recommended at this location.

Levee-like structure with inventory ID #31 is located on Big Bug Creek. Topographic information obtained from 10 meter USGS DEMs indicate that the effective Zone A was correctly shown, and the levee-like structure did not have any influence on the extent of the existing Zone A boundary. Therefore, there is no change in the floodplain.

Levee-like structure with inventory ID #42 is located on Timon Wash. Based on the FIS and topographic information from the USGS (i.e., 10m DEMs), approximate areas of 1-percent annual chance flooding in the event of failure of the levees were determined based on engineering judgment.

Levee-like structure with inventory ID #43 is located on Green Wash. Based on the FIS and topographic information from the USGS (i.e., 10m DEMs), approximate areas of 1-percent annual chance flooding in the event of failure of the levees were determined based on engineering judgment.

Levee-like structure with inventory ID #61 is located on Ramsgate Wash. Based on the FIS and topographic information from the USGS (i.e., 10m DEMs), the shaded and unshaded Zone X areas between the detailed flooding were recommended as the approximate areas of 1-percent annual chance flooding in the event of failure of the levee.

3.3 Vertical Datum

All FISs and FIRMs are referenced to a specific vertical datum. The vertical datum provides a starting point against which flood, ground, and structure elevations can be referenced and compared. Until recently, the standard vertical datum in use for newly created or revised FISs and FIRMs was the National Geodetic Vertical Datum of 1929 (NGVD 29). With the finalization of the North American Vertical Datum of 1988 (NAVD 88), many FIS reports and FIRMs are being prepared using NAVD 88 as the referenced vertical datum.

All flood elevations shown in this FIS report and on the FIRM are referenced to NAVD 88. Structure and ground elevations in the community must, therefore, be referenced to NAVD 88. It is important to note that adjacent communities may be referenced to NGVD29. This may result in differences in base flood elevations across the corporate limits between the communities.

As noted above, the elevations shown in the FIS report and on the FIRM for Yavapai County are referenced to NAVD 88. Ground, structure, and flood elevations may be compared and/or referenced to NGVD 29 by applying a standard conversion factor.

The conversion from NGVD 29 to NAVD 88 ranged between 2.0 and 3.15 for this community. Accordingly, due to the statistically significant range in conversion factors, an average conversion factor could not be established for the entire community. The elevations shown in the FIS report and on the FIRM were, therefore, converted to NAVD 88 using a stream-by-stream approach. In this method, an average conversion was established for each flooding source and applied accordingly. For Big Bug Creek, Granite Creek, and Hassayampa River elevations were converted to NAVD on a reach-by reach approach, applying different factors for the downstream and upstream reaches of the stream. The conversion factor(s) for each flooding source in the county may be found in the Table 8, "Vertical Datum Conversions," shown below.

The Base Flood Elevations shown on the FIRM represent whole-foot rounded values. For example, a Base Flood Elevation of 102.4 will appear as 102 on the FIRM and 102.6 will appear as 103. Therefore, users that wish to convert the elevations in this FIS to NGVD 29 should apply the stated conversion factor(s) to elevations shown on the Flood Profiles and supporting data tables in the FIS report, which are shown at a minimum to the nearest 0.1 foot.

For more information on NAVD88, see Converting the National Flood Insurance Program to the North American Vertical Datum of 1988, FEMA Publication FIA-20/June 1992, or contact the Spatial Reference System Division, National Geodetic Survey, National Oceanic and Atmospheric Administration, 1315 East-West Highway, Silver Spring, Maryland 20910 (Internet address http://www.ngs.noaa.gov).

TABLE 8 – VERTICAL DATUM CONVERSIONS

Stream Name	Conversion Factor
Agua Fria River (At Black Canyon City)	2.00
Agua Fria River (At Dewey – Humboldt)	2.64
Agua Fria River (At Prescott Valley)	2.70
American Wash	2.96
Ash Fork Draw Wash	2.84
Aspen Creek	3.15
Beaver Creek	2.37
Big Bug Creek (Upstream Reach/Downstream Reach)	2.46/2.23
Big Chino Wash	2.78
Big Chino Wash Irrigation Split	2.71
Big Chino Wash Overflow	2.78
Big Chino Wash Spill #1	2.78
Big Chino Wash Rt. 89 Overflow	2.78
Bitter Creek	2.53
Bitter Creek – South Fork	2.57
Black Canyon Creek	2.18
Blue Tank Wash	2.28
Boynton Canyon	2.74
Butte Creek	3.13
Cherry Creek	2.59
Chino Valley Stream	2.67
Chino Valley Stream East	2.72
Chino Valley Stream (Tributary)	2.72
Chino Valley Stream (With Levee)	2.67
Clayton Canyon Wash	2.66
Clipper Wash	2.70
Copper Canyon Wash	2.52
Dead Mule Canyon Wash	2.87
Deception Wash	2.64
Del Monte Wash	2.49
Dry Beaver Creek	2.38
Dry Creek	2.75
Dry Well Wash	2.72
Granite Creek (Upstream Reach/Downstream Reach)	3.00/2.70
Green Wash	2.70
Hassayampa River (Upstream Reach/Downstream Reach)	2.62/2.21
J.W. Draw	2.69
Jacks Canyon	2.61
Lonesome Valley Wash	2.75
Lonesome Valley Wash Tributary Reach 100	2.76
Lonesome Valley Wash Tributary Reach 200	2.75
Lonesome Valley Wash Tributary Reach 300	2.75

Conversion factors with two numbers separated by a slash indicate that different vertical datum conversion factors were necessary based on the stream location.

TABLE 8 – VERTICAL DATUM CONVERSIONS – continued

Stream Name	Conversion Factor
Lonesome Valley Wash Tributary Reach 330	2.75
Lonesome Valley Wash Tributary Reach 350	2.75
Lonesome Valley Wash Tributary Reach 360	2.74
Lonesome Valley Wash Tributary Reach 405	2.75
Lower Kelly Wash	2.25
Lucky Canyon Wash	2.52
Lynx Creek	2.80
Manzanita Creek	3.12
Martinez Wash	2.30
Miller Creek (At Prescott)	3.12
Miller Creek (At Yarnell)	2.75
Mint Wash	2.86
Model Creek	2.82
Navajo Drive Wash	2.74
North Fork Granite Creek	3.03
North Fork Miller Creek	3.04
North Navajo Drive Wash	2.77
North Tributary to South Branch Agua Fria River	2.80
Oak Creek	2.51
Oak Wash	2.58
Powder House Wash Tributary 1	2.20
Powder House Wash Tributary 2	2.21
Railroad Wash	2.46
Ramsgate Wash	2.85
Robert Wash	2.63
Russell Wash	2.43
Santa Cruz Wash	2.67
Silver Spring	2.82
Silver Springs Gulch	2.54
Skull Valley Wash	2.76
Sols Wash	2.33
South Branch Agua Fria River	2.81
South Rocky Boy Wash	2.76
Spring Creek	2.63
Telephone Tank Wash	2.63
Telephone Tank Wash Breakout	2.63
Texas Gulch Main Stream	2.75
Texas Gulch West Branch	2.69
Timon Wash	2.70
Verde River	2.37
Wash P	2.18
West Clear Creek	2.54
West Fork Miller Creek	2.77
Wet Beaver Creek	2.49

TABLE 8 – VERTICAL DATUM CONVERSIONS – continued

Stream Name	Conversion Factor
Williamson Valley Wash	2.69
Williamson Valley Wash - North Split	2.67
Willow Creek	3.02
Willow Creek Reservoir Tributary	2.97
Willow Creek Tributary	2.99
Zalesky Wash Main Stem	2.43

4.0 FLOODPLAIN MANAGEMENT APPLICATIONS

The NFIP encourages State and local governments to adopt sound floodplain management programs. To assist in this endeavor, each FIS provides 1-percent annual chance floodplain data, which may include a combination of the following: 10-, 2-, 1-, and 0.2-percent annual chance flood elevations; delineations of the 1- and 0.2-percent annual chance floodplains; and 1-percent annual chance floodway. This information is presented on the FIRM and in many components of the FIS, including Flood Profiles, Floodway Data tables, and Summary of Stillwater Elevation tables. Users should reference the data presented in the FIS as well as additional information that may be available at the local community map repository before making flood elevation and/or floodplain boundary determinations.

