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Arizona Stream Navigability Study for the Verde River:

Salt River Confluence to Sullivan Lake

Draft Final Report

Prepared for the

Arizona State Land Department

Date of Original Report: November 1993

Prepared by

CH2M HILL

SWCA Environmental Consultants
Arizona Geological Survey

Revised:

June 2003: **JE Fuller/Hydrology & Geomorphology, Inc.**

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HYDROLOGY & GEOMORPHOLOGY, INC.

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Preface

This report was prepared under contract to the Arizona State Land Department Drainage & Engineering Section. The report summarizes factual information relating to the navigability of the Verde River as of the time of statehood. This report provides information on the Verde River, from its confluence with the Salt River to its headwaters at Sullivan Lake near Paulden in Yavapai County. Information presented in this report is intended to provide data to the Arizona Navigable Stream Adjudication Commission (ANSAC) from which ANSAC will make a determination regarding the navigability of the Verde River. This report does not make a recommendation or draw any conclusions regarding title navigability of the Verde River.

The report consists of several related parts. First, archaeological information for the Verde River Valley relating to river uses is presented to set the long-term context of river conditions and river uses. Second, historical information from the periods prior to and including the time of statehood are discussed with respect to river uses, modes of transportation, and river conditions. Limited oral history information for the river is also presented. Third, a review of geologic influences on stream flow and river conditions is also presented. Fourth, historical and current land use information are described and presented in a GIS format. Fifth, historical and modern hydrologic data are summarized to illustrate past and potential flow conditions in the river. Sixth, a review of accounts of historical and modern boating is presented. Finally, appendixes of related information and a glossary are attached.

The original Verde River Stream Navigability Study was performed by CH2M HILL, Inc., the Arizona Geological Survey (AZGS), and SWCA, Environmental Consultants, Inc. in 1993 under contract #A3-0061 for the Arizona State Land Department. Project staff for the original study included V. Ottosawa-Chatupron, Arizona State Land Department, Project Manager; Jon Fuller, CH2M HILL team leader, hydrologist; Phil Pearthree AZGS geomorphologist; Dennis Gilpin, SWCA, historian; Marc Cederholm, SWCA, GIS specialist. Data summarized in this study were obtained from numerous agencies, libraries, and collections named in the appendixes of this report. Use of this document is governed by the Arizona State Land Department and the Arizona Navigable Stream Adjudication Commission. Revisions to the CH2M HILL report were completed in 1996 by JE Fuller/ Hydrology & Geomorphology, Inc. under contract #LOA 97-01, and in 2003 by JE Fuller/Hydrology & Geomorphology, Inc. under contract #AD000150-010.

Executive Summary

CH2M HILL, in cooperation with SWCA Environmental Consultants and the Arizona Geological Survey (AZGS), was retained in 1993 by the Arizona State Land Department (ASLD) to provide information to the Arizona Stream Navigability Adjudication Commission (ANSAC). ANSAC will use information provided by the project team to make a determination regarding the navigability or non-navigability of the Verde River. This report provides information on the portion of the Verde River located between Granite Reef Dam and the Sullivan Lake near Paulden. The 1993 CH2M HILL report was later revised in 1996 and 2003 by JE Fuller/Hydrology & Geomorphology, Inc. (JEF) under contracts to ASLD.

The basic approach to this study was to develop a database of information to be used by ANSAC in making a determination of navigability or non-navigability. Because the State's definition of navigability includes both actual navigation and susceptibility to navigation, the data collection effort was directed at two areas:

- Historical Uses of the River. Data describing actual uses of the river at the time of statehood were collected to help answer the question, "Was the river used for navigation?"

- Potential Uses of the River. Data describing river conditions at the time of statehood were collected to help answer the question, "Could the river have been used for navigation?"

Specific tasks for the study included agency contact, a literature search, summary of data collected from agencies and literature, and preparation of a summary report. The objectives of the agency contact task were to inform community officials of the studies, to obtain information on historical and potential river uses, and to obtain access to data collected by agency personnel. For the latter task, public officials from communities, towns, cities, and counties located within the study reach were contacted. The objective of the literature search was to obtain published and unpublished documentation of historical river uses and river conditions. Information collected from agency contacts was supplemented by published information from public and private collections.

The literature search focused on five subject areas: (1) Archaeology, (2) History, (3) Hydrology, (4) Hydraulics, and (5) Geomorphology. Archaeological data augment the historical record of potential river uses at statehood by providing an extended record of river conditions, use of river water, climatic variability, and cultural history along the rivers. Historical data provide information on actual river uses as of the time of statehood, but also provide information on whether river conditions could have supported certain types of navigation. SWCA historians prepared a chapter summarizing use of the river and adjacent areas in historic times, with special emphasis on the establishment, growth, and development of towns, irrigation systems, commercial activities, and developments. The hydrologic/hydraulic data are the primary source of information regarding susceptibility to navigation. These data include estimates of flow depths, width, velocity, and average flow conditions at statehood, based on the historical streamflow estimates, and available modern records for natural stream conditions at the time of statehood, as well as for existing stream conditions. Geomorphic data provide information relating to river stability, river conditions at statehood, and the nature of changes to the river since the time of statehood.

Other elements of the study included collection of land use information and ethnographic data. Land use data were compiled for the Lower Salt River and were entered in a GIS database. Land use data included existing title records from county assessor's offices, state and federal land leasing records from ASLD, the Bureau of Land Management, and the US Forest Service. Ethnographic data, or the recollections of individuals with personal knowledge of historical conditions, supplement formal historical and archaeological records. Interviews were conducted with long-time residents, professional historians, avocational historians, and professional land managers who were knowledgeable about the river.

The data collected was organized into six main subject areas: archaeology, history, ethnography, geology, hydrology, and land use. Archaeological evidence indicates that the Verde River has provided accessible, permanent water to semi-arid Arizona since the region was first inhabited. It provided water for irrigation and has been a communication and trade route among various cultures since prehistoric times. Irrigation systems have been documented by surface reconnaissance and excavation of prehistoric sites. To date, prehistoric canal systems have been mapped in three areas: Perkinsville, Horseshoe Reservoir, and around Fort McDowell. The upper and middle Verde appear to have contained the largest canal systems, based largely on the size of the floodplain and first terraces, although those in the lower Verde are the best documented. Most of the lower Verde canals were less than one mile in length, with numerous secondary canals measuring less than 400 meters long. The lower Verde canal systems often occur in concert with other water control features, such as check dams, terraces, and rock alignments. Physical evidence of prehistoric irrigation canals is limited, probably due to modern and historic disturbances by agriculture and other development.

One professional land manager, twelve professional historians, one avocational historian, and one long-term resident were interviewed about the Verde. Historians and long-term residents generally could recall some use of boats on the Verde River, some for limited commercial purposes.

Two stretches of the Verde River are historically well documented: the middle Verde from about Clarkdale to Childs and the lower Verde from Fort McDowell to the confluence with the Salt. The Yavapai, Pima and Apache were the principal Native American groups using the Verde in historic times. The Spanish were aware of the Verde River, and made two expeditions to the Indian mines that were probably in the vicinity of Jerome. Trappers from the United States explored the Verde in the 1820s. Permanent settlement began in 1863, when gold was discovered in Lynx Creek and the Hassayampa River, and Fort Whipple was established at Del Rio Spring (the headwaters of the Verde) in the Chino Valley. Civilian settlement of the middle Verde began in 1865, when white settlers began to produce hay and other crops for the military. Camp (later Fort) McDowell was established on the lower Verde in 1865, and civilian settlement began there soon afterwards.

In early historical descriptions, the Verde was considered a reliable source of good water, although it was marshy in many places, and malaria was a common complaint. The river also flooded regularly. During the late nineteenth century, the channel of the Verde became entrenched, which eliminated the malaria. The principal economic uses of the Verde in historic times were irrigation agriculture, mining, and hydroelectric power. Accounts of boating on the Verde are most numerous for the middle Verde and the lower Verde, the portions of the Verde for which historical documentation is most extensive. There are a couple of accounts of soldiers boating down the Verde River from Fort McDowell to Phoenix. At Camp Verde on the middle Verde, the army apparently kept a boat to ferry couriers across the Verde during periods of high water. In 1903, Dr. Ralph Palmer and a friend borrowed a steel boated some 16 miles down the middle Verde while duck hunting. In 1931, two trappers floated a flat-bottom boat from Clarkdale to the Fort McDowell to Payson Road. Recreational boating became more prevalent in the 1950s and continues today.

Regional physiography and geology of the Verde River exert a strong influence on the extent and character of its floodplain. The Verde River flows through some of the most rugged country in Arizona. During the past several million years, the Verde River has downcut hundreds of feet, occasionally leaving terrace deposits behind as a record of former valley floors. Because of this long-term downcutting, the Verde River is confined within a steep, narrow valley along much of its length. In these confined reaches, the floodplain is limited in extent, and historical changes in channel positions have also been limited. The potential for channel changes is greatest in Verde Valley and along the lower Verde River, where the floodplain is relatively broad.

The general form of low-flow channels of the Verde River is quite similar along its entire length. Low-flow channels typically are 50 to 200 ft wide, winding through a larger flood channel. The flood channel has well-defined banks in some places, but has no obvious banks in other areas. The width of flood channels varies substantially, from about 200 ft to 3200 ft wide. The width of the flood channel depends in large part on the character and width of the geologic floodplain, which is controlled by the erodibility of underlying rock units. Areas inundated during large floods typically include low terraces and vegetated slackwater areas. In confined canyon reaches, the entire canyon bottom is inundated during large floods.

The character and position of Verde River channels during the historical period, according to evidence seen in historical aerial photographs, indicate that low-flow channels have shifted positions in many reaches, but the larger-scale features of the flood channel have been fairly consistent. Modest changes in positions of flood-channel banks and total widths have occurred in many places, but other reaches exhibit little or no change during the past few decades. In most areas, the large floods of 1978 or 1980 occupied the same flood channels that were evident in 1953-54. Historical land surveys in the Camp Verde area and along the lower Verde River reveal that the general form of the flood channels of the Verde River have not changed substantially since statehood. Low-flow channels have shifted position to a greater degree than the larger flood channels. The size and general form of low-flow channels in Verde Valley, however, was about the same in the 1870's as it is today.

The hydrology of the Verde River, upstream of Horseshoe Reservoir, has not significantly changed since 1912. Flow rates, channel conditions, stream geomorphology, ground water conditions, and river uses are similar to conditions as of statehood. Around 1912, the Verde River was used for boating, fishing, trapping, irrigation and water supply. With the possible exception of trapping, these uses continue on the Verde River today. Data from USGS gage records indicate that the Verde River was and is perennial, with a base flow of 50 to 100 cfs controlled by nearly constant outflow from springs and ground water. High flow periods on the river typically occur from January to April, and have average monthly flow rates in excess of 1,000 cfs. Winter flows currently support several types of commercial/recreational boating operations.

Stream conditions in the Verde River would meet federal standards for recreational boating during most of the year, though no evidence of boating up the Verde River, or use of large machine-powered boats was found. No evidence of sustained commercial boating industries was found for the Verde River as of 1912, though isolated cases of commercial use of the river were found. Portions of the Verde River are currently boated for recreational purposes by commercial operations at certain times of the year.

The majority of the land along the Verde River is not privately owned, except in the Verde Valley between Camp Verde and Clarkdale. In the Verde Valley, many land claims and used pre-date statehood. Land uses along the Verde River include grazing, recreation, agriculture, residential, and commercial. Three Indian communities also claim and use portions of the Verde River study area.

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Chapter 1
Introduction

CH2M HILL, in cooperation with SWCA Environmental Consultants (SWCA) and the Arizona Geological Survey (AZGS), was retained by the Arizona State Land Department (ASLD) to provide information to the Arizona Stream Navigability Adjudication Commission (ANSAC). ANSAC will use information provided by the project team to make determinations of navigability or non-navigability for the Verde River. In this report, the following topics are presented for the Verde River:

- Project Background
- Definition of Navigability
- Limit of Study
- Methodology
- Summary of Results

The following chapters provide information on the results of investigations of the archaeology, history, geology, hydrology, and land use of the Verde River. Due to the technical nature of portions of these studies, a glossary of technical terms is provided at the back of this report.

Project Background

During recent years the State, and a number of private and public entities, have asserted claims of ownership on certain streambeds in Arizona. These claims are based on whether or not the streams were navigable as of the time of statehood.1 Under the "Equal Footing Doctrine," the states received sovereign title to the beds of navigable streams upon statehood. In the past, Arizona failed to act on its claims of streambed ownership, and other parties have asserted title to certain streambed lands. In assuming ownership of lands located in or near these streambeds, many of the current record title holders have constructed projects and made improvements to the land, paid property taxes, and have altered the stream ecosystems and riparian habitat.

On July 7, 1992, the Governor signed House Bill 2594 (H.B. 2594; A.R.S. 37-1101 to -1156) which established a systematic administrative procedure for gathering information and determining the extent of the State's ownership of streambeds. The main purpose of the Bill was to settle land titles by confirming State or private ownership, and to confirm State ownership in lands located in the beds of navigable streams. HB 2594 also created the Arizona Navigable Stream Adjudication Commission (ANSAC), a five-member board appointed by the Governor. ANSAC was directed to establish administrative procedures, prioritize Arizona streams to be analyzed, hold public hearings, and adjudicate navigability. The Bill also directed the ASLD to assist ANSAC in its investigatory role, and act as technical support staff for ANSAC. The original Verde River navigability report was prepared on behalf of ASLD under the provisions of HB 2594.

[1] Arizona obtained statehood on February 14, 1912.

In 1994, after ANSAC had made an initial classification that the Lower Salt River had characteristics of possible navigability as of the time of statehood, and had scheduled public hearings to receive evidence of navigability or non-navigability, the Arizona Legislature passed HB 2589. HB 2589 (ARS 37:1101-1156) revised and defined the criteria to be used to determine whether a stream was navigable or non-navigable, established an ombudsman office to represent the interests of private property owners, amended the powers of ANSAC to an advisory role, and made decisions of navigability subject to judicial review and action by the Arizona Legislature. The 1996 revision of the CH2M HILL report was prepared to reflect changes in the definition of navigability made under HB 2589.

In 1999, after the Arizona Legislature ratified ANSAC's recommendations that the Salt River and other Arizona rivers be found non-navigable, lawsuits were filed challenging the constitutionality of certain provisions in HB 2589. In response to the subsequent Arizona Court of Appeals decision, the Arizona Legislature enacted SB 1275, which removed the unconstitutional presumptions of non-navigability and limitations on information to be considered by ANSAC, and restored the applicable burden of proof in line with the so-called "federal test" of navigability. The 2003 revision of the original CH2M HILL report was prepared to reflect changes in the navigability statutes made under SB 1275.

Definition of Navigability

S.B. 1275 established a definition of navigability for use in the Arizona streambed program. The data collection effort for this study attempts to provide information that would enable ANSAC to determine if a given watercourse meets the criteria of the State's definition. The State's definition is:

> *'Navigable' or 'navigable watercourse' means a watercourse, or portion of a reach of a watercourse, that was in existence on February 14, 1912, and that was used or was susceptible to being used, in its ordinary and natural condition, as a highway for commerce, over which trade and travel were or could have been conducted in the customary modes of trade and travel on water.*

A.R.S. 37-1128 further states that ANSAC shall review all available evidence and render a determination as to whether the particular watercourse was navigable as of February 14, 1912. If the preponderance of the evidence establishes that the watercourse was navigable, the commission shall issue its determination confirming that the watercourse was navigable. If the preponderance of the evidence fails to establish that the watercourse was navigable, the commission shall issue its determination confirming that the watercourse was non-navigable.

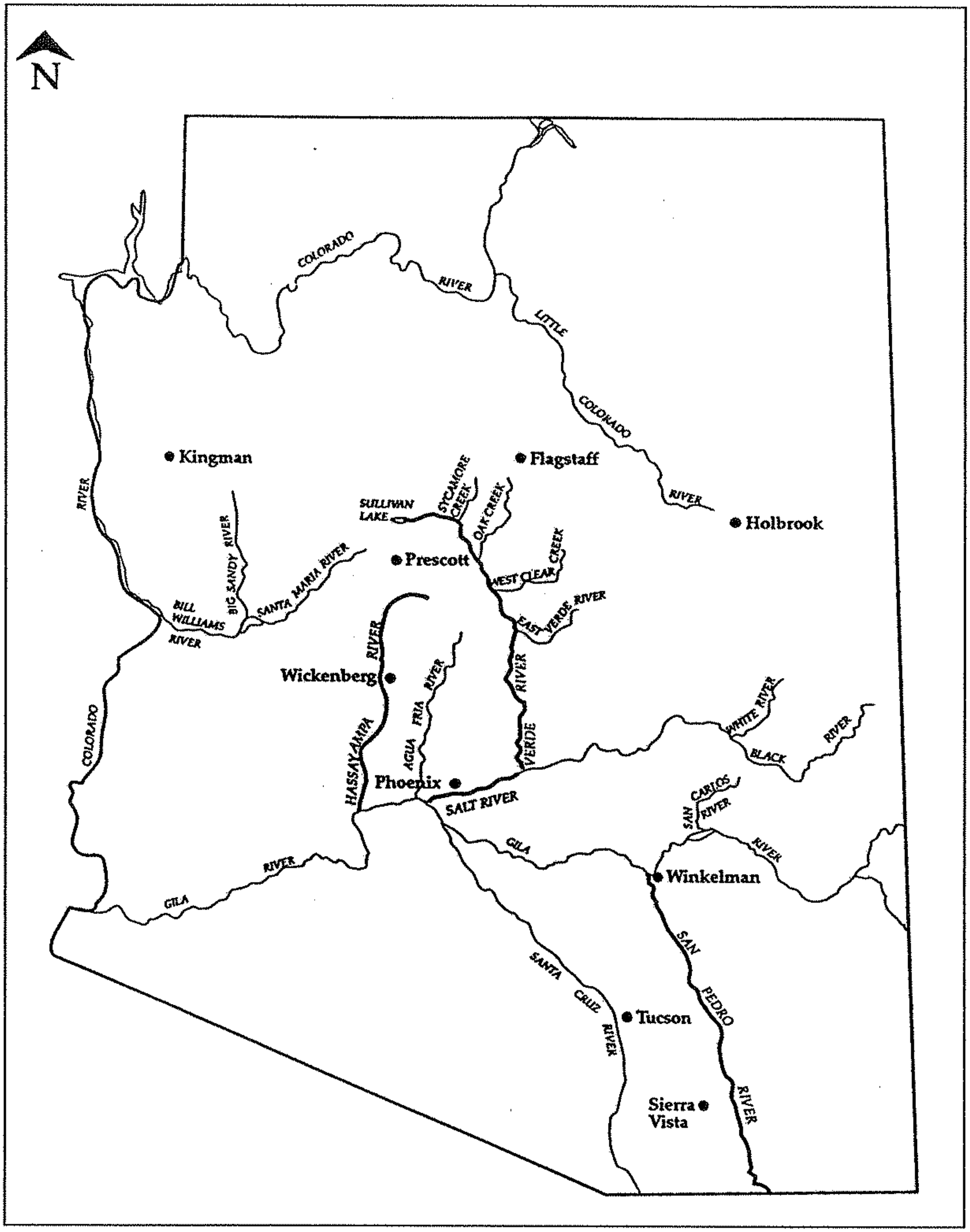

Figure 1-1. Location map for the Verde River and other major rivers of Arizona. The Verde River, shown by a bold line in this figure, heads in and flows through the rugged mountain region of central Arizona. The Verde River is deeply entrenched into the landscape, and the channel and floodplain of the river are limited in extent and confined by canyon walls along much of its course.

Limit of Study

This report presents evidence of past and existing river conditions and uses for the Verde River from the confluence with the Salt River to its headwaters at Sullivan Lake (Figure 1-1). This report provides factual information for the study area collected from existing data sources. No new analyses or technical evaluations were completed as part of the revisions of the report. Furthermore, no legal interpretation of the data collected was made with respect to the navigability or non-navigability of the Verde River. A recommendation regarding potential title navigability or non-navigability is not presented in this report, nor was it part of the scope of services for the investigation.

This report summarizes information on the Verde River. The scope of services for this study included five main tasks:

- Agency Contact
- Literature Search
- Data Summaries
- Land Use
- Final Report

The objective of agency contact and the literature search was to obtain existing information pertaining to stream navigability. These tasks included contact with various federal, state, local government and private agencies, and review of literature in public and private collections. Information obtained during the first two tasks was then reviewed and summarized to provide information on stream conditions and activities as of the time of statehood. A database of public and private land use information was collected for use by ASLD and ANSAC in later phases of the adjudication process.

Methodology

The basic approach to the stream navigability studies was to develop a database of information to be used by ANSAC in making navigability determinations. Because the State's definition of navigability includes both actual navigation and susceptibility to navigation, the data collection effort was directed at two areas:

- Historical Uses of the River. Data describing actual uses of the river as of the time of statehood were collected to help answer the question "Was the river used for navigation?" Specific tasks included agency contact, literature search, and ethnography.

- Potential Uses of the River. Data describing river conditions as of the time of statehood were collected to help answer the question "Could the river have been used for navigation?" Specific tasks included agency contact, literature search, hydrology, hydraulics, and geomorphology.

Specific activities for each of the major tasks in the stream navigability studies are summarized below. The objective of these activities was to establish whether the river was used for navigation, or whether sufficient data exist to indicate that navigation could have occurred.