4.1 Floodplain Boundaries

To provide a national standard without regional discrimination, the 1-percent annual chance flood has been adopted by FEMA as the base flood for floodplain management purposes. The 0.2-percent annual chance flood is employed to indicate additional areas of flood risk in the community. For each stream studied by detailed methods, the 1- and 0.2-percent annual chance floodplain boundaries have been delineated using the flood elevations determined at each cross section. Between cross sections, the boundaries were interpolated using topographic maps.

The 1- and 0.2-percent annual chance floodplain boundaries are shown on the FIRM (Exhibit 2). On this map, the 1-percent annual chance floodplain boundary corresponds to the boundary of the areas of special flood hazards (Zones A, AE, AH, and AO), and the 0.2-percent annual chance floodplain boundary corresponds to the boundary of areas of moderate flood hazards. In cases where the 1- and 0.2-percent annual chance floodplain boundaries are close together, only the 1-percent annual chance floodplain boundary has been shown. Small areas within the floodplain boundaries may lie above the flood elevations but cannot be shown due to limitations of the map scale and/or lack of detailed topographic data.

For the streams studied by approximate methods, only the 1-percent annual chance floodplain boundary is shown on the FIRM (Exhibit 2).

Approximate 1-percent annual chance floodplain boundaries in some portions of the study area were taken directly from the Flood Hazard Boundary Map for Yavapai County unless otherwise noted (U.S. Department of Housing and Urban Development, July 1978), the Town of Prescott Valley (FEMA, 1980), and Coconino County (U.S. Department of Housing and Urban Development, 1978).

For Yavapai County, some approximate flood boundaries were delineated using the topographic maps previously cited (USACE, February 1977; USACE, 1974; Aerial Mapping Company, 1979; Aerial Mapping Company, 1982).

For portions of West Clear Creek and other streams studied by approximate methods in the Town of Camp Verde, only the 1-percent annual chance floodplain boundary is shown on the FIRM (Exhibit 2). Approximate 1-percent annual chance floodplain boundaries in some portions of the study area were taken directly from the FIRM for Yavapai County (U.S. Department of Agriculture, 1964).

In the Town of Clarkdale, the boundaries for the approximate study on Minguez Wash were delineated on the same maps in conjunction with the determined elevations. The boundaries for the remaining approximate-studied streams were delineated on aerial photogrammetric maps at a scale of 1:8,400 (Cooper Aerial Surveys, Aerial Photogrammetry, Town of Clarkdale, Arizona, Scale 1:8,400, Tucson, Arizona, 1978). In accordance with FEMA guidelines, approximate floodplains less than 200 feet wide were determined to be areas of minimal flooding and were deleted.

The boundaries for the approximate study on Bell Canyon Wash for approximately 1 mile with the upstream start at Jacks Canyon Road were delineated using aerial photogrammetric data provided by Yavapai County at a scale of 1 inch = 100 feet at a 2-foot contour mapping scale and HEC-RAS modeling by Stantec Consulting, Inc. in 2002.

The boundaries for the approximate study of 2.7 river miles along Big Bug Creek, Red Rock Wash, Prickly Pear Wash, Concho Wash, Mesa Verde Wash, Black Rock Wash and Pima Wash were delineated using 2-foot contour mapping created from aerial photography flown at a scale of 1 inch = 100 feet provided by Cooper Aerial and collected in 1998. HEC-RAS modeling was done by Dibble and Associates in 1999.

The boundaries for the approximate study of along Alberson Wash were delineated using 2-foot contour mapping created from aerial photography flown at a scale of 1 inch = 200 feet provided by Aerial Mapping Company, Inc., and collected in 1998. HEC-RAS modeling was done by ASL Consulting Engineers in 1999.

The boundaries for the approximate study along Kachina Wash and Whistle Wash in the Town of Dewey-Humboldt were delineated using 2-foot contour mapping created from aerial photography flown at a scale of 1:6,000 provided by Cooper Aerial and collected in 1998. HEC-RAS modeling was done by Dibble and Associates in 2002.

The boundaries for the approximate study along Beaver Creek School Wash and Rimrock Creek in the were delineated using 2-foot contour mapping created from aerial photography flown at a scale of 1 inch = 100 feet provided by Cooper Aerial and collected in 1998. HEC-RAS and WSP modeling was done by Claycomb/Rockwell Associates, Inc., in 1999.

The boundaries for the approximate study of 4.5 miles along Yarber Wash in the Town of Dewey-Humboldt were delineated using 2-ft contour mapping created from aerial photography flown and provided by Southwest Mapping Technologies, Inc., and collected in 2005. HEC-RAS modeling was done by Project Engineering Consultants, Ltd., in 2005.

The boundaries for the approximate study along Oak Wash, Cherry Hills Wash, Rio Mesa Wash, Christina Draw, and Pipe Creek were delineated using 4-foot contour mapping created from aerial photography flown at a scale of 1” = 200 feet and provided by Analytical Surveys, Inc., and collected in 1992. HEC-RAS modeling was done by McLaughlin Kmetty Engineers, Ltd., in 1995.

4.2 Floodways

Encroachment on floodplains, such as structures and fill, reduces flood-carrying capacity, increases flood heights and velocities, and increases flood hazards in areas beyond the encroachment itself. One aspect of floodplain management involves balancing the economic gain from floodplain development against the resulting increase in flood hazard. For purposes of the NFIP, a floodway is used as a tool to assist local communities in this aspect of floodplain management. Under this concept, the area of the 1-percent annual chance floodplain is divided into a floodway and a floodway fringe. The floodway is the channel of a stream, plus any adjacent floodplain areas, that must be kept free of encroachment so that the 1-percent annual chance flood can be carried without substantial increases in flood heights. Minimum Federal standards limit such increases to one foot, provided that hazardous velocities are not produced. The floodways in this study are presented to local agencies as minimum standards that can be adopted directly or that can be used as a basis for additional floodway studies.

The floodways presented in this study were computed for certain stream segments on the basis of equal-conveyance reduction from each side of the floodplain. Floodway widths were computed at cross sections. Between cross sections, the floodway boundaries were interpolated. The results of the floodway computations are tabulated for selected cross sections (see Table 9, "Floodway Data," shown in Volume 2). In cases where the floodway and 1-percent annual chance floodplain boundaries are either close together or collinear, only the floodway boundary is shown.