Agency Contact

The objectives of the agency contact task were to inform community officials of the studies, to obtain information on historical and potential river uses, and to obtain access to data collected by agency personnel. For this task, public officials from communities, towns, cities, and counties located along the Verde River were contacted. Contact consisted of an initial letter describing the stream navigability study, its potential impacts on the community, and requesting information to be used in the study. Each community official was then contacted by telephone to answer questions about the study and to provide a second opportunity to provide information for the study. In addition, personnel from most local, state, and federal agencies with jurisdiction or interest in the river study areas were contacted by letter and telephone. Finally, a public meeting was held in the Town of Clarkdale to describe the purpose of the State's streambed program and to provide a forum for collection of data from the general public.

Historians, librarians and archivists from public and private museums, libraries, and other collections were also contacted. Letters requesting summaries of information pertaining to historical stream uses or conditions were sent to each institution, with follow-up telephone contact. Other contacts included letter and telephone requests for information to clubs, professional organizations, special interest groups, and environmental groups. Finally, attorneys involved with previous litigation or investigations of stream navigability in Arizona were contacted to obtain information. In most cases, contacts led to other persons thought to have information pertinent to the study. Several hundred persons were contacted as part of this task (Appendix A).

Literature Search

The objective of the literature search was to obtain published and unpublished documentation of historical river uses and river conditions. Information collected from agency contact was supplemented by published information from public and private collections. Literature search was focused on the following main categories:

- Archaeology
- History
- Hydrology
- Hydraulics
- Geomorphology

Historical literature searches were conducted to obtain information on the historical uses of the river and adjacent lands. Library research identified books, scholarly journals, magazine and newspaper articles, and unpublished materials that provide information on the history of the use of the river. City directories, Sanborne fire insurance maps, and General Land Office maps were also consulted to identify businesses located near the river. Literature searches in archaeology provided data on prehistoric and historic settlement patterns along the river, including evidence on paleoenvironment and irrigation agriculture. This research included published books and articles and "gray literature" or technical reports. Hydrologic, hydraulic, and geomorphic studies relating to historic navigability of the Verde River were also collected from city, county, state, and federal agencies. Published journal articles, books, and reports available from public library collections were also consulted.

Data Summaries

Data collected from the agency contact and literature search tasks were organized and synthesized by these subject areas: archaeology, history, oral history (ethnography), hydrology, hydraulics, geomorphology, and land use.

Archaeology

Archaeological data augment the historical record of potential river uses at statehood by providing an extended record of river conditions, use of river water, climatic variability, and cultural history along the river. SWCA archaeologists reviewed literature and other information collected during the literature search and agency contact tasks. An overview summarizing previous archaeological work in the area, paleoenvironments, the culture history, settlement patterns, and evidence relevant to navigability of the river was prepared and is presented in Chapter 2.

History

Historical data provide information on actual river uses as of the time of statehood, but also provide information on whether river conditions would have supported navigation. SWCA historians prepared Chapter 3 of this report summarizing use of the river and adjacent area in historic times, with special emphasis on the establishment, growth, and development of towns, irrigation systems, commercial activities, and developments. In addition, bibliographical essays were prepared, listing those institutions that have collections relating to the history of navigability and river use, and describing the relevant collections of these institutions.

Oral History

Oral history, or ethnographic data, are the recollections of individuals with personal knowledge of historical conditions. Oral history supplements formal historical and archaeological records. SWCA ethnographers conducted interviews with long-time residents, professional historians, avocational historians, and professional land managers who were knowledgeable about the Verde River. Names of potential interviewees were obtained from historical societies, public agencies, and private organizations contacted during the agency contact task. A total of 15 interviews were conducted for the Verde River. Chapter 4 and Appendix D summarize oral history information collected for the Verde River.

Hydrology/Hydraulics

Hydrologic/hydraulic data are the primary source of information regarding susceptibility to navigation. These data include estimates of flow depths, width, velocity, and average flow conditions as of statehood, based on the available records. CH2M HILL evaluated information collected during agency contact and literature search tasks. Literature, stream gage records, topographic maps, aerial photographs, and other data were used to develop an estimate of natural stream conditions as of statehood, as well as for existing stream conditions. Depth, velocity, and topwidth rating curves for existing and (near) statehood channel conditions were developed from historical gaging records. Estimates of 2-, 5-, 10-, 50-, 100-year, and average annual flow rates were obtained from stream gage data. Flow duration curves, and average monthly flow rates were also summarized. Finally, reports were prepared which discuss the role of climate change, irrigation, modern boating activities, and recreational navigation criteria on stream navigability. The data from these reports are presented in Chapters 7 and 8, and Appendixes E, F, and G.

Geomorphology

Geomorphic data provide information on river stability, river conditions as of statehood, and the nature of river changes since statehood. A summary of the geology and geomorphology of the Verde River was prepared and is presented as Chapter 5. This summary was based on literature and other information collected during agency contact and the literature search. The objectives of the geologic information summary was to estimate channel positions as of the time of statehood, assess the possibility of and mechanism for historical channel movement from its current position, provide evidence of geologic control of flow rates, and to estimate the location of the ordinary highwater mark.

Land Use

Land use data were compiled for the Verde River and were entered in a GIS database. Land use data included existing title owner records from county assessors' offices, state and federal land leasing records, ASLD, the Bureau of Land Management, and the US Forest Service. Existing improvements, commercial activities, and present use of lands were identified from land use mapping and reports, aerial photographs, and in some cases, by field visits. The GIS/Land Use task results are summarized in Chapter 6 and Appendix G. No revision of the land use database was made for the 1996 or 2003 revisions of the original CH2M HILL report.

Conclusion

The following chapters of this report describe historical uses of the Verde River as well as the types of activities to which the Verde River was susceptible as of the time of statehood. First, the archaeological record will be examined to provide a long-term history of river use, and to determine whether more recent river uses are unique to modern history (Chapter 2). Second, historical data will be presented which summarize the pattern of development on and near the river, document historical boating activities on the river, and provide historical descriptions of the river conditions around the period of statehood (Chapter 3). Third, historical documentation will be supplemented by ethnographic data which summarize some of the available oral history of the river (Chapter 4). Fourth, geologic impacts on river conditions, including geomorphic river changes and ground water-surface water interactions will be summarized (Chapter 5). Fifth, land use and ownership information will be presented (Chapter 6). Sixth, a summary of the Verde River hydrology will be presented which document typical flow conditions during the period before and as of statehood (Chapter 7). Seventh, information on federal boating criteria and boating records for the Verde River will be summarized (Chapter 8). Finally, appendixes which provide additional data on topics related to the Verde River study are attached.

Chapter 2

Archaeology of the Verde River Valley

Introduction

The archaeological record of the Verde River Valley provides information on prehistoric uses of the Verde River, settlement patterns in the region with respect to the river, and paleoenvironmental information which describes long-term flow characteristics of the river. This information may be used to help reconstruct the "ordinary and natural" conditions of the Verde River. Several topics are presented in this chapter. First, a discussion of past archaeological projects in the Verde River Valley is reviewed to describe the nature and amount of work that has been accomplished in the area. Second, a brief summary of prehistoric culture history of the Valley is outlined. Third, prehistoric uses of the river are summarized. Finally, environmental reconstructions completed by others are reviewed for the prehistoric time period.

The Verde River Valley is divided archaeologically into three zones: the lower Verde River, which extends from the Salt River confluence to Fossil Creek; the middle Verde River which extends from Fossil Creek to Sycamore Canyon; and the upper Verde River which extends from Sycamore Canyon to Sullivan Lake. These zone divisions are due to differences in the culture history of each reach.

Archaeological Projects

Archaeological investigations along the Verde River started in the 1890's when the Bureau of American Ethnology supported reconnaissance surveys and explorations by Cosmos Mindeleff (1896) and Jesse Walter Fewkes (1896, 1912). Table 2-1 lists selected archaeological projects in the Verde River Valley. Mindeleff's survey of the entire Verde Valley had the goal of determining if prehistoric cultures in this area had traits intermediate between what are now known as the Hohokam culture of the Salt and Gila River Valleys and the Sinagua culture of the Colorado Plateau. Fewkes conducted another reconnaissance survey in the upper and middle portions of the Verde Valley and excavated two sites to test certain Hopi migration myths. Between 1927 and 1930, Gila Pueblo, a private non-profit research group, sponsored a reconnaissance survey of the entire Verde River Valley and its major tributaries (Gladwin and Gladwin 1930a, 1930b). The goal of this survey was to determine the relationship between prehistoric Verde River Valley and Gila Valley inhabitants. None of these early surveys were systematically conducted, according to current standards. Instead, they recorded and sampled prehistoric cultural manifestations based on the knowledge of local people and informants. However, they served as early documentation of the prehistoric record prior to historic disturbance and vandalism, which was particularly prevalent in the 1920s and 1930s in the middle Verde River.

Table 2-1. Archaeological Projects Along the Verde River

Sponsor Institution	Type of Project	Areal Extent	No. Sites	Reference
Arizona State University	Perkinsville Valley survey	Perkinsville Valley, Upper Verde Valley	21	Whiffen and Kayser 1966
Northern Arizona University	Exhausted Cave excavation	Excavation (5 mi SE of Camp Verde)	1	Hudgens 1975
Prescott College	Land exchange survey	216 acres (Tuzigoot National Monument)	2	Gumerman, Thrift, and Miller 1973
Bureau of American Ethnology	Verde Valley survey	Verde River (judgmental)	79	Mindeleff 1896
Gila Pueblo	Verde Valley survey	Verde River and tributaries (judgmental)	185	Gladwin and Gladwin 1930a; 1930b
Gila Pueblo	Irrigation networks survey	Verde Valley (judgmental)		Midvale 1929-1967
Arizona State Museum	King's Ruin excavation	Excavation (Chino Creek)	1	Spicer and Caywood 1936
University of Arizona	Hidden House excavation	Excavation (Upper Verde)	1	Dixon 1956
Arizona State University & Archaeological Committee of the	Tuzigoot excavation	Excavation	1	Spicer and Caywood 1934
National Park Service/Museum of Northern Arizona	Beaver Creek survey	Beaver Creek east of Middle Verde	46	Schroeder 1960
Museum of Northern Arizona	Calkin's Ranch Site excavation	Excavation (Clear Creek)	1	Breternitz 1958
Museum of Northern Arizona, National Park Service, & Camp	Site excavation	Excavation (Near Camp Verde)	3	Breternitz 1960a
Museum of Northern Arizona	Site excavation		2	Breternitz 1960b
Smithsonian Institution	Site excavation	Excavation (near Sedona)	2	Fewkes 1896
Bureau of American Ethnology	Survey	Upper Verde River	?	Fewkes 1912
Museum of Northern Arizona	Dry Creek Site excavation	Excavation	1	Shutler 1950
Arizona Department of Transportation	Site excavation	Excavation (Lower Verde)	6	Hackbarth 1992
Gila Pueblo	Montezuma Castle Excavation	Excavation	1	Jackson and Van Valkenburgh 1954
Southwestern Monuments Association	Survey	East Verde River	28	Peck 1956
Bureau of Reclamation	Orme Reservoir Survey	24,320+ acres (Salt-Verde confluence)	178	Canouts 1975
Bureau of Reclamation	Orme Alternatives Survey	2,909 acres (Horseshoe Dam)	98	Fuller, Rogge, and Gregonis 1976
Bureau of Reclamation	Bartlett Dam Survey	929 acres (Bartlett Dam)	17	Hackbarth and Montero 1990
Design Workshop, Inc.	Verde River Greenway Survey	201 acres (Middle Verde)	9	Montero, Hackbarth, and Hutira 1992
National Park Service	Tuzigoot Survey	Tuzigoot National Monument & Hatalacva	8	Tagg 1986
Bureau of Reclamation and U.S. Army Corps of Engineers	Central Arizona Water Control Study Survey	10,429 acres (Horseshoe Reservoir)	437	Rice and Bostwick 1986
Bureau of Reclamation	Test excavations	Bartlett Dam	14	Seymour, Slaughter, and Deaver 1991

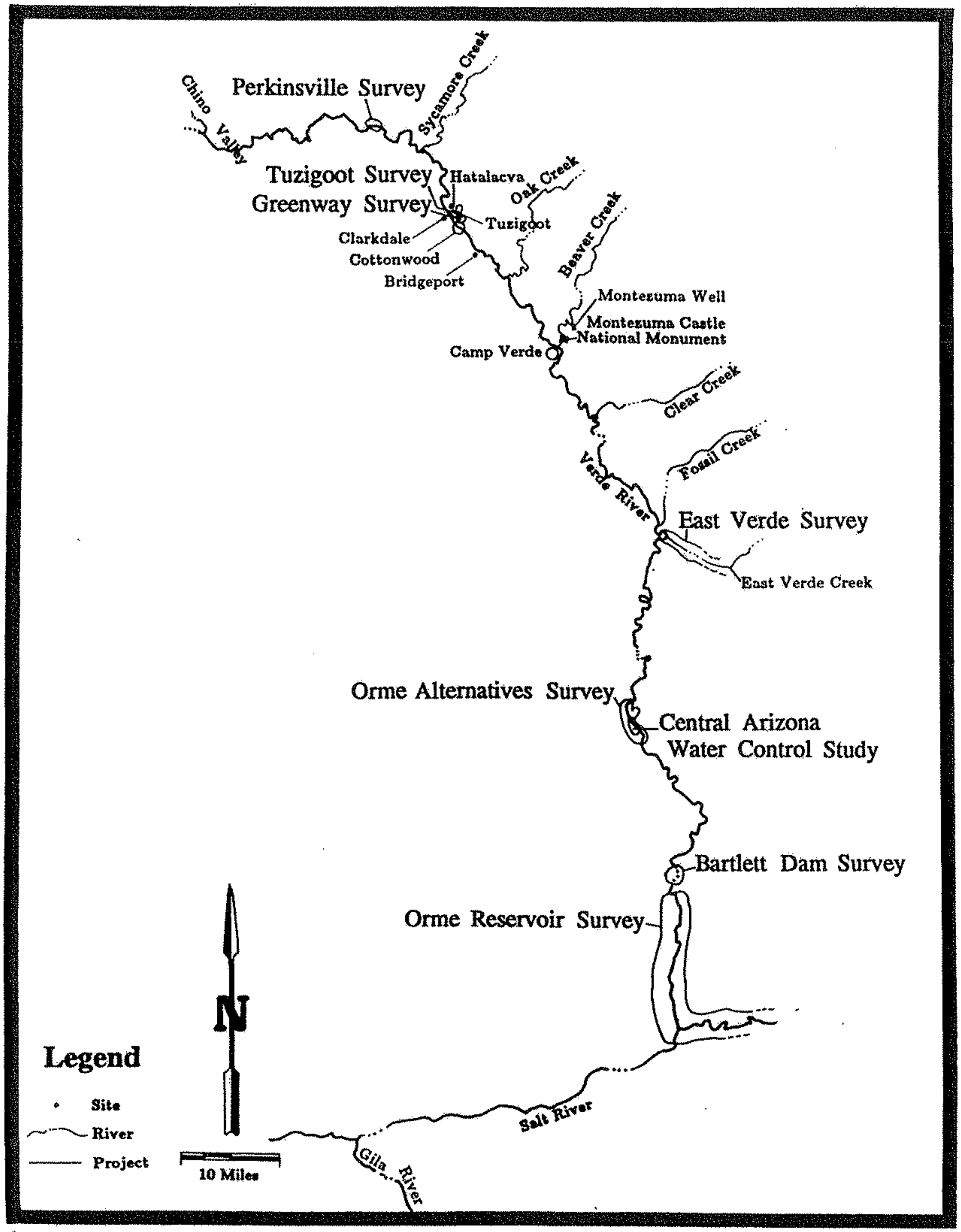

Figure 2-1. Archaeological project areas along the Verde River

From the mid-1930s to the mid-1950s, excavations were conducted at large late Classic period sites. Examples include the Hidden House cliff dwelling (Dixon 1956), King's Ranch Ruin (Spicer and Caywood 1936), Montezuma Castle (Jackson and Van Valkenburgh 1954), and Tuzigoot (Spicer and Caywood 1934) (Figure 2-1). After the 1950's, investigations were sporadic with efforts concentrated on surveys of smaller areas (Gumerman, Thrift, and Miller 1973; Peck 1956; Schroeder 1960; Whiffen and Kayser 1966), including the excavation of smaller sites and sites along tributaries (Breternitz 1958, 1960a, 1960b; Shutler 1950). Exceptions were the survey conducted by Frank Midvale (1929-1967) between 1929 and 1967 to locate and document prehistoric irrigation canals along the Verde River, and the large contract projects sponsored by federal and state agencies. Most of the latter type of work took place in the lower portion of the Verde River Valley and was related to water supply and flood control projects. One of the largest of these projects (24,320+ acres) was conducted in the confluence area to assess the impact of the proposed Orme Reservoir on cultural resources. A total of 130 sites were recorded within the Verde River arm of the proposed reservoir (Canouts 1975). A wide range of historic and prehistoric sites was recorded; prehistoric site types included large villages, rock shelters, rock art sites, agricultural sites, and lithic quarries. Another focus of this same project concentrated survey efforts around Horseshoe Dam (2,909 acres) and recorded an additional 98 sites (Fuller, Rogge, and Gregonis 1976). Additional survey of the Horseshoe Reservoir locality (10,429 acres) by Arizona State University for the Central Arizona Water Control Study completed the inventory and documented 437 sites (Rice and Bostwick 1986). Survey of 929 acres was undertaken by Northland Research, Inc. to the south and west of Bartlett Dam to provide an assessment of cultural resources that would be affected by proposed modifications to the dam and associated activities. A total of 17 sites were recorded (Hackbarth and Montero 1990), and subsequent testing of 14 of these sites by SWCA (Seymour, Slaughter, and Deaver 1991) documented characteristics of numerous site types. Northland Research, Inc. also conducted a survey (201 acres), the Verde River Greenway Survey (Montero, Hackbarth, and Hutira 1992), in parcels along the middle portion of the Verde River near Clarkdale, Cottonwood, and Bridgeport. Nine sites were recorded, contributing to our knowledge of middle Verde River settlement patterns and site diversity.

Archaeological overviews of the Verde River Valley or its constituent parts are recent contributions to the discipline. These overviews compile brief histories of archaeological research within their particular area and integrate the data to offer a more comprehensive view of prehistoric lifeways and settlement patterns. The earliest example of an archaeological overview was provided by Fish and Fish (1977) for the upper and middle portions of the Verde River Valley. Other, more recent, examples include a review of cultural resources along the upper Verde River Valley that lie within the Prescott National Forest (Macnider, Effland, and Ford 1989), an overview of the archaeology along the lower Verde River Valley that is contained within the Tonto National Forest boundaries (Effland and Macnider 1991), a brief review of archaeology along the middle Verde River Valley, with a focus on the Verde River Greenway project area (Montero and Hackbarth 1992), and a review of archaeological research in the lower Verde River Valley as part of the investigations of the State Route 87 Verde River Bridge Project conducted for the Arizona Department of Transportation (Hackbarth 1992).

Prehistoric Culture History

Overviews of archaeology along the Verde River typically are discussed according to three zones: the upper Verde River, middle Verde River, and lower Verde River. The culture history in each of these zones is distinctive, although there are similarities in the general patterns due to the connective thread of the Verde River.

Upper Verde River Valley

The upper Verde River encompasses the reach from Sullivan Lake to Sycamore Canyon, southeast of Perkinsville. Most of the upper Verde River floodplain is narrow, and topographic relief along the river is moderate (Macnider, Effland, and Ford 1989:Figure 3-2b). Prehistoric site types along the upper Verde River within the Prescott National Forest have been recorded as permanent habitation (59), temporary habitation (30), defensive (20), probable habitation (18), processing (14), communication (7), quarry/mines (1), agricultural (1), and indeterminate (32). Evidence of Paleo-Indian (8,000-12,000 B.C.) occupation of the upper Verde River Valley is restricted to one obsidian Clovis point base from the Perkinsville area. Archaic (8,000 B.C. - A.D. 1) Period occupation is represented by surface manifestations on the Pleistocene terraces overlooking the Verde River and in Chino Valley, remains of temporary seasonal hunting and plant processing camps, with an emphasis on hunting.

Archaeologists have divided the Formative Period of prehistoric culture into phases that reflect diagnostic artifact, site, and settlement types within a particular temporal framework. The Squaw Peak phase (A.D. 1-700) immediately followed the Archaic Period and represents a time of semi-sedentism, when hunting and gathering bands built shallow pit houses and surface dwellings in the upper Verde River Valley to accommodate more prolonged seasonal use of the Verde River (Fish and Fish 1977:12). Ceramics were introduced toward the end of this phase.

Hohokam culture traits, centered around the Salt and Gila river valleys, were introduced during the early Camp Verde phase (A.D. 800-1125), suggesting that Hohokam may have migrated into the area, coexisting with the indigenous population. Two different house types occur during this time: one type is similar to Sinagua-style pit houses, and one type is similar to Hohokam houses-in-pits. Two distinct site types emerge as well; the most numerous are small sites, which occur at elevations between 4,500 to 5,000 feet, and larger sites, of up to 100 houses, appear closer to the floodplain. Small sites range from one to six rooms per site and are arranged in a dispersed pattern. Large villages occur in a nucleated pattern and are represented by the Cloverleaf Ranch site and the Perkinsville site, AZ N:4:12 (ASU). Fish (1974) noted that the Perkinsville site overlooked the floodplain and several sections of associated prehistoric canals. The Perkinsville Valley is the only area that Midvale (1929-1967) and archaeologists (Fish 1974) have documented prehistoric irrigation systems. The Perkinsville site also contains a ball court, linking the site to the Hohokam cultural region where they were common. Another large site in the Perkinsville area, AZ N:4:21, has not been excavated, but surface indications of pit houses cover approximately two acres. Room sizes range from 172 to 452 ft^2, with a median size of 366 ft2 (Fish and Fish 1977:13).