In the case of shallow flooding in Yavapai County, the unpredictable flowpaths have made determination of a floodway meeting FEMA criteria impossible; therefore no floodway is presented in these areas (FEMA, 1999).

The hydraulic modeling of Deception Wash, Bitter Creek, and Bitter Creek South Fork in the Town of Clarkdale indicated that floodway encroachments would not be feasible in view of extremely high velocity zones (approximately 10 feet per second). This applied to all tributary stream reaches within the Town of Clarkdale. Tile floodways on these streams are coincident with the 1-percent annual chance floodplain boundary as shown on the FIRM (FEMA, 1982).

In the City of Cottonwood, no floodway encroachments were computed for those tributary streams to the Verde River in which all or a major portion of the 1-percent annual chance floodwaters are contained within well-defined channels. Encroachments into these well-defined channels would result in extreme high velocity zones, as is indicated by existing flow velocities of approximately 14 feet per second. The floodways on these streams were made coincident with the 1-percent annual chance floodplain boundary. The tributary streams along which the floodway concept was seen as appropriate were Silver Springs Gulch and Railroad Wash (FEMA, 1981).

In the Town of Prescott Valley, the 1-percent annual chance flood on North Navajo Drive Wash stays within the natural channel boundaries; therefore, no floodway encroachments were made for this wash (FEMA, 1982, revised 1990).

The area between the floodway and 100-year floodplain boundaries is termed the floodway fringe. The floodway fringe encompasses the portion of the floodplain that could be completely obstructed without increasing the water-surface elevation of the 1-percent annual chance flood more than one foot at any point. Typical relationships between the floodway and the floodway fringe and their significance to floodplain development are shown in Figure 1, "Floodway Schematic".

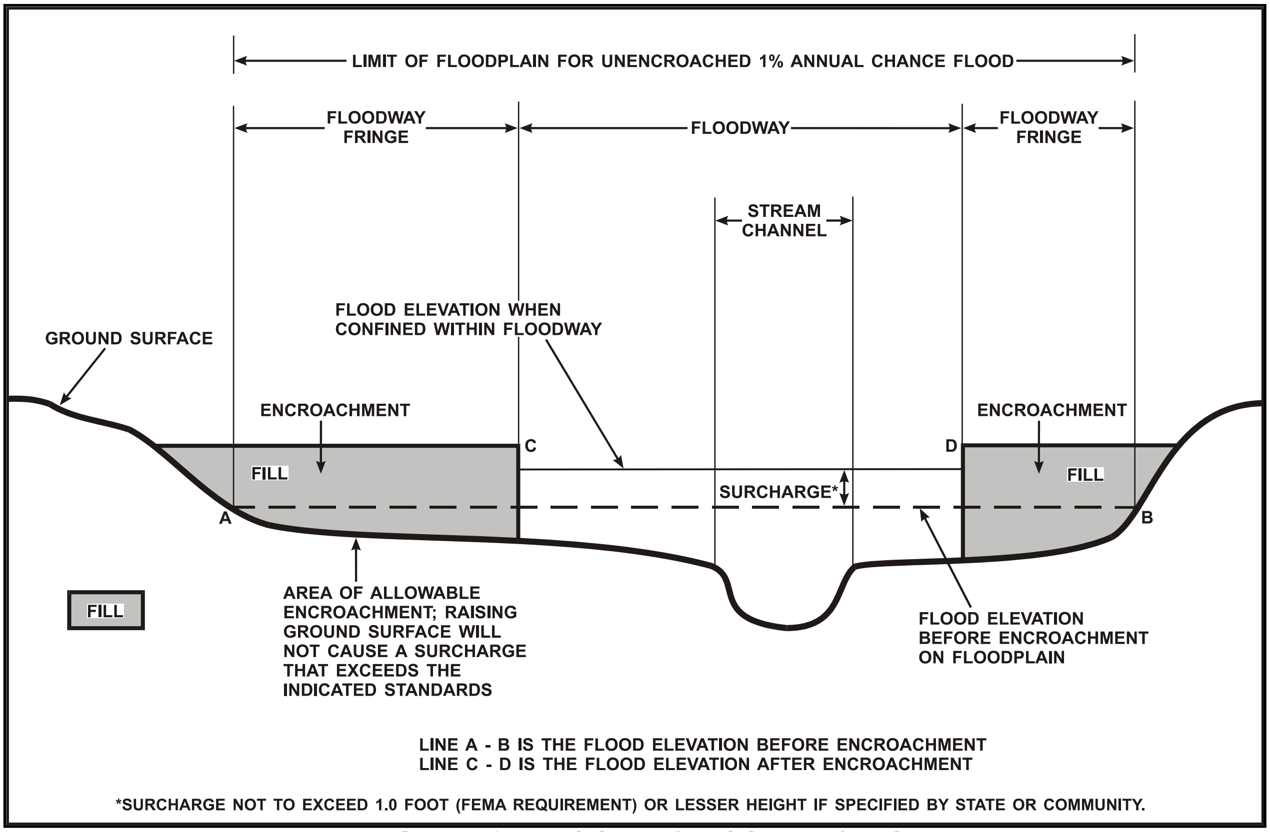

FIGURE 1 - FLOODWAY SCHEMATIC

5.0 INSURANCE APPLICATIONS

For flood insurance rating purposes, flood insurance zone designations are assigned to a community based on the results of the engineering analyses. The zones are as follows:

Zone A

Zone A is the flood insurance rate zone that corresponds to the 1-percent annual chance floodplains that are determined in the FIS by approximate methods. Because detailed hydraulic analyses are not performed for such areas, no base flood elevations or depths are shown within this zone.

Zone AE

Zone AE is the flood insurance rate zone that corresponds to the 1-percent annual chance floodplains that are determined in the FIS by detailed methods. In most instances, whole-foot base flood elevations derived from the detailed hydraulic analyses are shown at selected intervals within this zone.

Zone AH

Zone AH is the flood insurance rate zone that corresponds to the areas of 1-percent annual chance shallow flooding (usually areas of ponding) where average depths are between 1 and 3 feet. Whole-foot base flood elevations derived from the detailed hydraulic analyses are shown at selected intervals within this zone.

Zone AO

Zone AO is the flood insurance rate zone that corresponds to the areas of 1-percent annual chance shallow flooding (usually sheet flow on sloping terrain) where average depths are between 1 and 3 feet. Average whole-foot depths derived from the detailed hydraulic analyses are shown within this zone.

Zone AR

Area of special flood hazard formerly protected from the 1-percent annual chance flood event by a flood control system that was subsequently decertified. Zone AR indicates that the former flood control system is being restored to provide protection from the 1-percent annual chance or greater flood event.

Zone A99

Zone A99 is the flood insurance rate zone that corresponds to areas of the 1-percent annual chance floodplain that will be protected by a Federal flood protection system where construction has reached specified statutory milestones. No base flood elevations or depths are shown within this zone.

Zone V

Zone V is the flood insurance rate zone that corresponds to the 1-percent annual chance coastal floodplains that have additional hazards associated with storm waves. Because approximate hydraulic analyses are performed for such areas, no base flood elevations are shown within this zone.

Zone VE

Zone VE is the flood insurance rate zone that corresponds to the 1-percent annual chance coastal floodplains that have additional hazards associated with storm waves. Whole-foot base flood elevations derived from the detailed hydraulic analyses are shown at selected intervals within this zone.

Zone X

Zone X is the flood insurance rate zone that corresponds to areas outside the 0.2-percent annual chance floodplain, areas within the 0.2-percent annual chance floodplain, and areas of 1-percent annual chance flooding where average depths are less than 1 foot, areas of 1-percent annual chance flooding where the contributing drainage area is less than 1 square mile, and areas protected from the 1-percent annual chance flood by levees. No base flood elevations or depths are shown within this zone.

Zone D

Zone D is the flood insurance rate zone that corresponds to unstudied areas where flood hazards are undetermined, but possible.

6.0 FLOOD INSURANCE RATE MAP

The FIRM is designed for flood insurance and floodplain management applications.

For flood insurance applications, the map designates flood insurance rate zones as described in Section 5.0 and, in the 1-percent annual chance floodplains that were studied by detailed methods, shows selected whole-foot BFEs or average depths. Insurance agents use the zones and BFEs in conjunction with information on structures and their contents to assign premium rates for flood insurance policies.

For floodplain management applications, the map shows by tints, screens, and symbols, the 1- and 0.2-percent annual chance floodplains, floodways, and the locations of selected cross sections used in the hydraulic analyses and floodway computations.
The countywide FIRM presents flooding information for the entire geographic area of Yavapai County. Previously, FIRMs were prepared for each incorporated community and the unincorporated areas of the County identified as floodprone. This countywide FIRM also includes flood-hazard information that was presented separately on Flood Boundary and Floodway Maps, where applicable. Historical data relating to the maps prepared for each community, up to and including the June 6, 2001, countywide, are presented in Table 10, "Community Map History."

7.0 OTHER STUDIES

FIRMs were previously published for Yavapai County unincorporated areas, for the Towns of Camp Verde, Chino Valley, Clarkdale, and Prescott Valley, and for the Cities of Cottonwood, Prescott, and Sedona.

For the unincorporated areas of Yavapai County, the USACE has published Flood Plain Information reports for Verde River (Vicinity of Bridgeport and Camp Verde), Wet Beaver Creek (Vicinity of Lake Montezuma), Verde River and Tributaries (Vicinity of Clarkdale and Cottonwood), West Clear Creek, and Hassayampa River (Vicinity of Wickenburg) (USACE, 1975; U.S. Department of the Interior, 1981, editorial corrections, 1982; USACE, August 1976; USACE, 1972; 83, and 84). Because of more recent topographic mapping, hydrologic analyses based on longer lengths of record, and refined study procedures for this study, the Yavapai County Flood Insurance Study supersedes the Flood Plain Information reports (U.S. Department of Agriculture, 1964).

COMMUNITY NAME	INITIAL IDENTIFICATION	FLOOD HAZARD BOUNDARY MAP REVISIONS DATE	FIRM EFFECTIVE DATE	FIRM REVISIONS DATE
Camp Verde, Town of	July 25, 1978	None	August 19, 1985	September 27, 1991 September 20, 1996 December 19, 1997
Chino Valley, Town of	May 3, 1974	June 11, 1976	September 1, 1981	May 4, 1992
Clarkdale, Town of	August 23, 1974	November 28, 1975	December 1, 1982	None
Cottonwood, City of	June 7, 1974	May 2, 1975	September 16, 1981	November 19, 1987
Dewey-Humboldt, Town of [1]	July 25, 1978	None	August 19, 1985	May 18, 1992 September 20, 1996 December 19, 1997 June 8, 1998 March 9, 1999
Jerome, Town of [2]	None	None	None	None
Prescott, City of	May 17, 1974	None	February 2, 1977	March 29, 1983 September 4, 1985 March 16, 1988 August 19, 1991

[1] This community did not have its own FIRM prior to the first countywide FIS. The land area for this community was previously shown on the FIRM for the unincorporated areas of Yavapai County, but was not identified as a separate NFIP community. Therefore, the dates for this community were taken from the FIRM for Yavapai County.

[2] No Special Flood Hazard Areas Identified

[3] This community did not have its own FIRM prior to the countywide FISs for Yavapai and Coconino Counties. The land area for this community was previously shown on the FIRMs for the unincorporated areas of Yavapai and Coconino Counties, but was not identified as a separate NFIP community. Therefore, the dates for this community were taken from the respective FIRMs.

TABLE 10

FEDERAL EMERGENCY MANAGEMENT AGENCY

YAVAPAI COUNTY, AZ AND INCORPORATED AREAS

COMMUNITY MAP HISTORY

COMMUNITY NAME	INITIAL IDENTIFICATION	FLOOD HAZARD BOUNDARY MAP REVISIONS DATE	FIRM EFFECTIVE DATE	FIRM REVISIONS DATE
Prescott Valley, Town of	March 11, 1980	None	August 16, 1982	July 16, 1990
Sedona, City of[3] (Coconino County)	January 24, 1975	May 30, 1978	November 16, 1983	September 30, 1988
Sedona, City of [3] (Yavapai County)	July 25, 1978	None	August 19, 1985	May 18, 1992 September 20, 1996 December 19, 1997 June 8, 1998 March 9, 1999
Yavapai County (Unincorporated Areas)	July 25, 1978	None	August 19, 1985	May 18, 1992 September 20, 1996 December 19, 1997 June 8, 1998 March 9, 1999

[1] This community did not have its own FIRM prior to the first countywide FIS. The land area for this community was previously shown on the FIRM for the unincorporated areas of Yavapai County, but was not identified as a separate NFIP community. Therefore, the dates for this community were taken from the FIRM for Yavapai County.
[2] No Special Flood Hazard Areas Identified
[3] This community did not have its own FIRM prior to the countywide FISs for Yavapai and Coconino Counties. The land area for this community was previously shown on the FIRMs for the unincorporated areas of Yavapai and Coconino Counties, but was not identified as a separate NFIP community. Therefore, the dates for this community were taken from the respective FIRMs.

TABLE 10

FEDERAL EMERGENCY MANAGEMENT AGENCY

YAVAPAI COUNTY, AZ AND INCORPORATED AREAS

COMMUNITY MAP HISTORY

The only other study completed for the Town of Clarkdale is a report prepared by the USACE entitled, "Floodplain Information, Verde River and Tributaries, Vicinity of Clarkdale and Cottonwood, Yavapai County, Arizona", (USACE, August 1976). This report covers some areas studied for the FEMA study. A comparison of 1-percent annual chance flood elevations and flood profiles presented in the Town of Clarkdale study with those obtained by the USACE shows general disagreement between the two studies. The source of these differences was mainly attributed to differences in expected accuracy obtainable from the topographic information utilized to complete the two studies. The USACE utilized a topographic map at a scale of 1:4,800, with a contour interval of 5 feet. The study contractor for the FEMA study for the Town of Clarkdale utilized a topographic map at a scale of 1:2,400, with a contour interval of 2 feet. The discrepancy in flow profiles between the results obtained by the USACE and the study contractor was resolved through communications with the USACE, Los Angeles District Office.