During the late Camp Verde phase (A.D. 1000-1125) Hohokam influence all but disappeared; however, the Hohokam-style houses-in-pits were still in use. Decorated pottery found at sites were local to the Kayenta and Winslow areas, rather than the Hohokam area. Other artifacts and site features show contact with the Kayenta, Cohonina, and Prescott cultures. Settlement patterns were dispersed, and sites became smaller, often composed of one to six rooms. Structures were partially constructed of masonry and were randomly spaced, although oriented with respect to one another.

The Classic period of prehistoric occupation is represented in the upper Verde River Valley by the Honanki phase (A.D. 1125 to 1300) and the Tuzigoot phase (A.D. 1300-1425). During the Honanki phase, caves, caveates, and fortified sites appear. Caves and caveates that were inhabited are located in the Perkinsville area, and fortified sites were located on hilltops and other high vantage points. Sites contained pit houses (both Sinagua and Hohokam styles) and surface masonry roomblocks and were arranged in a dispersed pattern. During the Tuzigoot phase, settlement pattern changed from one of dispersed villages to consolidation into large pueblos and cliff dwellings. In the Perkinsville Valley, the Honanki phase is represented by eight pueblo sites that range from five to eleven rooms, three to eight of which are contiguous. Only two sites represent the Tuzigoot phase, one with two roomblocks of six rooms each and a large pueblo of approximately 58 rooms (Fish 1974). Cultural influence and trade appears to be to the northeast, in the Hopi and Chavez Pass areas.

Abandonment of the area occurred after A.D. 1425, although evidence of Yavapai use is documented for more recent, protohistoric times. The cause for the decline of the prehistoric population is not known but has been attributed to various causes, including drought, warfare, disease, waterlogged soils, and breakdown in trade networks.

Middle Verde River Valley

The middle Verde River continues south from Sycamore Canyon to Fossil Creek. From Sycamore Canyon, the floodplain is generally broader with a diversity of landforms such as mesas, ridges, and canyons (Montero and Hackbarth 1992:1). There are many parallels in culture history between the upper and middle Verde River valleys. In the middle Verde River there is no evidence of Paleo-Indian occupation and only meager traces of use during the Archaic period. A few late Archaic period sites are located around Oak Creek and its tributaries and emphasize the exploitation of plant resources.

The Formative period in the middle Verde River begins similarly as that for the upper Verde River. There is some evidence for the early occupation by agriculturalists between A.D. 1-800, followed by a long period in which sites exhibit evidence of Hohokam influence (A.D. 800-1125). However, by the late Camp Verde phase, Hohokam influence does not disappear as it did in the upper reaches of the Verde River. Instead, sites became larger and often had public architecture. Communal structures had a floor area over 323 ft^2, and house size ranged from 151 to 420 ft^2, with a median size of 301 ft^2 (Fish and Fish 1977:14). Architectural features typically associated with the Hohokam culture were present and included mounds, ball courts, and irrigation canals. Evidence of prehistoric irrigation canals along the middle Verde River is limited due to modern and historic disturbance, including historic agricultural practices. Mindeleff (1896:194) suggested the reason that the middle Verde River does not retain much evidence of vast prehistoric irrigation systems may be partly due to the heavy flow of the river, necessitating only short ditches, and partly because irrigation is not essential for successful cultivation along the floodplain. Areas documented as containing prehistoric canals include Camp Verde, Fossil Creek, about two miles below the mouth of Limestone Creek, and along Clear Creek. Corn, and possibly other crops such as chenopods and amaranth, were cultivated.

Hohokam traits decreased substantially during the Classic period, although canals, check dams, and terraces were still constructed for agricultural purposes. Although irrigation canals continued to be used, no data are available to indicate size or complexity of the systems or to accurately date the features. Most of the larger sites, which would have had associated irrigation systems, were excavated prior to the 1940s, and research at that time was not geared to answering questions related to water control features; therefore, knowledge of Verde River Valley prehistoric irrigation systems is limited. Architecture was mostly masonry, with both pit houses and contiguous masonry rooms co-occurring. Cultural affiliations turned to the north instead of the south, indicating Sinagua trade or migration. There was an increase in population, although room size decreased. Dispersed small pueblos and cliff dwellings were located on naturally elevated features overlooking the river, which has been interpreted as either defensive posturing or trade-related, and spaced apart approximately every 1.5 miles. Small pueblos averaged five rooms per site, with room sizes ranging between 75 and 431 ft^2 and a median of 205 ft^2. Cliff dwelling room sizes were smaller, with a 22-237 ft^2 range and a median of 65 ft^2 (Fish and Fish 1977:14-16). During the Tuzigoot phase, cliff dwellings and large multi-storied masonry pueblos centered around central plazas, such as Tuzigoot, Hatalacva, Montezuma Castle, and Tuzigoot Extension Ruin, were evidence of population aggregation. The average number of rooms expanded to 35 during this phase; at Tuzigoot, there was an average of eight rooms during the Honanki phase and 92 during the Tuzigoot phase (Tagg 1986:66). Field houses, associated with the increase in agriculture, were common; agricultural products included corn, beans, squash, and cotton. Canal features documented at Tuzigoot and Montezuma Well probably date to this time period. Settlement patterns show evenly spaced distribution of large pueblos and associated small sites along the valley and along Beaver and Oak Creeks (Pilles and Stein 1981).

Lower Verde River Valley

Below Fossil Creek to the Verde River's confluence with the Salt River is the lower Verde River Valley zone. Its floodplain gradually broadens, and its topography decreases from mountainous to gently sloping bajadas as one goes north to south (Hackbarth, Henderson, and Lancaster 1992:16). The large Orme Reservoir survey project recorded 78 habitation sites along the lower Verde River. Primary habitations contained trash mounds and ball courts and were often larger in size than secondary habitation sites, which exhibited less artifact and feature variation and were located in a wider variety of environmental settings (Canouts 1975:335). A total of 37 primary habitation sites were recorded; Canouts (1975:Table 16) divided these sites into four groups, based on average site size, with largest sites occurring closest to the river. Thirteen sites in Group 1 averaged 6 acres in size (1-3 trash mounds), 6 in Group 2 were 50 acres (6-9 trash mounds), 5 in Group 3 were 88 acres (11-22 trash mounds), and 4 in Group 4 averaged 246 acres (53-66 trash mounds). Ten sites contained ball courts, with each site group represented. Irrigation canals were present at seven sites, all of which were located either on the floodplain or on the Blue Point terrace (Chapter 5). Most of the canals were less than one mile in length, and numerous secondary canals measured under 1,300 feet in length. Thirty sites were locales for resource procurement and processing, such as plant gathering and processing; the largest procurement and processing site was 10 acres in area, and the average size was two acres.

To date, little evidence of Paleo-Indian or Archaic period occupation or use has been reported along the lower Verde River. The earliest well-documented sites occur during the Formative period and are Hohokam in character. Site types range from artifact scatters to extensive habitation sites with ball courts and are located on the floodplain, alluvial terraces, and adjacent bajadas. Agricultural features are typical. Early Formative period structures ranged from 22 to 513 ft^2, with a mean house floor size of 60 ft^2. Later structures are larger, with a mean size of 186 ft^2 (Hackbarth 1992:Table 16.1 and Table 4.8). The largest site known from this period is the Azatlan site, located close to the river's confluence. It contains over 100 trash mounds and at least 5 ball courts (Effland and Macnider 1991:37). The site stretches for about two miles along the river and has extensive water control systems.

During the Classic period of occupation, cultural affiliations change along the lower Verde River, except at the confluence of the Salt River where Hohokam traits remain. The southern portion of the lower Verde River shows Salado culture traits, and further north there is indication of both Salado and Sinagua cultural affiliation. Sites were mostly small, two to three room pueblos, although a few pueblos were over 60 rooms. Brazeletes pueblo, located four miles south of Horseshoe Reservoir, is a large 100+ room pueblo that was occupied during this time. AZ U:2:29(ASU) is a smaller, 6-room pueblo with a compound wall, located about two miles south of Horseshoe Dam (Fuller, Rogge, and Gregonis 1976:44). A drop in site density and consolidation of dispersed villages indicate population aggregation, similar to the pattern noted in the upper and middle Verde River areas. The Mercer Ruin in Horseshoe Basin, occupied during the late Classic period, reflects this trend and may contain as many as 300 rooms. Other multistory pueblos during the late Classic period average 35 rooms, and single story sites average six rooms (Effland and Macnider 1991:38). Abandonment occurred along this portion of the Verde River Valley around A.D. 1400.

Along the Lower Verde River, most irrigation water was derived from the river although tributary washes also may have served as sources of water for agricultural field systems. In addition, water conservation features, such as check dams, contour terraces, rock alignments, as well as canals, were used extensively. During the Orme Alternatives survey, these agricultural features designed to capture and manipulate the natural distribution of water derived from rainfall were found at 24, or 37.5%, of the sites (Fuller, Rogge, and Gregonis 1976: Table 6). The lower Verde River appears to be a system used to maximize diversity in agricultural strategies, which is typical of the Hohokam northern peripheral area.

Summary. Architectural, features, and artifactual traits shifted through time along the Verde River Valley. Hohokam influence from the south was evident early in the Formative period throughout the valley. Later, the upper and middle Verde River areas experienced a decrease in Hohokam traits, such as Salt River Valley decorated pottery, cremation of the dead, and ballcourts, and an influx of Sinagua traits. The upper Verde River, closest to the Sinagua area, experienced the shift in influence prior to the middle Verde River, which in turn changed affiliations prior to the lower

Verde River area, which is the furthest from the Sinagua cultural core. Other culture areas had an influence in Verde River Valley prehistory, including Prescott, Kayenta Anasazi, Cohonina, Chavez Pass/Hopi, and Salado, determined by distinguishable characteristics in the archaeological record.

Prehistoric River Use

The Verde River has provided accessible, permanent water to all three reaches of the Verde River Valley since the region was first inhabited. It provided water for irrigation for at least 1,000 years and has been a communication and trade route among various cultures since prehistoric times. The nature of the communication and trade is not known and, at this point in time, can only be speculated upon. Irrigation systems, however, have been documented by surface reconnaissance and excavation of prehistoric sites. Between 1929 and 1967 Frank Midvale conducted a reconnaissance survey along the Verde River Valley to locate, document, and map prehistoric irrigation canals. Maps identifying canal systems were made for three areas: 1) Perkinsville, 2) at what is now Horseshoe Reservoir, and 3) around Fort McDowell. Notes, maps, and photographs that are curated in the site survey files at the Department of Anthropology, Arizona State University, were compiled and documented onto Figure 2-2. Also recorded on Figure 2-2 are canals that were mapped by Omar Turney in 1901 (curated with Midvale's documents). Turney's canals are probably historic since they are not indicated on Midvale's maps, and Turney's map includes landowner's names. Prehistoric canal locations suggest that the size of the floodplain and first terrace determined the size and number of canals (Fish and Fish 1977:13).

The extent of prehistoric canals probably has been underestimated. In a letter to Sharlot Hall, John Davis, Verde River Valley farmer between 1871-1872, stated that there was evidence of prehistoric irrigation systems underlying the surface of the floodplain by 10-20 feet. According to his letter, a "great flood" exposed prehistoric canals and other features. Fortunately, as a farmer, Mr. Davis was able to recognize the canals and their potential significance. He described how, in this one area, the flood had washed away approximately 10 feet of soil to expose a 500-foot length of parallel canals that, alone, he believed had the capacity to irrigate several hundred acres. Although the letter did not detail where Mr. Davis had seen these irrigation features, he estimates that they continued under the Verde River Valley farms operating at that time and supported a dense population. Further, citing evidence of canals at higher elevations where, at the time, were not adaptable to cultivation, and the large number of prehistoric canals exposed after the flood, that "every available spot of ground was utilized for farming" (Davis ca. 1895). Based on Mr. Davis's observations, it may be assumed that locations at which many canal systems operated during historic times, and plotted by Turney, also were utilized prehistorically. In addition, prehistoric canals often were modified and used historically, with historic and recent cultivation destroying other prehistoric agricultural features (Tagg 1986:55). This probably was the case at Tuzigoot, the large late Classic period site in the middle Verde River, where historic farming has destroyed most evidence of prehistoric canals. Subsurface ditches were found at Tuzigoot during archaeological excavations that probably were remnants of prehistoric canals (Henderson 1973), and these underlie the historic systems.

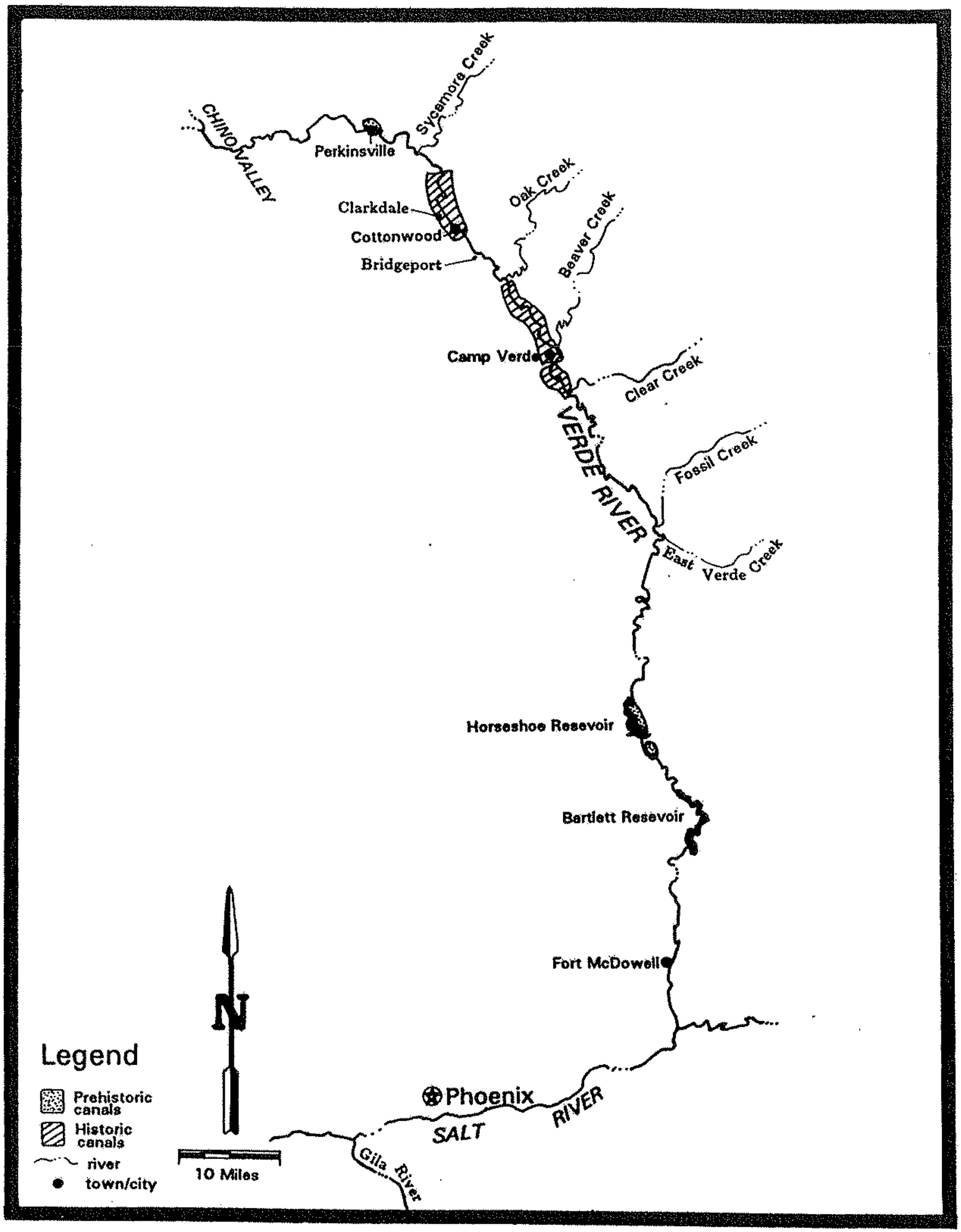

Figure 2-2. Canals that have been mapped along the Verde River. Prehistoric Canals were mapped by Midvale, and historic canals were mapped by Turney.

In the archaeological record, numerous irrigation canals appear during the early Formative period (A.D. 800-1000), and they took on an important role in subsistence practices. The upper and middle Verde River appear to contain the largest canal systems. The lower Verde River has smaller systems, and they seem to occur often in concert with other water control features, such as check dams, terraces, and rock alignments. This may be due to the character of the landscape, as well as a close cultural affiliation with Hohokam northern periphery agricultural strategies. In the upper and middle reaches of the Verde River, prior to this time, cultivation probably consisted of floodwater farming, in which agricultural fields were planted in the rich soils deposited on the floodplain, using the overflows of the river as a water supply. Peak flows that inundate the floodplain are produced by snow melt and precipitation collected by the river and its tributaries. Once irrigation systems were introduced to the area, greater control and stability of agricultural produce, including surplus, was possible and supported the increase in population and, later, population aggregation seen in the Classic period of occupation.

The fact that the Verde River served as a communication and trade link and focus is evident in settlement patterns, architectural and artifactual traits, and site structure. The distribution of sites inside and outside of the Verde River Valley suggests that the location of habitation sites was based on site size and its distance from the Verde River (Kearns, Polk, and Teague 1975:284), with the largest sites, able to accommodate the bulk of the population, closest to the river. During the Classic period, spatial distribution among sites became structured, with large pueblos and associated small sites evenly spaced. Along Beaver and Oak creeks, sites were spaced at approximate two-mile intervals (Pilles and Stein 1981). Such spatial patterning affords successful communication among sites and provides a reliable network for trade. The fact that the Verde River was central to that communication is evident by sites during the Classic period positioned overlooking the river. This has been interpreted as either a defensive posture or due to trade relations; both interpretations point to the river as the path of population movement. Another factor involved in site distribution is the character of the floodplain and alluvial terraces. Sites were usually situated on level areas close to arable and irrigable land.

Environmental Reconstructions

Reconstruction of the prehistoric natural environment in the Verde River Valley has occurred in several forms. Paleoclimatic studies of the lower Colorado Plateau are generally applicable to the Verde River Valley (Dean et al. 1985; Euler et al. 1979). Other studies have reconstructed the annual streamflow of the Verde River for the years A.D. 740 to 1370 using dendrochronologic data. Only meager data are available on biotic resources that were available prehistorically. This biotic resource information consists of recovered faunal bone, pollen, and macrobotanical samples, but is limited to data from the few archaeological excavations that have occurred over the last 10 years.

Euler et al. (1979) produced a paleoenvironmental record for the American Southwest by plotting geoclimatic and bioclimatic indicators for the Colorado Plateau. Indicators consisted of data from tree-rings, pollen records, and alluvial sediments. These data were analyzed within a temporal framework, and fluctuations through time were noted (Table 2-2). Dean et al. (1985) used similar data to produce a model of interaction between the cultural system (prehistoric populations) and the natural system (environment), and identified periods of stress. In general, periods of aggradation or

Table 2-2
Environmental Reconstructions Applicable to the Gila River Valley

Year (A.D.)	Effective Moisture*	Depositional and Erosional Cycles*	Dendroclimatic Variability*	Salt River Geomorphic Processes**
1500				
		Degradation	Frequent Oscillations	
1400				Marked lateral erosion and channel widening (A.D. 1356-1370)
1300				Stable Conditions; trend toward island-braided channel (infrequent high-magnitude flows); some channel avulsion probable; deepening of channel (A.D. 1197-1355)
	Low	Aggradation		
1200			Infrequent Oscillations	
		Degradation		Trend toward bar-braided channel (infrequent high-magnitude flows); some channel avulsion possible (A.D. 1052-1196)
1100				
1000		Aggradation		Trend away from bar-braided channel toward island-braided conditions; channel narrowing (A.D. 900-1051)
	High			
900				
			Frequent Oscillations	Establishment of bar-braided channel; channel widening and bank erosion (A.D. 798-899)
800	Low	Degradation		
				Channel Stabilization (A.D. 740-797)
700				
	High	Aggradation	Infrequent Oscillations	
600				

*From Masse 1991, after Dean et al. 1985 and Euler et al. 1979.
**From Gregory 1991, after Nials, Gregory, and Graybill 1989.

surface stability would be favorable for agriculture. Low water tables and channel entrenchment would restrict locations of agriculture based on floodwater farming; high effective moisture would increase the suitability of lowland areas. Dendroclimatic variability might have produced some short-term responses prehistorically to accommodate unusually high or low precipitation, such as relocation of agricultural fields or the expansion of irrigation systems (Dean et al. 1985:542-543).

Verde River streamflow for a 640-year period, A.D. 740-1370 was reconstructed by Graybill (1989; Stockton and Smith, 1981) by using tree rings to determine the prehistoric annual discharge. The width of annual tree rings are related to the annual precipitation, which in turn is related to average streamflow. Tree ring data are calibrated using modern gage records and contemporary tree ring information. Verde River streamflow was similar to that of the Salt River (also reconstructed in the same study), although the extreme highs are much less pronounced than those of the Salt River. Graybill (1989:34) explains that this is due to the tree-ring series from the Verde River drainage being more climatically sensitive and that they are more representative of basin-wide hydrologic variation than the Salt River series. It was found that the average flow from A.D. 740-1370 was somewhat less than modern average flows, due to a larger number of extremely high average flow years after A.D. 1800. The statistics for Verde River reconstructed flows are presented in Table 2-3. According to reconstruction statistics, the summer flows were less variable than the winter flows and were more predictable in terms of average amount of flow (Other climatic and hydrologic information is presented in Chapter 7 and Appendix G.)

Table 2-3
Statistical Description of Actual and Reconstructed Verde River Flow
July-June, October-April, and Estimated Summer Flow (from Graybill 1989)

Statistic	A.D. 1914-1979			A.D. 1800-1979	A.D. 740-1370
	Actual	Reconstructed		Reconstructed	Reconstructed
		GRCMN	AZNOF	GRCMN	AZNOF
Jul-Jun					
mean			556.83		537.91
s.d.			318.57		237.25
Oct-Apr					
mean			393.29		376.82
s.d.			261.04		192.60
Statistic			Estimated		Estimated
Summer[1]					
mean			160.41		161.09
s.d.			49.65		45.93

Note: Summer flow in thousands of acre-feet
[1] Actual summer flow includes the values for July, August, and September plus those of May and June of the succeeding year. Estimated summer flow is the simple remainder resulting from subtraction of the October-April reconstructed values from the July-June reconstructed values.

Conclusion

Archaeological evidence indicates that the Verde River has provided accessible, permanent water to the Verde Valley area since the region was first inhabited. The river provided water for irrigation and has been a communication and trade route among various cultures since prehistoric times, although no evidence of prehistoric boating has been documented. Prehistoric irrigation systems which diverted Verde River flows have been documented by surface reconnaissance and excavation of prehistoric sites. To date, prehistoric canal systems have been mapped in three areas along the river: Perkinsville, Horseshoe Reservoir, and around Fort McDowell. The upper and middle Verde River appear to have contained the largest canal systems, based largely on the size of the floodplain and first terraces, although those in the lower Verde are the best documented. Most of the lower Verde River canals were less than one mile in length, with numerous secondary canals measuring less than 1,300 feet in length. The lower Verde River canal systems often occur in concert with other water control features, such as check dams, terraces, and rock alignments associated with dry land farming. Physical evidence of prehistoric irrigation canals is limited, probably due to modern and historic disturbances by agriculture and other development. Irrigation systems along the Verde River may be limited in size compared to prehistoric irrigation systems on the Salt and Gila Rivers due to the heavy flow rates of the Verde River. High average and annual flows may have eliminated the need for long canals and may have eliminated the need for any irrigation at all in some reaches.

Chapter 3
History of the Verde River

Introduction

The recorded history of the Verde River begins with two Spanish expeditions to Indian mines in the late 1500s and early 1600s. Thereafter, the Verde River seems to have been bypassed by European colonists and left to the Yavapai and Apaches. Fur trappers from the United States began to trap along the Verde River in the 1820s. Lorenzo Sitgreaves and Amiel Weeks Whipple, surveying railroad routes in the 1850s passed just north of the Verde River. The United States military began to establish garrisons along the Verde River during the Civil War. Fort Whipple was established at Del Rio Springs, the source of the Verde River, in 1863 and briefly hosted the Arizona Territorial Government until the capital was established at Prescott in 1864. Camp Lincoln (later called Fort Verde) was established in 1864. Camp (later Fort) McDowell on the lower Verde River was established in 1865. Mining began in the 1860s also, along with farming. Throughout the late 19th century, the Verde River Valley was a center for irrigated farming. Indian Reservations were established throughout the 1870s and 1880s. Forts along the Verde River began to be abandoned in 1890. In 1909, a hydroelectric plant was constructed on the Verde River at Childs. The Santa Fe railroad constructed a line from Drake to Clarkdale in 1911. In the 1930s and 1940s, Bartlett Dam and Horseshoe Dam were constructed on the Verde River. Table 3-1 provides a general chronology of historical events along the Verde River, and Figure 3-1 illustrates the locations of significant places mentioned in the text.

The principal economic activities along the Verde River have been military, mining, and farming. Settlement has been concentrated in the middle Verde River Valley (above Camp Verde) and the lower Verde River (below Fort McDowell). Historical documentation of the river is concentrated on these two areas where military posts, farms, and white settlements were present. These accounts indicate that prior to about 1890 the Verde River above Camp Verde was a marshy stream. Flooding in the 1890s apparently changed the river to a stream with a better defined channel bed and banks. Historically, the primary use of the river has been for irrigation agriculture. Transportation in the region was mainly by horseback, mule train, wagon, and stage until a railroad was completed to Jerome in 1895. In the late nineteenth century and early twentieth century, boating occurred in the middle and lower Verde River Valley.

Historical Overview/Chronology

Historic Indian Use of the Verde River Valley

Historically, the Northeastern Yavapai (Wipukpaya), Southeastern Yavapai (Kewevkapaya), Pima, and Apache Indians used the Verde River Valley. The Northeastern Yavapai occupied the upper Verde River Valley and surrounding country (Gifford 1936:250; Macnider et al. 1989:35).

Table 3-1 Chronology of Significant Historical Events in the Verde River Valley	
1581	Chamuscado expedition to Verde Valley (Bolton 1932 cited in Brogdon 1952:2).
1582	Antonio de Espejo explores Verde Valley (Bolton 1932 cited in Brogdon 1952:2).
1583	Verde explored by Antonio de Espejo (Byrkit 1984:330; Granger 1984:649). He came into the Verde area looking for silver, but was supposed to be transporting supplies to missionaries in the area (Parker 1949a:25).
1598	Marcos Farfan of Oñate's expedition came to the Verde River looking for mines (Parker 1949a:25).
1599	Marcos Farfán de los Godos visits Verde Valley (Bolton 1932 cited in Brogdon 1952:1).
1600	Oñate came in search of mines on the Verde (Parker 1949a:25). He encountered this stream near its headwaters (Granger 1984:649).
1650	Southeastern Yavapai and Pima Indians lived and cultivated land in the vicinity of Mount McDowell (Bureau of Reclamation [BOR] 1976:75).
1744	Father Joseph Sedelmayr first to call it Verde (Granger 1984:649).
1826	Fur trappers traveled the Verde-Sylvester & James O. Pattie, Ewing Young and friends. Trapping continued along Verde until 1830s (Ayres & Stone 1984:7; Hill & Goff 1970:113; Walker & Bufkin 1986:17).
1829	"A trapping party led by Ewing Young and consisting of 40 men, including Kit Carson, traveled along the Verde River (Ayres & Stone 1984:36; Byrkit 1984:330; Walker & Bufkin 1986:17).
1830	Verde area visited by William Wolfskill, George Yount, and Pauline Weaver fur-trapping party (Ayres & Stone 1984:36).
1844	First documented historic intrusion into the lower Verde Valley area occurs when a party of 48 trappers passed through the lower Verde Valley (BOR 1976:106).
1853	Headwaters visited by Lt. Amiel W. Whipple (Granger 1984:649).
1860s	Mining in progress in area of Verde River, centered in Jerome and Clarkdale (Introcaso 1990:6).
1863	First white settlement in Verde Valley (Brogdon 1952:4). Ft. Whipple--just south of Verde headwaters--established (Introcaso 1990:6).
1864	Settlement of Verde Valley --irrigation and farming-- and subsequent Indian troubles (Farish 1915, Vol 4:215-46). Camp Lincoln established, later called Fort Verde (Hill & Goff 1970:150; Hodge 1877:215; McClintock 1916:157).
1864-71	Camp Lincoln in operation (Ayres & Stone 1984:36).
1865	Homestead Act passed. Camp McDowell established on the banks of the lower Verde River (Mawn 1979:45). Establishment of Camp Verde, and then later Fort McDowell, on the Verde River (Ayres & Stone 1984:7; American Association of Retired Persons, Cottonwood Chapter [AARPCC] 1984:25; BOR 1976:76; Hill and Goff 1970:150). Diamonds Ditch built on Verde (AARPCC 1984:25).
1865	Ft. McDowell established to protect settlers (Byrkit 1984:331; Byrkit 1978:49; Farish 1915, Vol. 6:70)
1865-1890	Fort McDowell in use by military (Ayres & Stone 1984:57).

Table 3-1 Chronology of Significant Historical Events in the Verde River Valley	
1866	Verde--Seen by Gen. Palmer (Granger 1984:650). Fort Lincoln built at Beaver Creek (Byrkit 1984:331; Byrkit 1978:42). Government Ditch built for supplying water to the Army's gardens at Fort McDowell (Ayres & Stone 1984:8). Soldiers at Camp McDowell clear 200 acres, planted a grain crop, and constructed a low crib work dam in the Verde River bed to channel water into an ***acequia*** (canal) which ran 4 miles to farmlands (Mawn 1979:7). In order to identify where fights with Indians took place the military frequently used the name Verde and the name gradually settled into being Verde River (Granger 1984:650). Pauline Weaver helped settlers on the Verde set up an irrigation system (Hall 1929:23-4).
1867	John Y.T. Smith--settled on Verde River as a hay rancher (Farish 1918, Vol. 6:70). Indian attacks and killings of miners and settlers (Farish 1918, Vol. 5:279-81). Camp Ilges--temporary military post established in vicinity of present-day Horseshoe Dam (Ayres & Stone 1984:36). Irrigation in use on the Verde (Ayres & Stone 1984).
1868	First irrigation canal built on the Verde (Byrkit 1978:50). Wood Ditch built on Verde (AARPCC 1984:25).
1869	Cottonwood Ditch built on river (AARPCC 1984:25).
1870s	Captured Indians were kept on a reservation set up near Camp Verde (Byrkit 1984:331).
1871	Schroeder Ditch built on Beaver Creek (AARPCC 1984:25). Temporary reservation established at Camp McDowell (Farish 1918, Vol.8:16; McClintock 1916:214).
1871-3	Ft. Lincoln moved to mouth of Beaver Creek and renamed Camp Verde (Ft. Verde) (Byrkit 1978:42; McClintock 1916:157).
1871-90	Fort Verde in operation (Ayres & Stone 1984:36).
1872	Temporary reservation at Camp McDowell abolished (Farish 1918, Vol.8:16). Wingfield #2 Ditch built on Clear Creek (AARPCC 1984:25).
1873	Department of Army moves Yavapai to Camp Verde. Yavapai dig five mile irrigation ditch along Verde River (U. S. Congress 1990:1). Temporary Indian Reserve established at Camp McDowell for mostly Southeastern Yavapai (BOR 1976:77). O.K. Ditch built on the Verde River (AARPCC 1984:25).
1874	Hickey Ditch built on river (AARPCC 1984:25).
1875	Yavapais at Fort McDowell, Camp Verde and Verde Valley relocated to the San Carlos Reservation (BOR 1976:76). Department of the Army moves Yavapai to the San Carlos Apache Indian Reservation. Yavapai excavate an irrigation ditch on the Gila River (U. S. Congress 1990:2).
1876	Owenby and Page #2 Ditch built on Oak Creek (AARPCC 1984:25).
ca. 1877	Verde--"fine river of eighty feet in width about fifty miles northeast form Prescott" (Hodge 1877:39).
1880s	Lower Verde--Cattlemen began grazing livestock along the river (Ayres & Stone 1984:36).
1883	The United Verde mine incorporated. Jerome begins as a town with its first post office (Brogdon 1952:14).
ca. 1884	Description of river: The Verde River is one of the largest northern branches of the Salt River, its upper branches rising at different points to the east, north, and northwest, from Prescott. It becomes a fine river of eighty feet in width about fifty miles northeast from Prescott, and thence runs a southerly course to its junction with the Salt River, near Camp McDowell. Its whole course is about one hundred and fifty miles. It receives the waters from the San Francisco Mountains, and other timbered slopes. It drains all the southern half of Yavapai County. The Tonto, Sipicue, Cherry, Agua Fria, and other large creeks, are also tributaries of the Salt River, coming in from the north. The main branches of the Salt River, the White and Black Rivers, are both swift-running mountain streams, and rise in the White Mountains. They are well stocked with the real speckled mountain trout, affording rare sport

Table 3-1 Chronology of Significant Historical Events in the Verde River Valley	
	to the fisherman (Wallace W. Elliot & Co. 1884:90).
1884	Waters are "clear and limpid"--river is "as large as the Gila"--"well stocked with fish" (Hamilton 1884:49). Verde--"capable of irrigating vast stretches of land" (Hamilton 1884:361).
1887-??	Development of irrigation on the Verde River (Jackson & Fraser 1991:7-19).
1888	Schuerman #1 Ditch built on Oak Creek (AARPCC 1984:25).
1889	Homesteads in the lower Verde Valley recorded in Fort McDowell records (BOR 1976:106).
1890	Ft. McDowell abandoned by the Army (BOR 1976:77; Byrkit 1984:331; Byrkit 1978:49; Ayres & Stone 1984:7).
1890s	Instigation of Rio Verde Project for irrigation--never completed (Introcaso 1990:9-10). Lower Verde--Overgrazing problems appeared (Ayres & Stone 1984:36).
1891	Ft. Verde abandoned (Byrkit 1984:331; Byrkit 1978:42).
1892	Jerome is an town of less than 500 people (*Jerome News*, 1-11-1913, cited in Brogdon 1952:33).
1899	United Verde Mine described as "not the greatest copper mine in the world in point of production, but ... certainly the richest copper mine in the world and probably the most profitable ... copper mine in the world (*Jerome Mining News*,11-20-1899, Supplement, cited in Brogdon 1952:33).
1900	J.J. Fisher discovers and land claims the Little Daisy Mine, which was to become the United Verde Extension in 1910, and in 1915 becomes Jerome's second great mine (Brogdon 1952:38).
1903	President Roosevelt authorizes the setting aside of Fort McDowell lands not settled, and the purchasing of non-Indian lands for the Yavapai Indians. Fort McDowell Indian Reservation established (U. S. Congress 1990:2). Fort McDowell Reservation established for the Mohave-Apache (Yavapai) on the Verde (Ayres & Stone 1984:8, 57; BOR 1976:78; Byrkit 1978:49;).
1905	Hurley V. Abbott lawsuit filed in Arizona Territory District Court to determine priority and ownership of water rights in the Salt River Valley (U. S. Congress 1990:2-3).
1907	Kent Decree awarding the Fort McDowell Indians only amount of water necessary then being used (7060 acre-feet) and on a temporary basis, until relocated to the Salt River Reservation (U. S. Congress 1990:4). Childs Hydro Plant built on the Verde at Childs near Fossil Springs (Parker 1949b:14-5; Byrkit 1984:331).
6/1909	Generating plant built at Childs on the Verde (Byrkit 1978:45).
1911	Santa Fe Railroad line from Drake to Clarkdale built (Byrkit 1978:37). Gittings Dam proposed and refused (Byrkit 1978:40).
1912	United Verde Copper Company began construction of a smelter on the Verde River to treat ore from its mines in Jerome. Clarkdale founded as a residential and business facility to serve employees of company (AARPCC 1984:68). Irrigated acreage on the Fort McDowell Indian Reservation reported to be 1,180 acres (BOR 1976:106).
1914	Camp Verde and Middle Verde Indian Reservations established (BOR 1976:78).
1915	Childs generating plant taken over by Arizona Power Company (Byrkit 1978:45).
1916	Irrigated acreage on the Fort McDowell Indian Reservation reported to be 102 acres (BOR 1976:106).
1917	Smelter town of Verde built. Fifteen hundred Verde District miners go on strike. Of the 1100 United Verde Mine

Table 3-1 Chronology of Significant Historical Events in the Verde River Valley	
	employees only 200 remain working, and these were mostly Mexicans (Brogdon 1952:52,63).
1936-39	Bartlett Dam constructed on the Verde (Salt River Project 1966:32).
5/1939	Bartlett Dam completed on the Verde (Byrkit 1978:49; Byrkit 1984:331; Introcaso 1990:62).
1944	Verde considered for Central Arizona Project--later abandoned (Byrkit 1978:44).
1944-46	Horseshoe Dam constructed on the Verde (Salt River Project 1966:32).
1948	Horseshoe Dam completed on the Verde by Phelps Dodge (Byrkit 1978:48; Byrkit 1984:331).

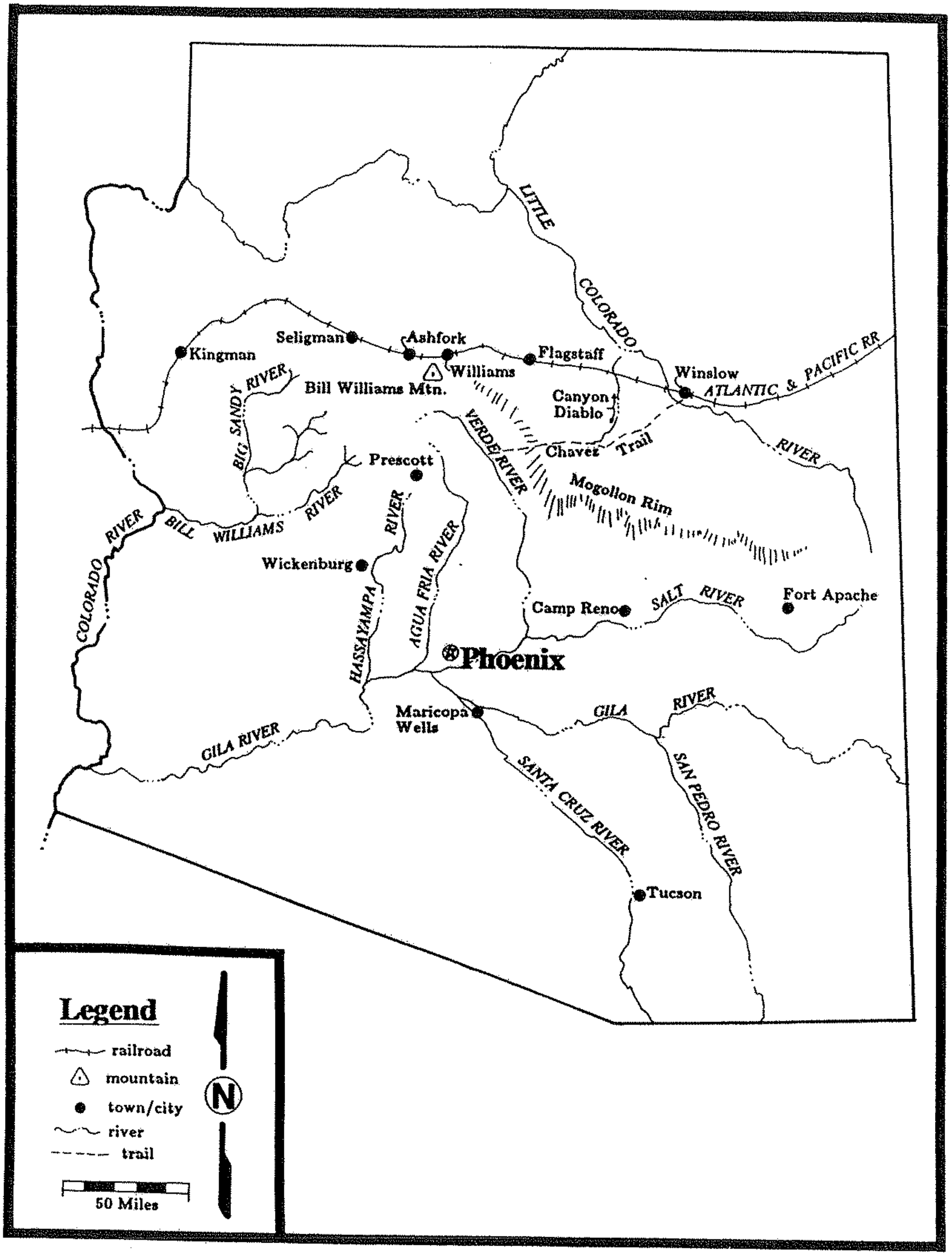

Figure 3-1a. General location map for Verde River historical sites.

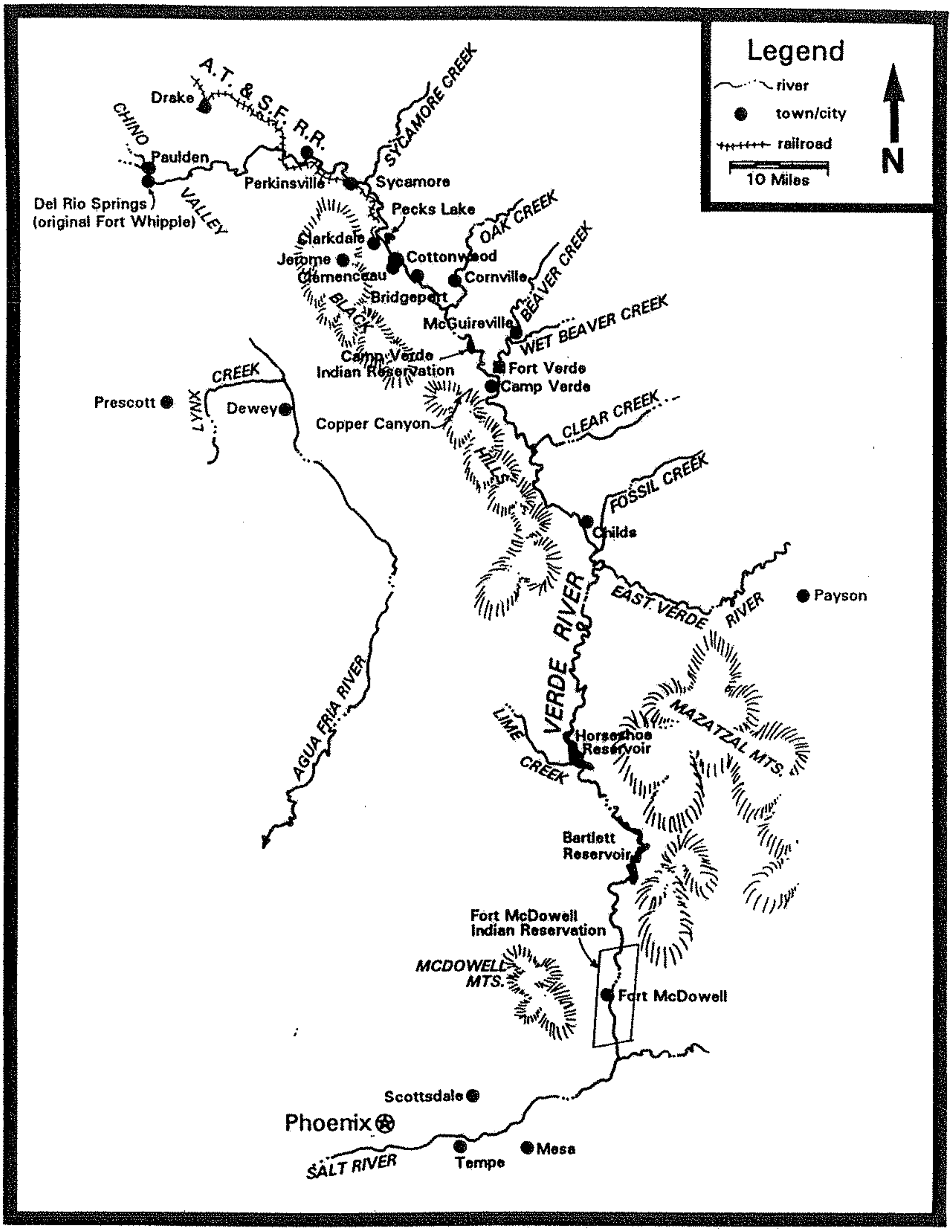

Figure 3-1b. Historical communities and sites along the Verde River.