There are two known flood studies completed for the Town of Cottonwood. One was prepared by the USACE and is entitled, "Flood Plain Information, Verde River and Tributaries, Vicinity of Clarkdale and Cottonwood, Yavapai County, Arizona" (USACE, August 1976); and the other is the original FIS for the City of Cottonwood, Arizona (FEMA, 1981). The 1976 report by the USACE covers some of the same areas that were studied for this study. A comparison of 1-percent annual chance elevations and flood profiles presented in this study with those obtained by the USACE shows general disagreement between the two studies. These differences were mainly attributed to the differences in expected accuracy obtainable from the topographic information utilized to complete the two studies.

The City of Sedona has a separately published Floodplain Management Study prepared by the Soil Conservation Service (Soil Conservation Service, et cetera).

This report either supersedes or is compatible with all previous studies published on streams studied in this report and should be considered authoritative for the purposes of the NFIP.

8.0 LOCATION OF DATA

Information concerning the pertinent data used in the preparation of this FIS can be obtained by contacting FEMA, Federal Insurance and Mitigation Division, 1111 Broadway, Suite 1200, Oakland, California 94607-4052.

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10.0 REVISIONS

This section has been added to provide information regarding significant revisions made since the original FIS report and FIRM were printed. Future revisions may be made that do not result in the republishing of the FIS report. All users are advised to contact the Community Map Repository at the address below to obtain the most up-to-date flood hazard data.

Yavapai County Flood Control District Office
1120 Commerce Drive
Prescott, Arizona 86305

10.1 First Revision (Revised October 16, 2014)

a. Acknowledgements

The hydrologic analysis for this revision was conducted by HDR and completed January 2008 (Reference 1) under contract to the Yavapai County Flood Control District. The hydraulic analysis and floodplain mapping for this revision was conducted by JE Fuller Hydrology and Geomorphology (JEF) and completed in December 2012 (Reference 2) under contract with Yavapai County Flood Control District. The establishment of detailed flood hazards for Squaw Creek, Mud Springs Wash, and Cougar Creek as well as the redelineation of detailed flood hazards for Agua Fria River and Black Canyon Creek within the unincorporated areas of Yavapai County was performed by BakerAECOM in February 2013 under FEMA contract number HSFEHQ-09-D-0368.

b. Coordination

A final CCO meeting was held on May 1, 2013 to review the results of this revision. The meeting was attended by representatives of the Yavapai County Flood Control District, FEMA, BakerAECOM, JE Fuller, and Arizona Department of Water Resources.

c. Scope of Study

This revision affects portions of Yavapai County, Arizona. This revision includes the establishment of detailed flood hazards for the following streams:

Squaw Creek
Cougar Creek
Mud Springs Wash

The streams redelineated using detailed methods include:

Agua Fria River
Black Canyon Creek

d. Hydrologic Analyses

For the Agua Fria River, discharges for the 10-, 2-, 1-, and 0.2%-annual-chance floods were computed using Log-Pearson Type III procedures utilizing USGS gage data for stations 09512500 and 09512800. The PeakFQ software program for flood frequency analyses was used for the computations (Reference 3).

The gage data for the Verde River were analyzed using Bulletin 17-B (Reference 4) procedures based on the cumulative years of gage records, peak discharges, log of discharges, variance of discharges, frequency factors, skewness, regional skew, station skew, and weighted skew.

For Black Canyon Creek, Mud Springs Wash, Squaw Creek, and Cougar Creek, discharges for discharges for the 10-, 2-, 1-, and 0.2%-annual-chance floods were computed using regression equations. The equations from the USGS Open File Report 78-711 (Reference 5) was used for Black Canyon Creek due to the drainage area exceeding 200 square miles while the USGS Water Supply Paper 2433 (Reference 6) was used for Mud Springs Wash, Squaw Creek, and Unnamed Tributary.

The discharge-drainage area relationships for the studied streams are shown below.

TABLE 11 – SUMMARY OF DISCHARGES

FLOODING SOURCE AND LOCATION	DRAINAGE AREA (sq. miles)	PEAK DISCHARGES (cfs)			
		10-PERCENT	2-PERCENT	1-PERCENT	0.2-PERCENT
AGUA FRIA RIVER					
Above Squaw Creek	754	23,240	40,310	48,540	66,650
At Squaw Creek	821	26,370	45,300	54,320	72,840
At Mud Springs Wash	943	26,730	45,870	54,980	73,540
At Black Canyon Creek	1,065	41,010	68,080	80,480	99,360
BLACK CANYON CREEK					
At Agua Fria River	244	14,200	30,100	38,000	56,600
SQUAW CREEK					
At Agua Fria River	56	3,970	11,900	17,500	37,000
MUD SPRINGS WASH					
At Agua Fria River	0.7	310	930	1,420	3,180
COUGAR CREEK					
At Agua Fria River	3.9	830	2,830	4,430	11,000

e. Hydraulic Analysis

The U.S. Army Corp of Engineers HEC-RAS Version 4.1 (Reference 7) was used to perform step-backwater profile calculations for approximately 11.8 stream miles of the Agua Fria River and tributaries including Black Canyon Creek, Squaw Creek, Mud Springs Wash, and Cougar Creek.

The downstream boundary condition for the Agua Fria River was set to utilize the normal depth method and a slope of 0.00814 ft/ft, the Black Canyon Creek was set to utilize the normal depth method and a slope of 0.00894 ft/ft, the Mud Spring Wash was set to utilize the normal depth method and a slope of 0.01321 ft/ft, the Squaw Creek was set to utilize the normal depth method and a slope of 0.0085 ft/ft, and the Cougar Creek was set to utilize the normal depth method and a slope of 0.01935 ft/ft.

The floodways were prepared using standard method 1 and method 4 in HEC-RAS. Additionally, no encroachment was allowed that would result in the energy grade being increased by one (1.0) foot.

Manning's "n" values were assigned using the methodology outlined by Flood Control District of Maricopa County (FCDMC) and adjusted as necessary based on various methods (References 8 - 10).

Cross sections were prepared according to the USACE HEC-RAS reference manual (Reference 11) and were developed from 2-foot contour interval photogrammetric data developed by Vertical Mapping Resources (VMR) in March 2005.

Within the study reach are six hydraulically significant bridges. These bridges are of various sizes, differ in construction materials, and have unique characteristics related to the piers and embankments. All bridges modeled were field surveyed to determine appropriate hydraulic parameters.

Along the Agua Fria River, one lateral weir overflow area was identified in the 2008 FIS and modeled using the HEC-RAS lateral structure option. The lateral structure option was chosen for this reach because the flow breakout type is most similar to a lateral weir overflow. The resulting overflow during the 100-year regulatory discharge is estimated to be approximately 269 cfs.

Floodway Data Tables and profiles for Agua Fria River and Black Canyon Creek were revised to account for adjustments to backwater elevations on these tributaries. For Squaw Creek, Mud Springs Wash, and Cougar Creek, Floodway Data Tables and profiles were created.

f. Floodplain Boundaries

For the streams studied, the 1% and 0.2%-annual-chance flood hazard boundaries were delineated the 2-foot contour interval photogrammetric data developed by Vertical Mapping Resources (VMR) in March 2005

g. References

1. Yavapai County Flood Control District, Hydrologic Analyses and Results for the Agua Fria River and Tributaries. Prepared by HDR, January 2008.

2. Yavapai County Flood Control District, Floodplain Delineation Study of Agua Fria River and Tributaries, Including Black Canyon Creek, Squaw Creek, Mud Springs Wash, and Un-Named Tributary. Prepared by JE Fuller Hydrology and Geomorphology, February 2012.

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10.2 Second Revision (Revised March 2, 2015)

a. Acknowledgements

The hydrologic and hydraulic analyses and floodplain mapping for this revision was conducted by Cardno WRG, Inc (Yavapai County Development Services Flood Control District, Technical Data Notebook for Big Bug Creek Flood Hazard Study. Prepared by Cardno WRG, Inc, August 2011 and WRG Design, Inc., Big Bug Creek Detailed Flood Hazard Study, February 10, 2008.) under contract to the Yavapai County Flood Control District. The redelineation of detailed flood hazards for Big Bug Creek and Hackberry Creek within the unincorporated areas of Yavapai County was performed by BakerAECOM in June 2013 under FEMA contract number HSFEHQ-09-D-0368.

b. Coordination

A final CCO meeting for this revision was held on September 18, 2013 to review the results. The meeting was attended by Yavapai County Flood Control District, the Town of Dewey-Humboldt, FEMA, Cardno and BakerAECOM.

c. Scope of Study

This revision affects portions of Yavapai County, Arizona. This revision includes detailed flood hazard analysis for the following streams:

Big Bug Creek	Hackberry Creek

LOMR Case Number 13-09-0731P, for Yavapai County (Unincorporated Areas), was also incorporated into this revision. This modification became effective on March 7, 2014 and impacts FIRM 04025C2878H and 04025C2886H. The flooding sources affected as part of this study are Concho Wash, Prickly Pear Wash and Red Rock Wash.

d. Hydrologic Analyses

For Big Bug Creek, discharges for the 10-, 4-, 2-, 1-, and 0.2%-annual-chance floods were computed using the USGS regional regression methodology in accordance with criteria outlined in the Level 2 procedures of the Arizona Department of Water Resources Flood Warning and Dam Safety Section's *Delineation of Riverine Floodplains and Floodways in Arizona*. The USGS's National Flood Frequency Program (NFFP) version 3.0 was used to calculate the peak flows (Reference 3).

The discharge-drainage area relationships for the studied streams are shown below.

TABLE 12 – REVISED SUMMARY OF DISCHARGES

FLOODING SOURCE AND LOCATION	DRAINAGE AREA (sq. miles)	PEAK DISCHARGES (cfs) 10-PERCENT	4-PERCENT	2-PERCENT	1-PERCENT	0.2-PERCENT
BIG BUG CREEK						
At Agua Fria River	60.5	3,820	6,780	11,300	16,500	31,400
At approximately 2,100 feet downstream of Brahma Drive	58.4	3,720	6,600	11,000	16,100	30,900
At Interstate 17	54.9	3,550	6,320	10,600	15,500	30,100
At Hackberry Creek	39.3	2,810	5,050	8,620	12,800	26,100
At Mayer	34.4	2,550	4,600	7,890	11,800	24,500
At Central Avenue	24.5	1,990	3,640	6,320	9,520	20,700
At approximately 500 feet downstream of F.S. 87 Road	19.7	1,700	3,130	5,460	8,280	18,500
At approximately 3,650 feet upstream of Ricks Pit Road	10.3	1,080	2,040	3,560	5,480	13,000
CONCHO WASH						
At downstream limit of detailed study	0.28	*	*	*	530	*
HACKBERRY CREEK						
At Big Bug Creek	10.6	1,220	2,280	4,050	6,240	14,400
PRICKLY PEAR WASH						
At Prickly Pear Drive	0.45	*	*	*	520	*
RED ROCK WASH						
At Catus Wren Drive	1.01	*	*	*	510	*
At downstream limit of detailed study	1.69	*	*	*	1,000	*

* Data not available

e. Hydraulic Analysis

The U.S. Army Corp of Engineers HEC-RAS Version 4.0 (Reference 4) was used to perform step-backwater profile calculations for approximately 22 stream miles of the Big Bug Creek and Hackberry Creek.

The downstream boundary condition for the Big Bug Creek was set to utilize the normal depth method and a slope of 0.00683 ft/ft.

A flow split was identified to occur at river station 21.214. A portion of the mainline flow was identified to spill toward a low lying sump with outfall back into the channel just downstream of river station 21.100.

The floodways were prepared using standard method 1 and method 4 in HEC-RAS. Additionally, no encroachment was allowed that would result in the energy grade being increased by one (1.0) foot. Floodway data tables for the flooding sources studied in this PMR including the incorporated LOMR are included as part of Table 9.

Manning's "n" values were assigned using the methodology outlined in Dr. Ven Te Chow's Open-Channel Hydraulics and the Flood Control District of Maricopa County's (FCDMC) Estimated Manning's Roughness Coefficients for Stream Channels and Flood Plains in Maricopa County, Arizona (Reference 5).

Cross sections were prepared according to the USACE HEC-RAS reference manual (Reference 6) and were developed from 2-foot contour interval photogrammetric data developed by Vertical Mapping Resources (VMR) in April 2007 (Reference 7).

Within the study reach are seven hydraulically significant bridges, two box culverts and one pipe culvert. These structures were field surveyed to determine appropriate hydraulic parameters.

f. Floodplain Boundaries

For the streams studied, the 1% and 0.2%-annual-chance flood hazard boundaries were delineated using the 2-foot contour interval photogrammetric data developed by Vertical Mapping Resources (VMR) in April 2007. The mapping is reported to be on the NAVD 88 vertical datum and the UTM NAD83 horizontal datum.

g. References

1. Yavapai County Development Services Flood Control District, Technical Data Notebook for Big Bug Creek Flood Hazard Study. Prepared by Cardno WRG, Inc, August 2011.

2. WRG Design, Inc., Big Bug Creek Detailed Flood Hazard Study, February 10, 2008.

3. U.S.G.S. National Flood Frequency Program, Version 3.2, October 2002.

4. U.S. Army Corps of Engineers, HEC-RAS River Analysis System, Version 4.0, March 2008.

5. Thomsen, B.W. and Hjalmarson, H.W., 1991, Estimated Manning's Roughness Coefficients for Stream Channels and Flood Plains in Maricopa County, Arizona, U.S.G.S: Tucson, Arizona, 126 p.

6. U.S. Army Corps of Engineers, HEC-RAS River Analysis System Hydraulic Reference Manual, Version 4.0, January 2010.

7. Vertical Mapping Resources, Inc. Topographic Mapping for Big Bug Creek, 2-foot interval contours, Flight date: April 3, 2007.