The Yavapai were primarily hunters and gatherers, although they practiced some agriculture. According to Fish (1974:5), the Yavapais practiced simple ditch irrigation and farmed approximately 20 acres of the upper Verde River floodplain in the 1870s. The rest of the floodplain was too marshy for farming. The Yavapai lived in small settlements (or rancherías) of only a few families (Gifford 1936; Khera 1978; Khera and Mariella 1983; Schroeder 1952, 1974; Stein 1981, 1984). The Apaches also had a mixed economy based on hunting of wild game, gathering of wild plants, and limited horticulture. Like the Yavapai, the Apache are considered a ranchería tribe, although they were even more mobile than the Yavapai (Basso 1983; Stein 1981, 1984).

Spanish Exploration

In 1583, Antonio de Espejo explored central Arizona and visited Indian mines that he had heard about from the Hopis. Although, Espejo described the mines as "very rich" (Bolton 1932:169, as cited by Brogdon 1952:2), Diego Pérez de Luxán, who accompanied Espejo, said that these mines were "so worthless that we did not find in any of them a trace of silver, as they were copper mines, and poor" (Hammond and Rey 1929:127, as cited by Brogdon 1952:2-3). In 1599, Captain Marcos Farfán de los Godos (one of the lieutenants of New Mexico Governor Oñate) visited the mines and described them as "very wide and rich and of many outcrops, all containing ores" (Bolton 1932:169, as cited by Brogdon 1952:3). Farfán even "found an old shaft, three estados [an estado is the height of a man] in depth, from which the Indians extracted the ores for their personal adornment and the coloring of their baskets, because in this mine there are brown, black, water-colored, blue and green ores" (Bolton 1932:169, as cited by Brogdon 1952:2-3, Bolton's editorial comment). In 1604, Oñate described the mines based on the accounts of Espejo and Farfán. The exact destination and routes of the early Spanish explorers to the Indian mines of central Arizona are not known. Bancroft (1888) thought that Espejo and Farfán went to the vicinity of Bill Williams Mountain. Bolton (1916) thought that Espejo went to the Bill Williams Fork and Farfán went to the Big Sandy. Hammond and Rey (1929) were the first to suggest that the Indian mines were in the Verde River Valley, and Katherine Bartlett (1942) has provided a more detailed reconstruction of their route that is widely accepted.

Padre Luís Velarde's 1716 description of the Pimería Alta states that the major rivers of the region were the Gila and the Colorado but also mentions "two others, called the Salado and the Verde River, the first because it is salty, and the latter perhaps because it runs among greenish shapes or rocks" (Wyllys 1931:116).

American Trappers

In 1826, trappers James Ohio Pattie, Ewing Young, and others traveled up the Salt River, trapping beaver along the way. At the Verde River (which they called the San Francisco River), the party split, and Ewing Young went up the Verde River, while Pattie continued up the Salt River. Young followed the Verde River to its headwaters, then returned to the Salt River (Byrkit 1978:34). Young returned to the Verde River with 40 other trappers (including Kit Carson) in 1829, following the Salt River to the Verde River, then traveling up the Verde River to the Chino Valley (Byrkit

1978:35, 46; Pierson 1957:325-326). Wolfskill, Yount, and Weaver trapped the Verde River in 1829 and 1830.

United States Military Exploration

In 1851, Captain Lorenzo Sitgreaves passed south of Bill Williams Mountain during his survey for a transportation route from Zuni to the Colorado River (Sitgreaves 1853). His Camp 21 was at the headwaters of a tributary of the Verde River, although he mistakenly thought he was at the headwaters of the Bill Williams River (Foreman 1941; Macnider, Effland, and Ford 1989:35; Wagoner 1975). Lieutenant Amiel Weeks Whipple passed through the Chino Valley during his survey of a railroad route in 1853 (Whipple 1941). In 1854, after guiding the Whipple expedition to California, Antoine Leroux returned to Taos by way of the Pima Villages on the Gila, up the Verde River (which he called the San Francisco River) to the junction of Cañon Diablo and the Little Colorado River. During this trip he discovered the ruins of the Verde River Valley. Leroux kept a journal of this trip, which was published by Whipple (1856). His route became known as Leroux's Trail (Foreman 1941:13).

Permanent Anglo Settlement

In 1863, gold was discovered on the Hassayampa River and Lynx Creek, a tributary of the Verde River (Pierson 1957). On December 23, 1863, the First Cavalry, New Mexico Volunteers, commanded by Col. J. Francisco Chaves, established Fort Whipple at Del Rio Springs in the Chino Valley near the gold fields (Byrkit 1988:15). Territorial Governor John N. Goodwin and the rest of the territorial administration arrived at the fort in January of 1864 (Byrkit 1978:36). Later in 1864, Fort Whipple and the Arizona territorial capital were moved to Prescott (Macnider 1989:35). During 1864, Col. Chaves made three trips between Fort Whipple and New Mexico. His route took him from Del Rio Springs south, down Copper Canyon to the Verde ("San Francisco") River, then up the Beaverhead Malpais and along the rim of Cañon Diablo to the Little Colorado River. It became known as the Chavez (spelled with a z) Trail (Byrkit 1988:18-22).

In 1865, New Mexico Volunteers from Fort Whipple established an unofficial garrison on the middle Verde River, which was officially designated Camp Lincoln in 1865, and later (1868) renamed Camp Verde. The present location for Camp Verde was selected in 1871, and occupied in 1872. The post was renamed Fort Verde in 1879. Fort Verde was ordered abandoned in 1890; abandonment was completed in 1891 (Brogdon 1952:5-6; Corbusier 1968:252, n.1; Eason 1966; Munson 1981:32).

Civilian settlement of the middle Verde River valley began in 1865, when J.N. Swetnam and James Parrish led colonists to the valley (Verde Valley Pioneers Association 1954: VIII-IX). In 1865, white settlers raised barley on 200 acres at the junction of the Verde River and Clear Creek. They threshed the barley by hand and sold it at Fort Whipple (Farish 1915, IV:215, as cited by Brogdon 1952:4). By 1880, most of the arable land in the valley was under cultivation (Rickard 1932:287, as cited by Brogdon 1952:5). Camp McDowell, on the lower Verde River, was established in 1865, and civilian settlement around it began soon after, following the same pattern as at Camp Verde.

General George Crook was assigned to Arizona in 1871 (Stein 1981:21). The Tonto Apache and the Yavapai surrendered to Crook at Fort Verde in 1873 and were placed on the Rio Verde Reservation. The Rio Verde Indian Agency was established in 1871 (Simmons 1985:81; Stein 1981:21). (Brogdon [1952:6] and Corbusier [1968:269] both say 1873.) The agency headquarters was located on the east site of the Verde River, three miles southeast of Peck's Lake. The reservation extended 10 miles on each side of the river for 40 miles upstream. In 1874, the Agency headquarters was moved to the west side of the river near present-day Clarkdale, and the Indians dug a four-mile-long ditch to irrigate 53 acres of corn, melons, pumpkins, and potatoes (Simmons 1985:81). In 1875, the 1400 Indians residing there were moved to San Carlos (Brogdon 1952:6; Corbusier 1968:269).

The mining claims that later became the United Verde Copper Company's mine at Jerome were patented beginning about 1876. M.A. Ruffner patented the Eureka Claim on June 16, 1876, and Ruffner and Angus McKinnon patented the Wade Hampton Claim on June 18, 1877 (Brogdon 1952:9). The United Verde Copper Company was formed in 1883, and the Jerome Post Office was established the same year (Brogdon 1952:14).

In 1890, Fort McDowell was abandoned (Byrkit 1978:49). That same year, Fort Verde was ordered closed, which was completed in 1891 (Munson 1981:32). In 1894, Congress passed an act (28 Stat.L, 491) allowing abandoned military posts to be homesteaded (Stein 1984:32-34). A number of farmers settled on the old Fort McDowell property, but all were removed in 1903, when the post was made into an Indian Reservation. On February 3, 1895, the 10,000-acre Rio Verde Reservation was opened for settlement, and within six weeks, almost 4000 acres had been claimed (Brogdon 1952:6; Munson 1981:32). The fort buildings were sold in 1899 (Munson 1981:32).

Early transportation in the middle Verde River Valley was typically conducted on horseback, mule train, wagon, and stage. Stage service between Prescott and Ash Fork was established in 1878 (Macnider et al. 1989:36). Railroad service reached northwestern Arizona in 1882, Prescott in 1886, and Jerome in 1895 (Wahman 1983). As a result of a fire in the upper levels of the United Verde Mine at Jerome, a new mine entrance was constructed at Hopewell, 500 feet below the old entrance at Jerome. The Verde Valley Railroad constructed a line from Drake to the newly established town and smelter at Clarkdale circa 1911-1912, where a smelter was built between 1912 and 1915. The Verde Tunnel and Smelter Railroad built a line between Clarkdale and Hopewell from 1913 to 1915 (Wahman 1983:19).

Construction of a hydroelectric plant at Childs began in 1907, and by 1909, the plant was in operation. In 1915, Arizona Power Company built a second hydroelectric plant (Byrkit 1978:45). In 1939, Bartlett Dam on the lower Verde River was completed (Byrkit 1978:49). Horseshoe Dam, above Bartlett Dam, was completed in 1948 (Byrkit 1978:48).

Historical Descriptions of the River[1]

The early Spanish explorers of the Verde River provided only cursory descriptions of the river, and their exact destination and routes are not known, although Bartlett's (1942) reconstruction is generally accepted. Speaking of the general vicinity of the mines, Espejo (1966:227) said, "The general aspect of the land where the mines are located is good; there are rivers, marshes, wood, and also--on the riverbanks--great quantities of Castile grapes, walnut trees, flax, mulberries (*morales*), maguay plants, and prickly pears." Luxan, who accompanied Espejo, wrote that on May 8, 1583, "we found a large and copious river which flowed from north to south, which we called El Rio de los Reyes" (Bartlett 1942:30). (Note that Hammond and Rey's [1966] translation of this account [Pérez de Luxán 1966:197] describes the El Río de Reyes a "a large river, carrying a great volume of water.... Close to it was a marsh into which flowed a stream of water.") Bartlett (1942:30) believes that this "River of the Kings" was the Verde River. Farfán's expedition passed through the region in November of 1598 and, as reconstructed by Bartlett (1942:33), described Beaver Creek as "a river of fair width and much water, with good pasture and a cottonwood grove," then crossed Oak Creek ("another river, wider than the first"), and finally crossed the Verde River ("another river, much larger, which flowed from the north"). Farfán de los Godos (1953:413) also said that "there was a great abundance of water in the rivers and springs mentioned above. Many mills could be established here with excellent water wheels, which would make drawing of water very easy." Farfán's group "did not see any fish in this river because of the short time they spent there" (Farfán de los Godos 1953:413). On the other hand, "They found many Indians clothed in the skins of beaver, very fine and well tanned" (Farfán de los Godos 1953:413).

Whipple (1941:188) passed through the Chino Valley[2] on January 13, 1853, and stated, "We have found no water in it above the streams that enter south of the Picacho; but the soil seems so moist of itself, that probably, without irrigation, it might be cultivated to better advantage even than the Zuñi valley."

In 1870, the Surgeon General of the Army published a report on health and sanitation at military posts, including Fort McDowell and Camp Verde (Surgeon General 1870). Assessments of both posts include descriptions of the Verde River, abstracted as follows.

As described by the Surgeon General (1870), Fort McDowell was established in 1865, and by early 1866, construction had been completed. The garrison cleared 150 acres of bottomland for cultivation and irrigated it with river water brought by an acequia from four miles up river. The farm was worked by employees of the Quartermaster Department but later was leased to private citizens who produced grain for the quartermaster and cavalry animals. Ten acres were retained for use as a post garden where troops raised corn, sorghum, beans, tomatoes, beets, radishes, and melons; potatoes, onions, and grapes did not survive (Surgeon General 1870:459-460). "On both

[1] NOTE: In this section, the spelling and grammar of quotations from historical documents have been left as written in the original document.

[2] Chino Valley is located upstream of the Verde River study area (Figure 3-1).

sides of the Verde River, near the post, the mesa rises almost from the water's edge, becoming more and more broken by deep and narrow ravines, until it blends with the foot-hills of the mountain ranges on the east and west. The river is thus well confined, and its bottom lands free from marshes. The strip of easily irrigated bottom land is very narrow, yet much good soil could be reclaimed by irrigation from large acequias" (Surgeon General 1870:459). "The water supply has been wagoned in barrels from the Rio Verde since the post was established. It is of excellent quality" (Surgeon General 1870:461). "Although the Rio Verde contains an abundance of fish, the troops seldom have recourse to fishing as a pastime, the produce being soft and flavorless" (Surgeon General 1870:461). Fort McDowell was fortunate in that malaria was not a problem there (Surgeon General 1870:461).

According to the Surgeon General (1870:468), "Camp Verde, formerly known as Camp Lincoln, is situated on the east bank of the Rio Verde." The Surgeon General (1870:469) went on to say, "The post was originally established by two companies of Arizona volunteers, mostly Mexicans who were in the service during the late war." The post was originally an outpost of Fort Whipple, and shelters were "excavations on a hill-side, completed with logs and shelter tents" (Surgeon General 1870:469). Regular troops arrived at the post in 1866, and in 1868 "[b]etter and more permanent quarters commenced" (Surgeon General 1870:469). Still, "[t]he officer's quarters are miserable hovels...," and the commanding officer lived in a 12 x 13 foot shack "of rough boards, with gaping seams" (Surgeon General 1870:467). "The Verde River Valley, during the greater portion of its course from north to south, is extremely narrow, being little other than a cañon with rugged and barren hills on either side, but in this locality it is about seven miles wide, with a rich alluvial bottom, which, to some extent, has been farmed by settlers. When irrigated it is very fertile and yields fine crops of corn, which is the staple product" (Surgeon General 1870:468). "The post garden, situated six miles below the post where Clear Creek joins the river, is nominally cultivated by from three to five men detailed for that duty; but the supply is not such as the extent and fertility of the soil at command would yield with careful cultivation. It has produced, however, a small cart-load of onions, beets, corn, cabbage, melons, and cucumbers twice a week for four or five weeks during the season, and provided the garrison with sauerkraut during the winter; .... In this vicinity, there are three or four small ranches farmed by German and American settlers" (Surgeon General 1870:469). "The diseases which prevail are chiefly malarial,.... During the drier seasons of the year most of this class of cases come from the men on duty at the post gardens and other low localities" (Surgeon General 1870:469). "The spring rains occur during March, and, with the snow on the mountains, usually occasion floods, which inundate many of the bottom lands; similar floods are an accompaniment of the July rains; but the rapid current of the river, the sandy soil of the inundated lands, and the high winds which are prevalent during these stormy months, speedily drain and dry off all surface water" (Surgeon General 1870:469). "On the tongue of land formed by the junction of Beaver Creek with the Verde, three-quarters of a mile below the post, there is a considerable tract of low bottom, on which a rank vegetation springs up after the spring and autumn rains. This appears to be the chief source of the malarial diseases which affect the garrison, more especially at the latter season. The water of both these streams is of excellent quality, free from any marked amount of organic or inorganic impurities, and turbid only during floods" (Surgeon General 1870:469).

In the 1870s, the upper Verde River was so marshy that the Yavapais were able to farm only 20 of the 125 acres available on the floodplain (Fish 1974:5). William Henry Corbusier was the surgeon at the Rio Verde Indian Agency, located 16 miles above Camp Verde. His wife, Fanny Dunbar Corbusier, described the setting of the agency in 1874:

The agency was situated near the foot of the Black Mountains, on a clear, rapid stream of water that sank into the rocks 3 miles above and came out hot water below. ... It soon cooled off and in doing so, deposited lime for some distance along its course. ... Rains fell in March and July, and, together with melting snow from the mountains, often caused a sudden rise of many feet in the river, which then became a raging torrent, carrying along great trees and large rocks (Corbusier 1968:244, 252).

William H. Corbusier also mentioned the propensity of the river to flood. Of February, 1875, he wrote:

> *This was the flood time of the year. I had seen the Verde suddenly come raging down, tearing away everything before it--great trees and even rocks tossed about like so much straw. On one trip, while crossing a peaceful little stream, a wall of water and debris came out of nowhere and swept away most of our packtrain in the twinkling of an eye, and then in a few minutes subsided to a trickling stream (Corbusier 1968:269).*

Mrs. Mary Boyer arrived in the middle Verde River Valley in 1874. She stated, "The Verde River at that time was just about the size of the Woods ditch of today. Wild mustard and grass grew profusely everywhere and large cottonwood trees could be seen in the distance (Verde Valley Pioneers Association 1954:42).

Leonora Bristow Lee, born in 1873, moved to Cottonwood from Missouri in 1875. She later wrote:

> *In those days malaria was common. Everyone had it in the summer. There were few, if any, floods, and the Verde River spread out wide, and so shallow you could cross it on clumps of grass. Willow and undergrowth were so heavy all over the river bed that the water was forced into standing pools which bred mosquitoes. That may have been the cause of the malaria. Some thought we may have had it when we came, but when the run-off got bigger and the river was cleaned out occasionally with flood, the malaria disappeared (Verde Valley Pioneers Association 1954:133).*

Hiram Hodge (1877:39) said of the Verde River that "It becomes a fine river eighty feet in width about 50 miles northeast of Prescott...." Martha Summerhayes, the wife of an officer at Fort McDowell, wrote of swimming in the Verde River near the fort in 1877 (Summerhayes 1911:219).

Charles Douglas Willard moved to the Verde River Valley, across the Verde River from Clarkdale, in 1879. He wrote:

> *When I first saw the Verde Valley it was a hunter's and stockman's paradise. Wild game was everywhere and the grass was knee high and plentiful. The land was like a sponge and when it rained the water was absorbed into the ground immediately, so very little ran into the river channel and the small amount that did run into the river bed, stood in pools which*

became stagnant and polluted with malaria germs, consequently many people were stricken with malaria, but they had to administer their own medicine, such as calomel and quinine, because there were no doctors available. Most everybody that came to the Verde Valley brought cattle, horses or sheep with them and the stock soon trampled the spongy land down to solid ground, thus causing the rain water to run into the river channel, which was then only about 100 feet wide and the flood waters often rose to six or seven feet high, causing the river to cut into banks, change the course of the main river channel and the river bed spread to half a mile wide in places (Verde Valley Pioneers Association 1954:150).

Jessie Belle Shelley also moved to the middle Verde River Valley in 1879. "She says there was lots of malaria ever in the Verde Valley when she first came to it. The Verde River flowed in a definite course with grass covered banks as those were the days before erosion began too badly in the valley" (Verde Valley Pioneers Association 1954:187).

Dr. Edgar A. Mearns, surgeon at Fort Verde and an accomplished naturalist, stated that in the 1880s, the Verde River "was deep, flowed slowly, and was impeded by many beaver dams" (Mearns 1904:354-359, as cited by Fish 1974:5). Dan J.W. Huntington, who served at Fort McDowell in the 1880s, said that the river was "full of beaver dams with plenty of fish behind these dams" (Huntington 1957:7, as cited by Stein 1984:9).

Charles C. Stemmer first saw the middle Verde River Valley in 1879. "There were stacks of wild hay on the bench land of the Valley. The erosion on the Verde River and its tributaries was scarcely noticeable and I heard the folks say many were sick with malaria. Many small lagoons all along the Verde River furnished breeding places for mosquitoes that sometimes clouded parts of the Valley. There were flocks of quail and all kinds of rabbits" (Verde Valley Pioneers Association 1954:113).
A resident of the Verde Valley described to Minkley and Alger (1968:95) what the Verde River was like in the vicinity of Perkinsville in the 1890s. "According to Mrs. Nick Perkins (personal communication), the floodplain of the river was quite stable in the 1890s, and Yavapai Indians were using canals to irrigate their crops along the banks of the stream. The river flowed slowly, impeded by many beaver dams, and extensive marshes occupied the floodplains."