10.3 Third Revision (Revised October 16, 2015)

a. Acknowledgements

The hydraulic analysis for the Verde River revision was conducted by HDR and completed January 25, 2011 under contract to the Yavapai County Flood Control District (Reference 1). The establishment of approximate Zone A flood hazards as well as redelineation of existing flood hazards for various streams in the Town of Clarkdale, City of Cottonwood, Town of Camp Verde, and the unincorporated areas of Yavapai County was performed by BakerAECOM in April 2012 under FEMA contract number HSFEHQ-09-D-0368 (Reference d). The appeal of Del Monte Wash and Silver Springs Gulch was submitted by Atkins, accepted, and was incorporated into this PMR (Reference 3).

b. Coordination

A final CCO meeting was held on June 5, 2012, to review the results of this revision. The meeting was attended by the Town of Camp Verde, the Town of Clarkdale, the City of Cottonwood and Yavapai County.

c. Scope of Study

This revision affects portions of Yavapai County, Arizona, including the Towns of Clarkdale and Camp Verde and the City of Cottonwood. This revision includes modeling and updates of Zone A flood hazards for the following streams:

Beaver Creek
Black Canyon Creek
Cherry Creek
Cherry Creek Overflow
Del Monte Wash
Grampa Wash

Mescal Wash
North Fork Mescal Gulch
Oak Creek Tributary 1
Oak Creek Tributary 2
Oak Creek Tributary 3
Oak Creek Tributary 4
Oak Wash
Pecks Lake
Pecks Lake Tributary
Pipe Creek
Silver Springs Gulch
Unnamed Creek A
Unnamed Creek B
Unnamed Creek C
Unnamed Creek D
Unnamed Creek F
Wikiup Creek
Wilber Canyon Creek

Some streams, or portions of streams, studied by detailed methods in the September 3, 2010 FIS were redelineated on more detailed and up-to-date terrain data for this effort. Those streams include:

Beaver Creek
Bitter Creek
Cherry Creek
Copper Canyon Wash
Deception Wash
Lucky Canyon Wash
Oak Creek
West Clear Creek

The Verde River was restudied by detailed methods from approximately 3 miles upstream of the Tuzigoot Bridge in the Town of Clarkdale downstream to approximately 3 miles downstream of the confluence with West Clear Creek in unincorporated Yavapai County (a distance of approximately 41 miles). Revised Base (1%-annual-chance (100-year)) Flood Elevations (BFEs), 1% and 0.2%-annual-chance (500-year) flood hazard boundaries, and 1%-annual-chance floodway boundaries have been produced.

LOMR Case Number 12-09-2694P was partially incorporated into this revision. This modification became effective on December 27, 2013 and impacts FIRMs 04025C1815G, 1820G, 2180H, and 2185G. All Profiles (210P, 210Pa, 266P-268P) and FWDTs were incorporated into this FIS. Only the data on 2180H was incorporated into the FIRM panels per this PMR revision. The flooding source affected as part of this study is Wet Beaver Creek and Russell Wash.

REVISED SUMMARY OF DISCHARGES

FLOODING SOURCE AND LOCATION	DRAINAGE AREA (sq. miles)	PEAK DISCHARGES (cfs)			
		10-PERCENT	2-PERCENT	1-PERCENT	0.2-PERCENT
RUSSEL WASH					
At confluence with Wet Beaver Creek	15.3	1,610	5,300	8,110	18,000

LOMR Case Number 13-09-0851P was partially incorporated into this revision. This modification became effective on August 20, 2013 and impacts FIRM 04025C1389G and 1393H. All profiles (91P-98P) and FWDTs were incorporated into this FIS. Only the data on 1393H was incorporated into the FIRM panels per this PMR revision. The flooding source affected as part of this study is Deception Wash.

LOMR Case Number 13-09-1967P was partially incorporated into this revision. This modification became effective on February 9, 2015 and impacts FIRM 04025C1759G, 1775G, and 1778H. All profiles (201P-201Pd, 298P-313P) and FWDTs were incorporated into this FIS. Only the data on 1778H was incorporated into the FIRM panels per this PMR revision. The flooding sources affected as part of this study are Oak Wash, South Branch Oak Wash, Cherry Hill Wash, and Rio Mesa Wash.

REVISED SUMMARY OF DISCHARGES

FLOODING SOURCE AND LOCATION	DRAINAGE AREA (sq. miles)	PEAK DISCHARGES (cfs)			
		10-PERCENT	2-PERCENT	1-PERCENT	0.2-PERCENT
CHERRY HILLS WASH					
At State Route 260	1.25	342	541	669	1,037
OAK WASH					
At Fir Street	4.54	794	1,123	1,248	1,677
At confluence with Verde River	5.30	2,320	3,411	4,230	11,500
RIO MESA WASH					
At State Route 260	0.76	363	549	631	843
SOUTH BRANCH OAK WASH					
At Confluence with Oak Wash	0.45	339	549	694	944

d. Hydrologic Analyses

For the Verde River, discharges for the 10-, 4-, 2-, 1-, and 0.2%-annual-chance floods were computed utilizing USGS gage data for stations 09504000 and 09506000 in the Verde Valley Basin. The USACE Hydraulic Engineering Center (HEC) Statistical Software Package (SSP) for flood frequency analyses was used for the computations. Gage station 0950400 is located in Prescott National Forest on the left bank, approximately 1.7 miles downstream from Sycamore Creek and 5.6 miles north of Clarkdale. Station 09506000 is also located in Prescott National Forest on the right bank, approximately 600 feet upstream from Chasm Creek and 9 miles southeast of Camp Verde (References 1 & 4). Gage characteristics are provided in the table below.

GAGE SUMMARY

Gage Number	Drainage Area	Period of Record	Maximum Q	Date of Max
09504000	3,503 sq. mi.	46 years	53,200 cfs	2/2/1993
09506000	5,009 sq. mi.	32 years	119,000 cfs	2/20/1993

The gage data for the Verde River were analyzed using Log-Pearson Type III procedures based on the cumulative years of gage records, peak discharges, log of discharges, variance of discharges, frequency factors, skewness, regional skew, station skew, and weighted skew. The gage data provided an additional 30 years of record as compared to the previously-published hydrologic analysis for the Verde River.

Revised discharge-drainage area relationships for the Verde River are shown below.

REVISED SUMMARY OF DISCHARGES

FLOODING SOURCE AND LOCATION	DRAINAGE AREA (sq. miles)	PEAK DISCHARGES (cfs)			
		10-PERCENT	2-PERCENT	1-PERCENT	0.2-PERCENT
VERDE RIVER					
At USGS gage no. 09504000	3,124	22,750	55,100	75,100	136,700
At US Route 89A bridge	3,247	23,900	58,200	79,600	149,700
Below confluence with Oak Creek	3,776	28,700	72,100	100,000	193,900
Below confluence with West Beaver Creek	4,287	33,500	86,300	121,200	241,000
Below confluence with West Clear Creek	4,619	36,800	96,000	135,600	273,900
At USGS gage no. 09506000	4,645	37,000	96,800	136,700	276,500

For the approximate Zone A studies, 1%-annual-chance discharges were taken from section 3.1 of this FIS report. In cases where effective discharges were not available, discharges developed by Yavapai County using USGS regional regression equations were used (Reference 5).

e. Hydraulic Analysis

For the Verde River, water surface elevations and floodway limits were computed using georeferenced modeling data within the USACE HEC-GeoRAS computer software (Reference 6). Both upstream and downstream study limits are bound by the Prescott National Forest, while the downstream limit is also bound by the Coconino National Forest. No future developmental impacts are anticipated in these areas.

The downstream boundary condition for the Verde River was set to utilize the normal depth method and a slope of 0.004734 ft/ft, based on a 2,000-foot sample reach. No known water surface elevation for this location was available from the previous study.
The floodway was prepared using standard method 1 and method 4 in HEC-GeoRAS. These two methods reflect the same encroachments at each cross section, with the exception of a customized adjustment applied at the 10th Street Bridge that results from poor alignment between the approach roadway and the bridge structure.

Irrigation canals and diversion structures were modeled assuming they are at capacity and cannot divert or convey flow. Additional modeling considerations were made for the Interstate 17 embankment and bridges (Reference 1).

Manning's "n" values were assigned for the existing conditions, as they are related to each area of similar roughness for the 1%-annual-chance storm event at the time of study. The values were determined using the methodology outlined by USGS (Reference 8) and adjusted as necessary using various methods (Reference 1).

Cross sections were prepared according to the USACE HEC-RAS reference manual (Reference 9) and were developed from LIDAR data supplied by Yavapai County.

The Verde River study reach includes eight hydraulically significant bridges. These bridges are of various sizes, differ in construction materials, and have unique characteristics related to the piers and embankments. All bridges were modeled using both the energy and momentum equations to facilitate the analysis of the structures in low flow conditions with a coefficient of drag (Cd) set between 1.2 and 2.0 with respect to the structure type. High flow methods were set to utilize pressure and/or weir flow, with a submerged inlet + outlet Cd set to 0.8.

Levees that are considered to be naturally occurring and nonstructural have not been accredited and are subject to natural degradation and destruction from storm events over the course of time. All levee areas were individually evaluated to ensure that the flood hazard mapping extents reflect a "natural valley" condition (Reference 1).

Floodway Data Tables and profiles for Cherry Creek, Copper Canyon Wash, Lucky Canyon Wash, and Oak Creek were revised to account for adjustments to backwater elevations on these tributaries. For Beaver Creek Bitter Creek, and Deception Wash only the profiles were updated, as no cross sections were impacted by the changes.

For the approximate Zone A analyses (except for Beaver Creek), starting water surface elevations were calculated using the normal depth method. Cross sections were obtained from LIDAR data supplied by Yavapai County with spacing between cross sections ranging from 500 to 1,500 feet (with closer spacing as needed). The banks and ineffective flow areas were established manually. Hydraulic structures were not included in the Zone A modeling; therefore, backwater effects at bridges and culverts have not been considered.

Aerial photography was used to estimate the Manning's "n" values for the channel and overbank areas on each flooding source. Coefficients of 0.04 and 0.05 were used for the channel and overbank, respectively.

For Beaver Creek, the starting water surface elevation was a known elevation taken from the detailed study along Beaver Creek published in the September 3, 2010 FIS (Reference 10). Beaver Creek Manning's "n" values were adjusted to tie-in to the detailed study (Reference 2).

Portions of Del Monte Wash and Silver Springs Gulch were analyzed (Reference 3) for approximate methods using two methods: USACE's HEC-RAS computer program Version 4.1.0, in conjunction with Geographic Information Systems (GIS); and the FLO-2D software program (Version 2009.06). Cross section data used in the HEC-RAS computer analysis was obtained from photogrammetric topographic data meeting 2-foot contour interval accuracy obtained in April of 2007 (Reference 11).

In the two-dimensional modeling of Silver Springs Gulch and Del Monte Wash, a computational grid size of 30-foot by 30-foot was used for the approximate analysis. This grid cell size resolution was sufficient in determining the flooding extents and depths along the studies streams for this approximate study. Channel elements were input into the two-dimensional model to allow for channel conveyance as well as overland flow to determine the flooding limits. The channel geometries were obtained from photogrammetric topographic data meeting 2-foot contour interval accuracy obtained in April of 2007.

Manning's roughness coefficient values (or *n* values) for one-dimensional flows in the HEC-RAS model were determined from 2006 Phillips and Tadayon method. The Manning's *n* values used for each cross section were determined based on field visits, photographs of the natural landscape, and aerial imagery. A summary table of Manning's *n* values used in the HEC-RAS models are listed in the table on the following page.

Roughness coefficients for two-dimensional flow were determined from recommendations in the FLO-2D Reference Manual, the California DWR guidelines for FLO-2D modeling in the Central Valley, and previous experience. In order to validate the roughness coefficients, the velocities in the output model were examined to ensure realistic velocities were obtained in the model. High water marks or other historical data was not available for either flooding source. The table below summarizes the roughness coefficients used in the two-dimensional model.

MANNING'S ROUGHNESS COEFFICIENTS

1-D Roughness Coefficients	n-value
Streets, pavement	**0.018**
Undeveloped land, graded/cleared/pasture	**0.030**
Undeveloped land, away from channel	**0.041**
Silver Springs main channel, dwnst Main St.	**0.044**
Silver Springs main channel, most locations	**0.046**
Del Monte main channel	**0.048**
Commercial development, big box	**0.060**
Silver Springs overbank, dwnst Main St	**0.061**
Commercial development, medium box	**0.065**
High Density residential development	**0.075**
Overbank, next to channel, hvy veg	**0.096**

TWO DIMENSIONAL ROUGHNESS COEFFICIENTS

2-D Roughness Coefficients	n-value
Asphalt and Streets	**0.030**
Channel, Vegetated	**0.065**
Open Land, No Debris	**0.070**
Open Land, Sparse Vegetation	**0.120**
Open Land, Light Vegetaion	**0.150**
Grass Cover	**0.150**
Commercial	**0.170**
Residential	**0.200**
Dense Residential	**0.250**
Dense Vegetation	**0.300**

In many locations due to the steep terrain, the HEC-RAS model defaulted to critical depth when the model was run under subcritical flow regime. This suggested that there might be localized supercritical flow at multiple locations. However, since FEMA states that hydraulic modeling for floodplain mapping studies should assume that flow remains in the subcritical regime, all HEC-RAS models have been executed under the assumption of subcritical flow, and all results presented herein have been obtained through subcritical flow analysis.

f. Floodplain Boundaries

For the Verde River, 1% and 0.2%-annual-chance flood hazard boundaries were delineated using a Triangulated Irregular Network (TIN) surface provided by Yavapai County. The TIN was generated using 2007 LIDAR data acquired at a 1-meter post spacing for a 193-square-mile area by Vertical Mapping Resources (Reference 9).

The 1%-annual-chance flood hazard boundaries for streams studied by approximate methods, as well as redelineated effective detailed studies, were also delineated using the aforementioned TIN. These flooding sources are listed in Section 10.1c above.

g. References

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4. U.S. Department of the Army, Corps of Engineers, Hydrologic Engineering Center, HEC-SSP, Version 1.1, April 2009.

5. Yavapai County Flood Control District, Yavapai County GIS Tools Project, October 2010.

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8. U.S. Department of the Interior, Geologic Survey, Selection of Manning's Roughness Coefficient for Natural and Constructed Vegetated and Non-Vegetated Channels, and Vegetation Maintenance Plan Guidelines for Vegetated Channels in Central Arizona, Phillips and Tadayon, 2006.

9. U.S. Department of the Army, Corps of Engineers, Hydrologic Engineering Center, HEC-RAS Hydraulic Reference Manual, Version 3.1, March 2008.

10. U.S. Department of Homeland Security, Federal Emergency Management Agency, Flood Insurance Study, Yavapai County, Arizona and Incorporated Areas, September 3, 2010.

11. Vertical Mapping Resources, Light Detection and Ranging (LiDAR) collection and aerial imagery, State Plane NAD83, NAVD88, 1-meter post spacing for 193 square miles, flight date April 24, 2007.