In 1891, exceptional flooding occurred on the Verde River and was reported by archaeologist Cosmos Mindeleff (1896). An undated letter (Davis 1895) to the historian Sharlot Hall from John Davis (who farmed in the Verde Valley in 1871 and 1872 and who died in 1906) describes a Verde River flood, perhaps the one mentioned by Mindeleff:

The great flood 4 years ago caused the river to leave its channel in many places cutting a new one, washing off the surface soil to the depth of from 10 to 20 feet exposing to the estonished beholder former Irrigating canals in perfect state of preservation. In one place in paticular the surface Soil was washed away to the depth of 10 feet .... In another locality where the flood washed away several acres of a cultivated farm exposing to view a former channel of the river with a stone dam across it, which when first exposed was 4 feet higher than the old channel, built in a streight line across the river, the outer walls of which were laid with immence stones with smaller ones between. Growing over the dam and ditch were great trees over 5 feet in diameter.

Dr. Ralph F. Palmer arrived in Camp Verde just after Christmas, 1902. He described the Verde River as 50 feet wide and no more than waist deep, with banks two to three feet high and a "steep but gravelly slope to the sand wash below" (Palmer 1979:26).

Stein (1984:48) summarizes descriptions of farming at Fort McDowell in the early 1900s. She states that "The greatest problem the Indian farmers was obtaining adequate water" .... At the head of some of the ditches, dams were built across the river, which washed out the dams four or five times a year.

Archaeologists Winifred and Harold S. Gladwin studied the Verde River in the 1920s and stated, "The only cultivable lands are the alluvial terraces along the bed of the stream, and these are subject to sudden and violent floods owing to the sharp declivity and the immense watershed drained by the river" (Gladwin and Gladwin 1930:166).

Historical Uses of the Verde River

Farming

Pierson (1957:327) states that hay cutters began using the middle Verde River Valley possibly as early as 1863 and certainly by the summer of 1864. Farming on the middle Verde River, near Camp Verde, began in 1865 just after the establishment of the garrison. The early farmers raised crops for sale at Fort Whipple and Prescott. In 1865, white settlers raised barley on 200 acres at the junction of the Verde River and Clear Creek. They threshed the barley by hand and sold it at Fort Whipple (Farish 1915, IV:215, as cited by Brogdon 1952:4).

According to Goddard (1984:25), the principal irrigation ditches in the middle Verde River Valley and their dates of establishment were the Eamon or Diamonds Ditch (1865), the Wood Ditch (1868), the Cottonwood Ditch (1869), the O.K. or Middle Verde Ditch (1873), and the Hickey Ditch (1874). Groseta (1984), though, says that the Cottonwood Ditch originated with the Apache Reservation Ditch, which was dug in 1874, and that the application for water rights for this ditch was filed in 1877.

In 1870, the Surgeon General (1870:469) reported "three or four small ranches farmed by German and American settlers" near the post garden six miles below Camp Verde, and also mentioned settlements on Clear Creek. At Fort McDowell, the garrison cleared 150 acres of bottomland for cultivation and irrigated it with river water brought by an acequia from four miles up river. The farm was worked by employees of the Quartermaster Department but later was leased to private citizens who produced grain for the quartermaster and cavalry animals. Ten acres were retained for use as a post garden where troops raised corn, sorghum, beans, tomatoes, beets, radishes, and melons; potatoes, onions, and grapes did not survive (Surgeon General 1870:459-460).

Mrs. Mary Boyer, who arrived in the middle Verde River Valley in 1874, mentioned that the settlers hauled hay by wagon to the fort (Verde Valley Pioneers Association 1954:42). Naomi

Bristow Straham, another early settler in the middle Verde Valley, also described cutting hay and hauling it to the fort about 1875.

In 1875, Fanny Corbusier described the post garden as follows:

> *The river at this point runs south into a canyon, but here its valley broadens and the bottomlands have a very rich soil, which, with irrigation, yields abundant crops of all sorts. The post garden produced beets, onions, corn, cabbages, cucumbers, and melons in great quantities, and most of the officers raised chickens, which feasted upon the abundance of wild grains and insects (Corbusier 1968:253).*

Circa 1876, a man named Frank Jordan operated a mill below Camp Verde (Verde Valley Pioneers Association 1954:26).

In 1876, James Baker settled along the Upper Verde River and established a ranch which eventually ran 10,000 head of cattle. Drought and market prices curtailed the herd size and Baker later entered into a partnership with John G. Campbell (Granger 1960). Marion A. Perkins bought the ranch around the turn-of-the-century and when the Atchison, Topeka, and Santa Fe Railroad built the line from Drake to Clarkdale during the early 1910s, the Perkinsville station was established where the railroad crossed Perkins' property (Granger 1960, as cited by Macnider et al. 1989:36).

In 1878, the four Willard brothers arrived in Cottonwood and began ranching. In the 1880s, they turned to farming and were involved in the construction of the Cottonwood Ditch. Two of the brothers drowned in the Verde River (Byrkit 1978:41).

As late as 1879, "there were only a few scattered ranches in the Upper Verde Valley" according to Charles Douglas Willard (Verde Valley Pioneers Association 1954:150).

By 1880, most of the arable land in the middle Verde valley was under cultivation (Rickard 1932:287, as cited by Brogdon 1952:5). Hamilton (1884:113, 338, as cited by Pierson 1957:338) stated that in 1884, 3000 acres along the Verde River were being farmed and a canal under construction would bring another 1000 acres under production. Production of food for the fort remained an important agricultural activity. Rebecca Jane Casner reported taking milk and butter by buggy from her farm on Beaver Creek to the fort in about 1889 (Verde Valley Pioneers Association 1954:50).

Charles C. Stemmer first saw the upper Verde River Valley in 1879 and was impressed by the "stacks of wild hay on the bench land of the Valley." He and his mother moved to a farm across the Verde River from Cottonwood in 1899. "There were 65 fruit trees on the property; about 24 nice grape vines (Verde Valley Pioneers Association 1954:113).

Stein (1984:34) states that most data on Fort McDowell for the period 1895 to 1900 come from water survey reports. These describe the attempts by Euroamerican farmers to practice irrigation agriculture. The Government Farm and Ditch, built by the military, was run by civilian contractors from 1868 to 1890. After the post was closed, the farm and ditch were abandoned until 1894, when

Euroamerican settlers began using them. In 1903, the farm and ditch became part of the Indian reservation (Stein 1984:46-47). According to Stein (1984:48),

> *The greatest problem facing the Indian farmers was obtaining adequate water.... Both the Jones and the Government ditches had a dam in the river. Four or five times a year these dams washed out.... In the spring of 1905 the upper two miles of the Jones Ditch were regraded and moved 100 ft farther from the river. Hardly had the grade been set when the river rose and cut its banks. When the water began to recede, the Indian farmers cleared the upper portions of the canal and, by recutting it to a flatter grade, got water into it without the aid of a weir. When the floodwaters subsided farther, the Indians built a brush weir and were able to get sufficient water to irrigate their crops.*

In 1908, William Goddard and Cole Reid, two farmers in the upper Verde River Valley, bought a threshing machine. "It was shipped to Dewey, and they brought it down Copper Canyon. The roads in those days were not very good for that kind of equipment to travel. The Verde River was their worst enemy, as there was always quick sand. I have seen that old engine bogged down to the fire box many times. It was quite a job digging it out and pulling it out with horses" (Verde Valley Pioneers Association 1954:198).

Mining

The nearest mines to the Verde Valley were those at Jerome, but they had a significant impact on the development of the valley. As stated earlier, mining of copper pigments occurred prehistorically in the Verde River Valley, and the earliest Spanish exploration of the valley was prompted by Hopi accounts of these mines. The exact location of the mines visited by the Spanish is not known, and the Spanish never developed the mines. The mines at Jerome were established in 1876 and prompted the construction of wagon roads and railroads into the area. The first railroad into the area (from the Chino Valley to Jerome) was completed in 1895 (Wahman 1983:7). Circa 1911-1912, a railroad was constructed to the newly established town of Clarkdale, site of a new smelter (Wahman 1983:19).

Hydroelectric Power

Hydroelectric power was a significant use of the Verde River. In 1897, cattleman Lew Turner discovered Fossil Springs on Fossil Creek ten miles above its confluence with the Verde River. From 1907 to 1909, the water from this spring was harnessed by the construction of the TAPCO hydroelectric plant along the Verde River at Childs. From a dam below the spring, a flume carried the water to Stehr Lake (a reservoir above Childs), from which the water plunged through a penstock into three generators at the plant. The water then emptied into the Verde River. Arizona Power Company built a second hydroelectric plant in 1915. In the 1920s, the power plants on the Verde provided all of the electricity for Camp Verde, Jerome, Mayer, Payson, Pine, Prescott, and 70 percent of Phoenix (Byrkit 1978:45).

Regional Transportation

Byrkit (1988) points out that the Verde River Valley was accessible to Hopi by the Palatkwapi Trail, which was in use prehistorically. Col. J. Francisco Chaves, who commanded the New Mexico Volunteers who established Fort Whipple, incorporated portions of this route in the Chavez Trail, the original route to Fort Whipple.

The Surgeon General's 1870 report on Fort McDowell stated that "It is reached by steamer from San Francisco to San Diego, California, thence by mail stage via Yuma to Maricopa Wells, from which place a weekly mail is carried north to the post" (Surgeon General 1870:459). Floods on the Salt River and Gila, though, sometimes "cut the post off from communication with the outside world for three and four weeks at a time" (Surgeon General 1870:459). In the winter of 1867-1868, troops from Fort McDowell built a wagon road from the fort to Camp Reno on Tonto Creek (Surgeon General 1870:460).

In 1873, Crook's wagon road was constructed from Camp Verde to Fort Apache (Pierson 1957:337). The mail trail to Camp Lincoln (present day Camp Verde) was described as coming in from a fort to the east, then crossing over Baker's Butte, passing the Verde Ruins, and heading west through Government Gap, through the Agua Fria Valley, over Lynch Creek hill to Fort Whipple (Verde Valley Pioneers Association 1954:7).

Fanny Corbusier described Camp Verde in 1874 as being located "50 miles by road east of Prescott and 90 miles by trail north of Camp McDowell" (Corbusier 1968:252). The old road to the post went down Grief Hill; a graded road through Copper Canyon was constructed in 1875 (Corbusier 1968:252).

Mrs. Mary Boyer reported that in about 1874, settlers hauled hay by wagon to Camp Verde (Verde Valley Pioneers Association 1954:42). Naomi Bristow Straham, who settled in the middle Verde River valley in 1875, wrote "my father worked at hauling hay for the government with an ox team. The hay was cut with heavy hoes and raked with a hand rake. It was then hauled to Fort Verde.... My father then hauled wood on contract to Fort Verde from Clear Creek" (Verde Valley Pioneers Association 1954:56). Tack Gaddis arrived at what is now McGuireville in 1875. He wrote that "The Arnolds kept the mail station. It was a division point. The mail was carried horseback from Prescott on east" (Verde Valley Pioneers Association 1954:128). According to Charles L. Morris, "The mail line carried on horse-back from Camp Verde to Pine" (Verde Valley Pioneers Association 1954:131). William Loy moved to Prescott with his parents in 1876. "Instead of oxen they had horses and mules, and they found ready work for them hauling freight to Camp Verde. ... The only roads into the valley at that time were the Copper Canyon road from the southeast and the old Beaver Head road from the northeast" (Verde Valley Pioneers Association 1954:141).

According to Byrkit (1988:30), "By 1876, the Star Line Transportation Company had established a stage route from Prescott to Santa Fe, carrying mail and passengers." The 500-mile trip took seven and one-half days, with one of its stops at Camp Verde. "The Gilmer, Salisbury & Company Stage Lines established service between Prescott and Ashfork in 1878" (Macnider et al. 1989:36].

About 1879, according to Charles Douglas Willard, "We bought a few of our supplies from the Post but hauled most of them from Prescott via the Cherry Creek road. Toenail Point on Cherry Creek was so steep on the east side that four horses could hardly pull an empty wagon up the grade. It took us at least four days to make the trip" (Verde Valley Pioneers Association 1954:150).

The railroad across northern Arizona reached Williams in 1882, but wagons, stages, and pack trains remained the primary means of transportation in the Verde River Valley for another decade. C.C. Callaway arrived in the middle Verde River Valley in 1882, having taken the railroad to Williams, a Concord stage to Prescott, and a buckboard carrying mail to Camp Verde. Heading east to Strawberry, he encountered a government pack train (Verde Valley Pioneers Association 1954:86-87).

A wagon road was built from Ash Fork to Jerome about 1882 (Brogdon 1952:16). Most commodities were freighted into Jerome from Prescott, however. "J.F. Miller Company, established in Jerome in 1891, had the contract to haul all freight in and out of the town" (Brogdon 1952:24). They had 600 horses and mules, and would use 8 to 20 head to pull 2 to 4 wagons (Brogdon 1952:24, n.17).

Writing of the middle Verde River Valley circa 1883, Mrs. Mack (Luna B.) Willard said, "When supplies were needed, they were brought from Prescott or Flagstaff, requiring a trip of four or five days, or often more, if the roads were muddy" (Verde Valley Pioneers Association 1954:73). Circa 1889, Rebecca Jane Casner wrote of taking a buggy from Beaver Creek to Fort Verde, "and it took us all day to go down and back" (Verde Valley Pioneers Association 1954:50).

In 1899, Charles C. Stemmer hauled wood, ranch products, and dry swill by wagon from Cottonwood to Jerome. He and his mother moved from Cottonwood to Flagstaff because "there were no bridges then across the Verde River or its tributaries and much of the time the Verde was a raging torrent and we kids could not get to school" (Verde Valley Pioneers Association 1954:115).

Dr. Ralph Palmer arrived in Camp Verde shortly after Christmas, 1902, taking "Grant Ead's stage, which ran daily from Dewey Station to the Verde" (Palmer 1979:20). At the time, the only "real roads," in Dr. Palmer's estimation, were to Jerome and Prescott. "There were a few ruts going to ranches up and down the valley, and one passable road up Beaver Creek... . There was also a road going across the river and up a canyon to the Mogollon Rim, and thence along the rim for many miles to the San Carlos Indian Reservation and on to El Paso--an old army trail" (Palmer 1979:22).

In 1882, the Atlantic and Pacific Railroad was completed across Arizona. A wagon road was built from Jerome to Ash Fork, and mule teams hauled ore from the mines over this road to the railhead (Wahman 1983:1). The Prescott and Arizona Central constructed a line from Prescott Junction (present-day Seligman) to Prescott in 1885 and 1886, which allowed ore from Jerome to be hauled by wagon to the railhead in the Chino Valley (Wahman 1983:3). In 1892, the Santa Fe, Prescott and Phoenix Railroad began construction of a line from Ash Fork to Phoenix, which reached Prescott in 1893 and Phoenix in 1895 (Wahman 1983:4-5). This route replaced the old Prescott and Arizona Central Line, which ceased operations in 1895 (Wahman 1983:4). From 1894 to 1895, the United Verde and Pacific Railway built a railroad from Jerome Junction in the Chino Valley to

Jerome (Wahman 1983:7). In 1894, a fire began in the upper levels of the United Verde Mine at Jerome. This fire eventually resulted in the construction of a new mine entrance at Hopewell, 500 feet lower than the old mine entrance at Jerome. Circa 1911-1912, the Verde Valley Railroad (owned by the Santa Fe) constructed a railroad from Drake to the newly established town of Clarkdale, where a new smelter was built between 1912 and 1915. The Verde Tunnel and Smelter Railroad then (1913-1915) constructed a railroad from Clarkdale to Hopewell (Wahman 1983:19).

The Central Arizona Railroad built a line from Seligman to Prescott in 1886, but this railroad failed and was replaced by a line from Ash Fork to Prescott, built in 1893 by the Santa Fe, Prescott & Phoenix Railroad. A railroad from Ash Fork to Phoenix was completed in 1893 (Brogdon 1952:22), and a railroad spur was completed to Jerome in 1895 (Brogdon 1952:23). During 1911 and 1912, a railroad was constructed from Cedar Glade on the Santa Fe, Prescott and Phoenix Railroad to the Verde River and the new town of Clarkdale (Brogdon 1952:26). In 1915, the Verde Tunnel and Smelter Railroad Company built a line from Clarkdale to Hopewell (at the United Verde Copper Company mine entrance).

Historical Accounts of Boating on the Verde River

In 1873, Charles Hayden attempted to float logs down the Salt River and to establish a lumber mill at Tempe, but he was not able to get the logs through the canyons upstream (*Weekly Arizona Miner*, June 14, 21, 28, 1873). According to Fireman (1969:202), "Hayden turned up the Verde, thinking it the next-best stream to provide logs for the needs of central Arizona." This effort also failed.

Munson (1981:28-29) contains a picture of two men in a boat on the Verde River about 1887. At least one of the men appears to be wearing an army uniform, and the picture was probably taken near Camp Verde. The "collapsible U.S. Army issue boat [was] used to take couriers across the Verde during period of high water" (Munson, personal communication, as cited by Research Management West 1987:12). The photograph credit states that the original photograph is in the Library of Congress, which may have more information.

At least two newspaper accounts describe soldiers boating down the Verde River from Fort McDowell to Phoenix. They are as follows:

> *Arizona Gazette*, February 14, 1883: "The Salt River is a navigable stream and should be included in the river and harbor appropriation. North Willcox and Dr. G.E. Andrews, U.S.A., of McDowell, landed at Barnum's pier, on the Salt River Valley Canal, at three o'clock yesterday afternoon, direct from McDowell, having accomplished the voyage from that point to this port, in a canvas skiff. The running time proper was about eighteen hours, and the trip would have been thoroughly pleasant, had rain not fell upon them, during the night in which they camped out. The jolly mariners are now enjoying a good time among their friends in this city."

> *Phoenix Herald*, December 12, 1888: "The death of Major E.J. Spaulding, which occurred on Monday at the Mesa dam on Salt River is to be deeply regretted for a good man, a

> thorough and brave officer, has come to his too early grave. While coming down to Phoenix with Capt. Hatfield in a canoe and shooting as they came, they were about to lift their boat over the Mesa dam, when the major attempted to remove his gun from the boat, and in doing so it was discharged, killing him almost instantly. He was Commandant at Ft. McDowell, Major of the 4th Cavalry and an officer highly esteemed by his superiors and men under him."

Reed (1977:140) also mentions the death of Major Spaulding, and cites both the *Phoenix Herald* and the *Post Return* for December 1888. Reed (1977:140) makes it clear that Major Spaulding "left the garrison with Captain Charles A.P. Hatfield bound for Phoenix in a canoe."

According to Scott Soliday, research historian at the Tempe Historical Museum, an article in the *Mesa Free Press* of 1890 or 1891 describes how, after Fort McDowell was abandoned, A.J. Chandler had logs or sawn timber from the fort floated down the Verde River and then used in the head gates of the Consolidated Canal (Scott Soliday, personal communication to Douglas Mitchell, 8/12/93). (This article has not been located.)

In early 1903, Dr. Ralph Palmer and a friend, Joe Crain, boated some 16 miles along the Verde River while duck hunting. Dr. Palmer (1979:29) wrote:

> *Sunday morning Joe and I borrowed a steel boat from Dave Wingfield whose father Henry ran the general store. This boat was slung on the axle of two wheels. The horse that pulled it was accustomed to go up the river some five miles and, when turned loose, would take the wheels back to the corral by himself. We also borrowed a couple of shot guns and bought some shells. We launched the boat and had some 16 miles of river to float down. Between us, we got about a dozen ducks and had a swell time.*

Although this adventure was novel to newcomer Dr. Palmer, it was obviously routine to others in the valley, especially the horse!

In 1931, Fred Fogel and Karl Gireaux launched their flat-bottom boat, the *Sunny-side Up*, at Clarkdale, intending to float to Granite Reef Dam, trapping along the way. Three weeks and 70 miles into their trip, they reported that "the river becomes easier to navigate the farther south they go...." After five weeks, they were 18 miles above the old Fort McDowell to Payson road, which was their new destination (*Verde Copper News*, February 6, 1931, February 20, 1931).

Recreational boating and canoeing seems to have begun in earnest in the 1950s. Accounts of this recent recreational use of the river are summarized in Research Management West (1987). Slingluff (1990) describes current boating conditions. (Also see Chapter 8 & Appendix H.)

Discussion

Reliable flow in the perennial Verde River was a major factor in historical development of the Verde River Valley. The earliest settlers used the river for irrigation of crops grown to supply nearby military establishments and mining camps. The river also served as a source of water for domestic and commercial use, such as hydroelectric power. Early descriptions of the Verde River include discussion of flowing water (as opposed to descriptions of dry or intermittent flow mentioned in early descriptions of other Arizona rivers). Early descriptions also mention beaver and fish populations, as well as frequent floods. Floods mentioned caused dramatic increases in water levels in the river, eroded channel banks, damaged irrigation structures, and sometimes lasted for significant periods of time.

Historical documentation of the Verde River is best for the middle Verde River Valley between Clarkdale and Camp Verde and for the lower Verde River from Fort McDowell to the Salt River confluence. The middle Verde River experienced similar changes in channel geomorphology that occurred on other desert streams in the 1800s. Before about 1890, the middle Verde River was a marshy stream, or had marshy floodplains. In the late nineteenth century, though, floods scoured the streambed, forming a better defined channel.

The Verde River was used for irrigation, smelting (at Clarkdale), power production (at Childs), and water supply. Historical accounts of boating on the Verde River do exist, though the vast majority of transportion in the region by horses, mule trains, wagons, and railroad. Overland transportation was often difficult, especially during rainy periods. Published accounts of boating prior to 1912 exist for those portions of the Verde River that are best documented historically--that is, the middle Verde River Valley above Camp Verde and the lower Verde River below Fort McDowell.

Chapter 4
Oral History

Oral history for the Verde River was obtained primarily by writing and calling historical societies, federal and state agencies, and private organizations with interests in the various rivers and eliciting information about the history of the rivers, sources of information about the rivers, and names of individuals who might be knowledgeable about the rivers. The list of historical societies, museums, and historians was derived from records of the Arizona State Land Department, the Arizona Historical Society (which has a list of member institutions), guidebooks to Arizona museums (e.g. Fischer and Fischer 1993), personal knowledge and contacts, and Mary Lu Moore, historian with the Arizona Attorney General's Office. A list of contacts was compiled and letters describing the project were sent to each. A few individuals and organizations sent written responses to the initial mailing, but most were contacted by telephone after the initial mailing. During each contact and interview, individuals were questioned about their knowledge of the river as well as about who might be able to provide additional information on the history of each river. A list of interview topics and questions, a sample contact letter, and a synopsis of interview notes are attached as Appendix D.

In general, interviewees were characterized as falling into one of four groups: (1) professional land managers; (2) professional historians, archaeologists, and museum curators; (3) avocational historians; and (4) longtime residents along the rivers. One professional land manager, twelve professional historians, one avocational historian, and one long-term resident were interviewed about the Verde River. The professional land manager interviewed was Louis Hood, Tribal Planner with the Fort McDowell-Apache Indian Community. Professional historians interviewed included Julio Betancourt (United States Geological Survey), Don Bufkin (Arizona Historical Society), Jim Byrkit (Northern Arizona University), Suzanne Dewberry (National Archives Federal Records Center, Laguna Niguel, California), Thelma Holveck (Scottsdale Historical Society and Museum), Mary Lu Moore (Arizona State Attorney General's Office), Bob Munson (Fort Verde State Historical Park), Scott Soliday (Tempe Historical Museum), Michael Sullivan (Tonto National Forest), Betty Tome (Camp Verde Historical Society), Bob Trennert (Arizona State University), and Angie Vandereedt (National Archives of the Old Coast Guard). Joann Hanley (Scottsdale Historical Society and Museum) was the avocational historian interviewed. Pete Groseta (Cottonwood, Arizona, resident and irrigation ditch boss) was the long-term resident interviewed, but he might also be considered an avocational historian, since he has published at least one article (Groseta 1984). Earl Zarbin, a retired Phoenix newspaperman, has written extensively on water issues in Arizona and has compiled an index of articles on water in Arizona from Arizona newspapers published between 1859 and 1918 (Zarbin n.d.).

Individuals interviewed were divided as to whether the Verde River could have been boated at the time of statehood. A number of individuals (for example, Julio Betancourt, Don Bufkin, Suzanne Dewberry, Joann Hanley, Bob Trennert, and Angie Vandereedt) expressed a lack of knowledge about the subject of boating, though they were knowledgable about other aspects of the Verde River. Michael Sullivan, the archaeologist with the Heritage Program for the Tonto National

Forest, stated that the Forest has some old military records from the Verde River area, as well as the journal of Joseph Pratt Allyn, one of the first district judges, who traveled down the Verde River (on horseback).

Jim Byrkit and Bob Munson, who have written extensively on the history of the Verde River, both stated that the Verde River could not be considered navigable, but both gave examples of boating or transporting goods or products down the stream. Mr. Byrkit said that the Verde River could not be navigable and that he has not heard or does not know of the Verde River ever being navigated for commercial purposes. According to Byrkit, boating on the Verde River is recreational, or white water boating, and is normally possible only in February and March. Byrkit claims that during other months the Verde River cannot be run because it dries up or because it is dangerous, and that a lot of people have died in the Verde River because they enter the river during flooding. Speaking about the history of the Verde River, he said that when the Spaniards and first Anglos entered the area of the Verde River they encountered a swamp. Afterwards, with the introduction of cattle, the river environment changed, and it might have been navigable afterwards. Nowadays it may be navigable perhaps in a shallow-bottomed boat going downstream. Mr. Byrkit said that the river was used for floating logs to build a lodge in 1958. Bob Munson said that describing the Verde as a navigable river was like "trying to make a silk purse out of a sow's ear." Mr. Munson added that nobody used for the river for commercial purposes either prior to or following the territorial period. Mr. Munson thought that it was possible that mountain men may have used canoes but since most of them were illiterate, there are no written records of them having done so. During the 1880s, Fort Verde was issued a collapsible boat, because they needed a way to get messages and messengers across the river in times of high water. The boat was also used for fishing, and there is a photo of the boat at the Fort. Mr. Munson felt that it was unlikely that the Verde River was ever boated for commercial purposes.

Betty Tome (Camp Verde Historical Society) mentioned that at one point the soldiers at Fort Verde used a boat for fishing. Scott Soliday (Tempe Historical Museum) recalled seeing a reference to an article in the *Mesa Free Press* of 1890 or 1891 that describes how Mr. A. J. Chandler had logs or sawn timber from the dismantled Ft. McDowell floated down the Verde and Salt Rivers to use for constructing head gates for the Consolidated Canal. This article has not been located. Earl Zarbin sent two letters providing references to boating, ferries, and fish. These references pertained essentially to the Salt and Verde Rivers. In his letter of June 14, 1993, Mr. Zarbin cited two accounts of soldiers boating from Fort McDowell to Phoenix. The first article, in the *Arizona Gazette* (February 14, 1883), described the 18-hour trip of North Willcox and Dr. G.E. Andrews in a canvas skiff. The second article, in the *Phoenix Herald* (December 12, 1888), described how Major E.J. Spaulding, the commandant at Fort McDowell, and Captain Charles A.P. Hatfield were canoeing down from Fort McDowell, hunting along the way, and while lifting their canoe over the Mesa Dam, Major Spaulding's gun accidentally discharged, killing him.

Most of the accounts of boating on the Verde River mentioned by the interviewees are documented elsewhere in historical archives, newspapers, or publications (Chapter 3). For example, the photograph of the boat mentioned by Mr. Munson and Ms. Tome is published in Munson (1981:28-29).

Chapter 5

Geology and Geomorphology of the Verde River

Introduction

The Verde River is a perennial stream that heads in Chino Valley in north-central Arizona, flows generally southeast through the rugged terrain of central Arizona, and empties into the Salt River east of the Phoenix metropolitan area. This chapter presents the following information:

- An outline of the geologic and geomorphic framework of the Verde River
- A description of the physical character of the channel of the Verde River
- An evaluation of how channel morphology and position have changed in the past century
- A description of the procedures used to delineate the ordinary high water mark.

Physiography and Geologic Setting

The Verde River heads in and flows through the rugged Central Mountain Physiographic Province of central Arizona (Figure 5-1). The Central Mountain Province is a transitional physiographic region between the high elevation, relatively flat Colorado Plateau of northern Arizona and the lower elevation Basin and Range province of southern and western Arizona with its alternating basins and mountain ranges. The Central Mountain Province is characterized by the most rugged relief in Arizona; large, high mountain ranges and deeply dissected alluvial basins are common. The Verde River flows from northwest to southeast through the central mountain zone of Arizona. The uppermost portion of the Verde drainage basin is relatively undissected (Chino Valley). However, downstream from Chino Valley the Verde River is entrenched into a narrow deep canyon, and it remains entrenched well below the surrounding countryside all the way downstream to its confluence with the Salt River.

The entrenchment of the Verde River, and much of the rugged terrain along the river, reflect the dramatic downcutting of the Verde River that has occurred in the past few million years. The reasons for this downcutting are not certain. However, it is likely that the drainage in the central mountain region was generally closed during the late Miocene (5 to 10 million years ago), and has gradually become integrated as the modern regional drainage network developed in the past few million years. Broad regional uplift of the Central Mountain area may also have driven downcutting by the major rivers that flow through it, including the Verde, Salt, Agua Fria, Hassayampa, and Gila Rivers (Pewe, 1978; Menges, 1983; Menges and Pearthree, 1989; Huckleberry, 1993).

The Verde River developed its modern form around 2 to 2.5 million years ago. Prior to that time, sediment was accumulating in playas or shallow lakes in Verde Valley (Bressler and Butler, 1978; Nations et al, 1981). During the time of accumulation of the Verde Formation in Verde Valley, approximately 8 to 2 million years, drainage at the southern end of the

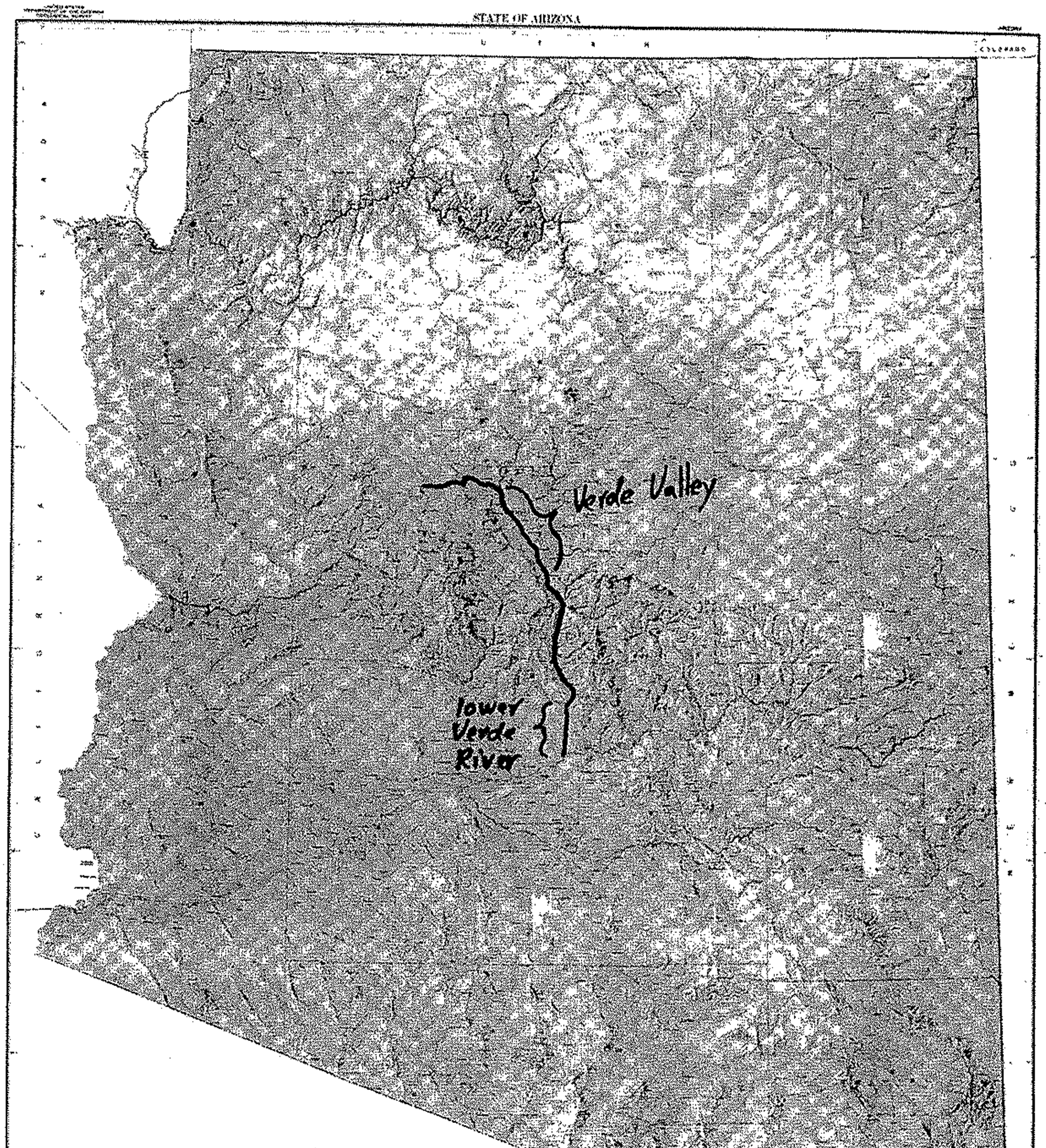

Figure 5-1. The physiographic setting of the Verde River. The Verde River, shown by a bold line in this figure, heads in and flows through the rugged mountain region of central Arizona. The Verde River is deeply entrenched into the landscape, and the channel and floodplain of the river are limited in extent and confined by canyon walls along much of its course. The two reaches where valley is relatively wide are the Verde Valley and the lower Verde River below Bartlett Dam.

Verde Valley was dammed or at least prevented from downcutting by a combination of volcanic activity and faulting. Dramatic downcutting of the river began in Verde Valley about 2.5 million years ago, when the natural dam was breached, and has continued to the present time. The form of the Verde River upstream and downstream from Verde Valley during the past 10 million years is less clear. Upstream of Verde Valley, a closed depositional basin existed in the Perkinsville area in the late Miocene to Pliocene (about 10 to 2 million years ago; McKee and Anderson, 1971). Sometime during the late Pliocene to early Pleistocene, drainage in the Perkinsville area was captured and integrated with Verde Valley. Downstream of Verde Valley, the Verde River probably began to carve a deep valley into the landscape in the late Miocene and Pliocene, prior to integration of the Verde Valley drainage.

Long-term downcutting has continued all along the river through the Quaternary Period (the past 2 million years), leaving behind terrace deposits that record former positions of the bed of the Verde River (Figure 5-2; Pope and Pewe, 1973; Pope, 1974; Pewe, 1978; Pearthree, 1993; House and Pearthree, 1993). Most of these terrace deposits are thin veneers deposited on erosion surfaces carved on top of the various rock types found along the river. Verde River terraces may represent periods when the river temporarily ceased downcutting and eroded laterally and broadened its floodplain. In some cases, these terrace deposits may represent periods of aggradation and filling of the entrenched river valley (House and Pearthree, 1993). Holocene (less than 10,000 years old) terrace and channel deposits along the Verde River are quite thin, and underlying rock units are exposed at many localities in the bed of the river, implying that the long-term trend of stream downcutting has continued to the present.

Long-term downcutting and the relative erodibility of pre-Quaternary bedrock and basin-fill units effectively controls the extent and character of Quaternary alluvial deposits and the floodplain along the Verde River. The geology of the central mountain area is transitional between the relatively simple and homogeneous geology of the Colorado Plateau and the very complex, heterogenous geology of the Basin and Range. Because the geology of the central mountain area is complex and variable, the Verde River flows through a number of different types of rock units with varying susceptibility to erosion. In areas where the Verde River flows through resistant bedrock, the river valley is steep and narrow, and alluvial deposits and the floodplain are limited in extent (Figure 5-2b). This situation typifies nearly all of the Verde River between Paulden and the northern Verde Valley, and most of the river between southern Verde Valley and Bartlett Dam. There is very little potential for significant changes in channel position or character in these reaches. Where lithologies are less resistant to erosion, such as most of the Verde Valley and downstream from Bartlett Dam, the river valley is broad, the floodplain is relatively wide, and the potential for significant changes in channel position is greater (Figure 5-2a).

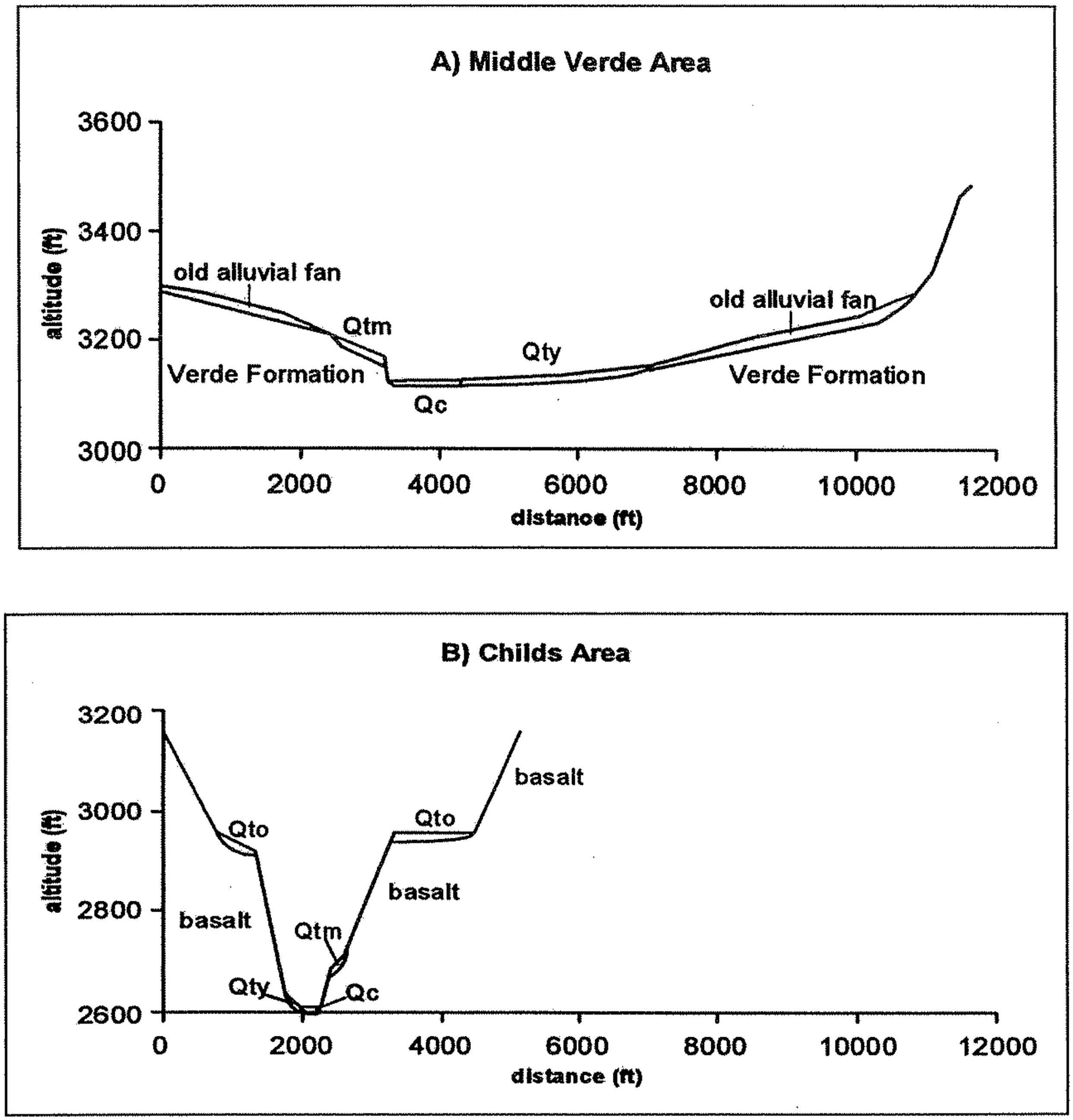

Figure 5-2. Topographic cross-sections of the Verde River valley illustrating differences in the topographic confinement of the river. The Verde River has been confined to areas shown by Qc (active channels) and Qty (young terraces) during the past few thousand years. Older river terraces dating to the middle (Qtm) and early (Qto) Pleistocene record former positions of the valley floor left behind as the river continued to downcut. The potential for changes in channel position is much greater in reaches where the floodplain is broad, such as in the Middle Verde area. The position of the channel cannot change substantially and the entire valley bottom may be inundated during large floods in reaches where the river is topographically confined, such as the Childs area.

Geomorphology of Verde River Channels

Even though the Verde River is entrenched in a deep valley and young alluvial deposits are thin along all of its course, the streambed and many of the banks of the river are formed in very young, unconsolidated alluvium. Everywhere along the river, a low-flow channel exists that conveys perennial base-flow discharges. Low-flow channels typically are a few feet deep or less and 50 to 200 ft wide, although the width and depth of these channels is quite variable. The bed forms of the low-flow channels are characterized by a repeating sequences of pools (deeper water areas) and riffles or rapids (shallow water areas typically dominated by cobbles and small boulders). Alternating pool-and-riffle sequences are characteristic of streams that carry coarse bedload sediment.

Low-flow channels of the Verde River are invariably located within a much larger channel that is shaped by annual and large floods. These flood channels are typically on the order of 1,000 ft wide, and are as wide as 4,000 ft along the lower Verde River. Deposits associated with the flood channels typically are coarse gravel bars and finer sandy areas. Flood channels are evident because of freshly deposited sediment and the lack of abundant large vegetation; in many reaches, the margins of flood channels correspond with prominent banks. Young river terraces commonly exist along the margins of and slightly higher than flood channels. These terraces typically are heavily vegetated unless they have been altered by human activity. Many of these young terraces are part of the floodplain, as they are inundated during the largest floods. Flooding on terraces is relatively shallow; the impact on the terrace vegetation typically is not great.

The young alluvium that forms the channel bed and low banks of the Verde River is generally composed of coarse gravelly deposits and much finer sandy overbank or slackwater deposits. This young sediment is not very cohesive and is susceptible to scour and bank erosion during large flow events. Older river deposits typically are coarse, with underlying rock units indurated to a greater or lesser degree. These older river deposit units are much more resistant to lateral bank erosion than young stream deposits. Thus, the potential for changes in channel morphology and shifts in channel position during large floods is greatest in areas where young terraces are extensive. However, terraces with dense vegetation are more stable which makes the river less subject to changes.

The extent of young deposits of the Verde River (channel deposits and low terraces) defines the extent of the geologic floodplain. As used in this chapter, the geologic floodplain is the area along the river that has been subject to erosion and deposition by the Verde River in the past few thousand years. Changes in channel position that have occurred during the past few thousand years have occurred within the limits of the geologic floodplain. The geologic floodplain is bounded by older geologic units such as bedrock, basin-fill sediments, older deposits of the Verde River, or alluvial fan or terrace deposits of tributary streams. Typically, the margins of the geologic floodplain are associated with significant topographic relief that provides a significant constraint on lateral migration of stream channels.

Data Used to Reconstruct Channel Form and Position

Two sources of data were utilized in an effort to evaluate the nature of any possible changes in character or position of the channels of the Verde River. Historical aerial photographs dating from the 1980, 1972, and 1953 or 1954 were obtained for virtually all of the Verde River; aerial photographs dating to the 1946 or 1950 were available for most of Verde Valley. Data and notes from land surveys conducted in the late 1800's and early 1900's provide some information about channel form and position at times much closer to statehood. The utility of cadastral survey data varies from survey to survey, depending on the objective of the survey and the care taken to record observations of the river channel.

Historical aerial photographs were used to evaluate potential changes in channel form and position during the past four decades. The extent of channels was defined from aerial photographs using two main criteria: (1) prominent, recognizable channel banks; and (2) the absence of abundant vegetation, indicating that the area had fairly recently been swept by significant flow. In ideal situations, these two criteria correspond. In general, however, the latter criterion was used more than the former because of the lack of definitive channel banks in some areas. In other reaches, heavily vegetated areas were included within the channel because multiple small channels flow through them. The channels defined using historical aerial photographs correspond to the flood channels discussed earlier, and may in places exceed the "ordinary highwater mark".

Historical surveys of township section boundaries provide abundant information regarding low-flow channels of the Verde River in Verde Valley, but provide limited information regarding the nature and positions of flood channels. Surveyors in the 1870's typically noted the width and sometimes the depth and general character of channels containing water as they crossed them (Foster, 1873, 1877). They did not provide sufficiently detailed description of the areas adjacent to the low-flow channels to permit evaluation of the character and extent of flood channels. However, a resurvey conducted in the Camp Verde area in 1892 following the large flood of 1891 (Drummond, 1892) documented the existence of a flood channel that is comparable to the modern flood channel. Most of the lower Verde River was surveyed in 1911 (Farmer, 1911), near the time of statehood. The channel of the Verde River that was documented in this survey was the flood channel, since it had similar dimensions as flood channels seen on aerial photographs.

Historical Changes in Channel Form and Position

Aerial photographs from the 1950's and 1980's along the Verde River from Perkinsville to the confluence with the Salt River reveal no dramatic shifts in flood-channel position, nor changes in general flood-channel form during this period. Positions of flood channels at various time in the photographic record were plotted at 1:24,000-scale in the Verde Valley and along the lower Verde River downstream from Bartlett Dam in order to investigate in

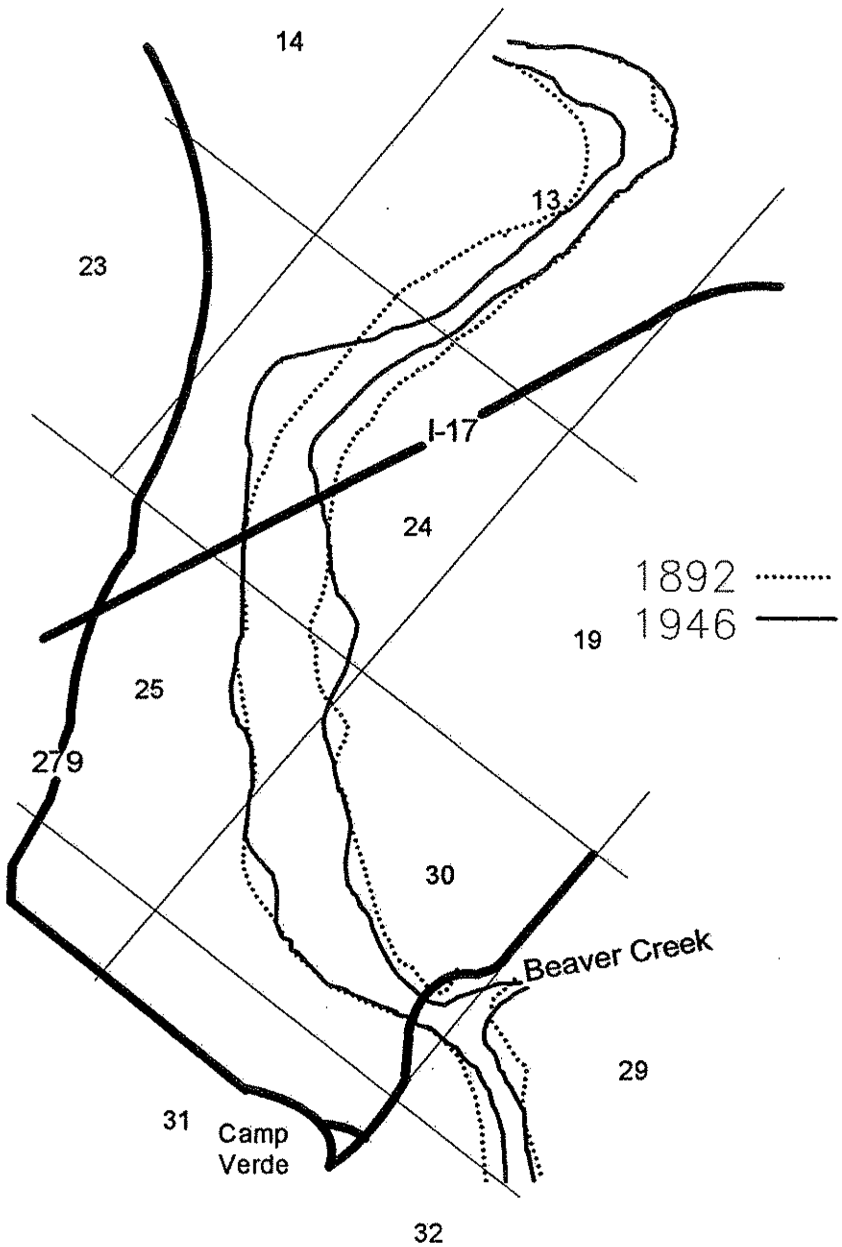

Figure 5-3a. Changes in the position and width of the flood channel of the Verde River in the Camp Verde area between 1892 and 1946. Channel positions in 1892 were surveyed by Drummond (BLM archives). Channel positions in 1946 were interpreted from aerial photographs.

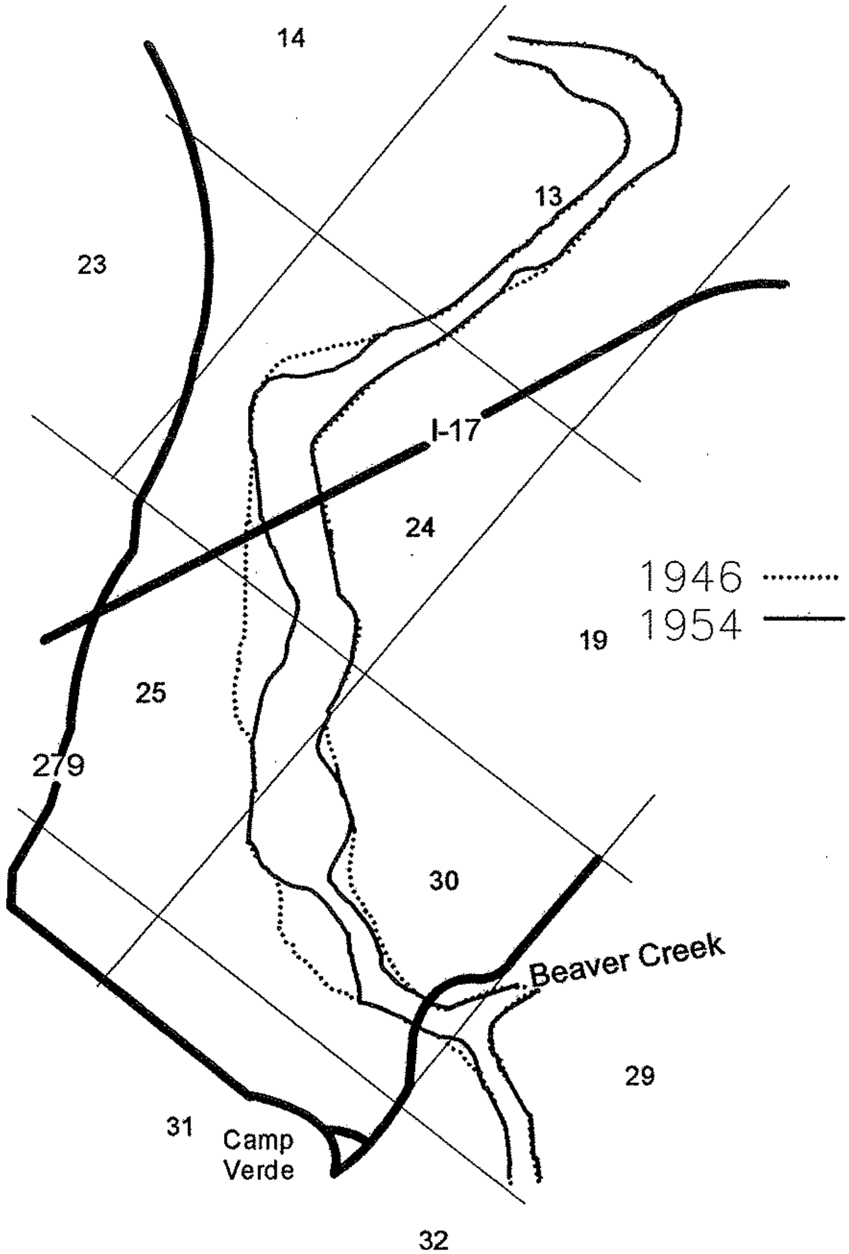

Figure 5-3b. Changes in the position and width of the flood channel of the Verde River in the Camp Verde area between 1946 and 1954. Channel positions were interpreted from aerial photographs.

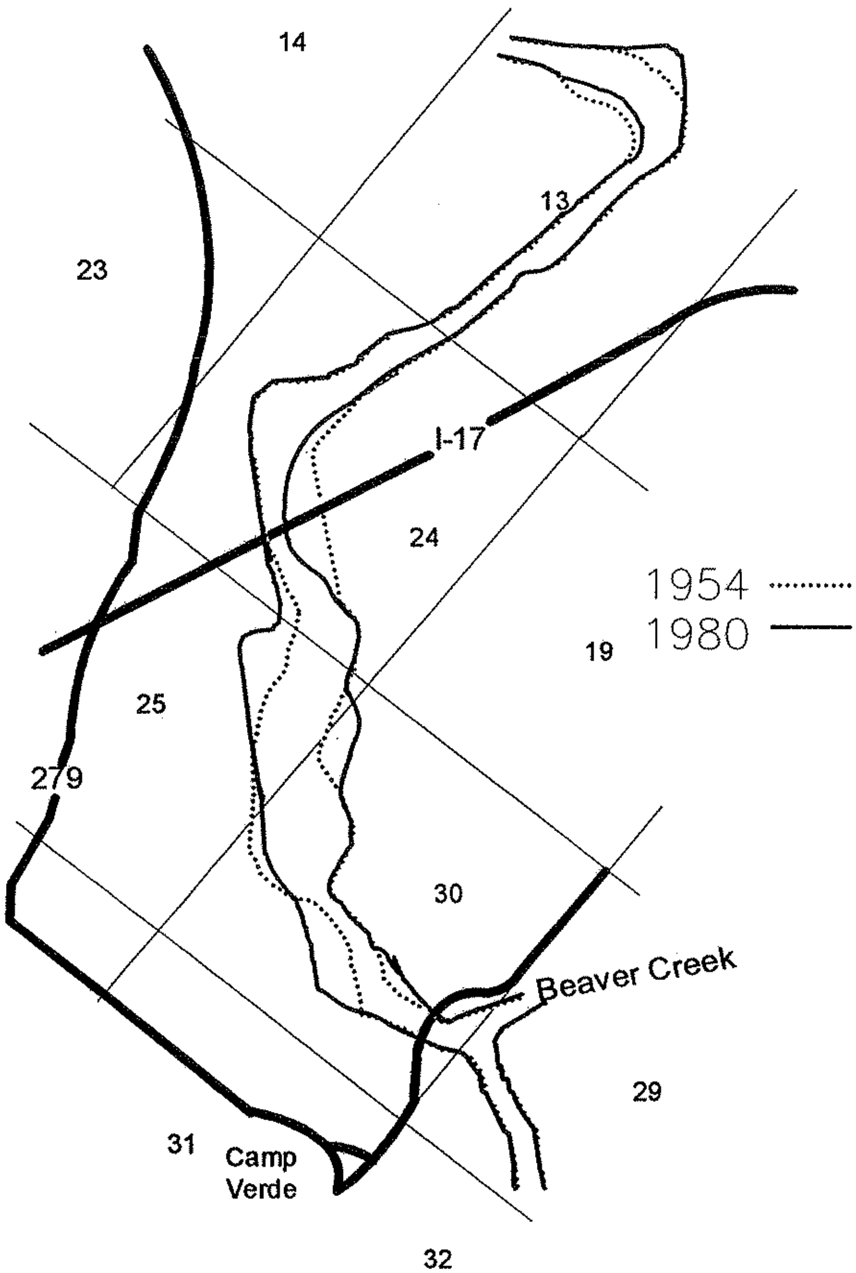

Figure 5-3c. Changes in the position and width of the flood channel of the Verde River in the Camp Verde area between 1954 and 1980. Channel positions were interpreted from aerial photographs.

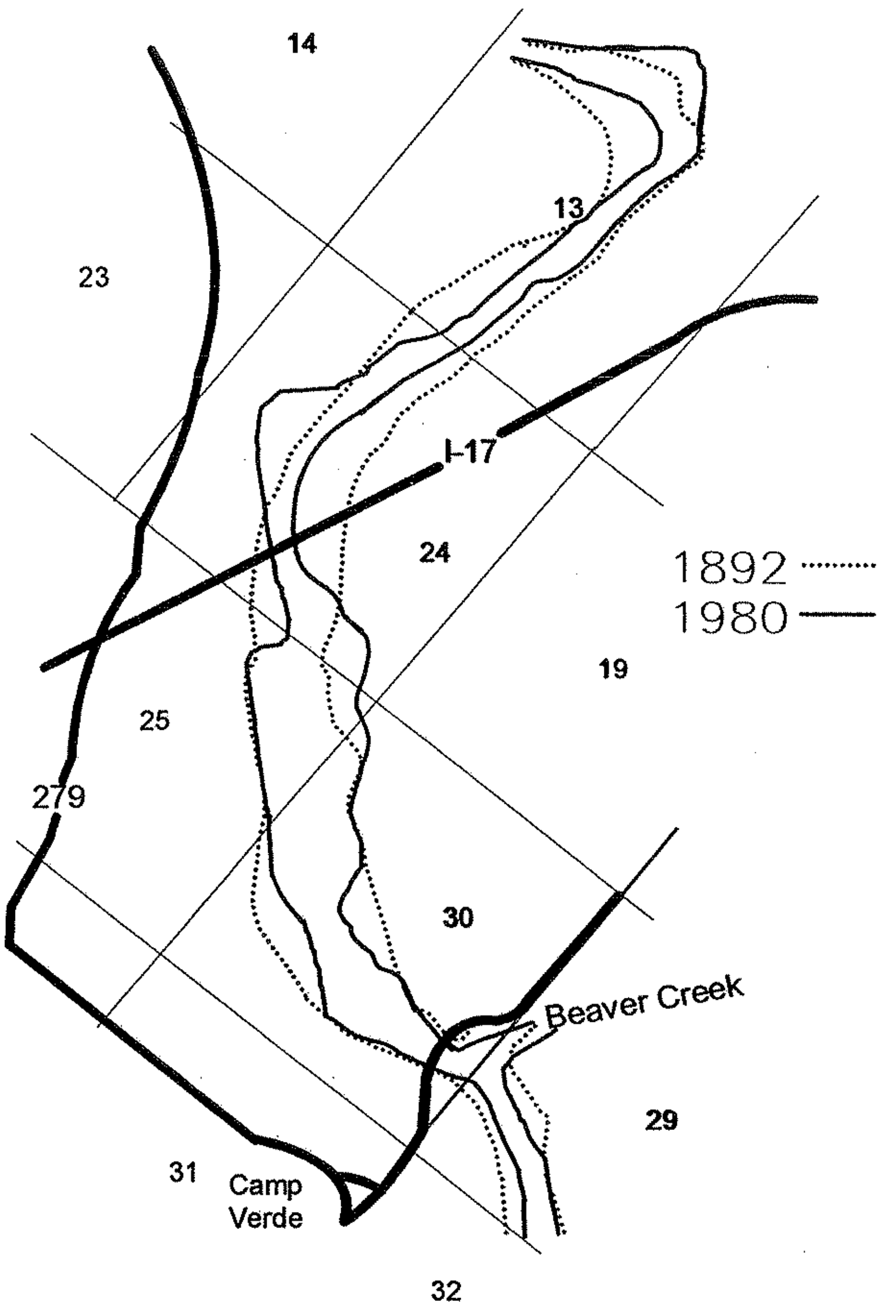

Figure 5-3d. Net changes in the position and width of the flood channel of the Verde River in the Camp Verde area between 1892 and 1980.

more detail whether lateral bank erosion and shifts in channel position had occurred (Figures 7 and 8). In the Camp Verde area and along much of the lower Verde River, positions of flood channels in the late 1800's and early 1900's were documented using GLO land survey data. This section discusses the evolution flood channels in Verde Valley and along the lower

Verde River, and considers the character of low-flow channels through time.

Flood Channels. The character of flood channels of the Verde River has changed little during the period of photographic record (since about 1950), but locally there have been substantial changes in channel width during this time mainly due to bank erosion during floods. In the Verde Valley, the general tendency was for channels to become narrower between 1950 and 1972 (Plate 1; Figure 5-3; Tables 5 and 6), a period of minimal flood activity. During this interval there was a fairly large flood on the Verde River in 1952, but none thereafter (Figure 5-4). Between 1972 and 1980, channels widened considerably in many places (typically outsides of meander bends); in a few places, however, channels were narrower in 1980 than they were in 1972. Channel widening most likely occurred during the large floods on the Verde River in 1978 (2 floods) and 1980.

There was a slight tendency for net channel widening between 1950 and 1980. Flood channel width increased at eight section-line crossings, with a maximum widening of 320 feet (Table 5-1). Channel width decreased at four section-line crossings during this same interval, with a maximum narrowing of 540 ft. The most extreme increases and decreases in flood channel width in Verde Valley between 1954 and 1980 were 720 ft. and 430 ft., respectively (Table 5-2). Along much of the Verde River in Verde Valley, however, there was little or no change in channel width between 1950 and 1980 (Plate 1). More than 50 percent of the section-line crossings (16) exhibited no net change in channel width during this period.

The history of the flood channel of the Verde River is more complete in the Camp Verde area because of the land survey conducted there 1892 (Drummond, 1892). In addition, aerial photographs from 1946, 1954, 1972, and 1980 cover this area. The flood of 1891 was the largest during the historical period, and probably was one of the largest floods on the Verde River during the past 1,000 years (O'Connor et al., 1986). The flood channel that existed immediately after the flood had dimensions similar to the modern channel. The 1891 flood may have caused a considerable amount of change in flood-channel position and morphology. The survey of 1892 specifically recorded the new positions of "meanders" of the Verde River in the Camp Verde area, and several hundred acres of "fine bottomland" were washed away in the flood and replaced by channel gravel (Drummond, 1892).

The position of the flood channel changed somewhat between 1892 and 1946, but there were no dramatic shifts in channel position. The channel widened in some places and narrowed in others, but on balance it did not change very much (Table 5; Figure 5-3a). There were several large floods during the period between 1892 and 1946 (Figure 5-4), and they evidently maintained or renewed the flood channel of the Verde River. The width of the channel generally decreased between 1946 and 1954; some of the decreases in channel width were fairly dramatic (Figure 5-3b). There was a fairly large flood recorded downstream on the Verde River in 1952, but it evidently did not dramatically impact the flood channels in the Camp Verde area. Human encroachment on the flood channel may have caused much of the channel narrowing. By 1980, the flood channel was generally wider than in 1954 (Figure 5-3c).

Table 5-1
Changes in Widths of Flood Channels of the Verde River Since 1892 in Verde Valley

LOCATION		CHANNEL WIDTH (ft)				NET CHANGE (ft)			
Township	Section Line	1892	1946, 1950	1954	1980	1892 to 1950	1950 to 1954	1954 to 1980	Total Change
T13NR5E	6/7	1040	1040	800	1040	0	-240	240	0
	5/6	1520	n.d.	960	960		-560*	-560	
T14NR5E	32/5	1280	n.d.	720	720		-560*	0	-560
	29/32	1200	720	720	880	-480	0	160	-320
	30/29	720	400	320	320	-320	-80	0	-400
T14NR4E	25/30	2240	1920	1600	2240	-320	-320	640	0
	24/25	1440	2160	1200	1520	720	-960	320	80
	13/24	1280	480	480	480	-800	0	0	-800
	14/13	240	240	240	240	0	0	0	0
	11/14	n.d.	640	480	640		-160	160	0
	2/11		640	640	800		0	160	160
	3/2		640	640	640		0	0	0
	4/3		1280	1280	1280		0	0	0
T15NR4E	33/4		1040	960	960		-80	0	-80
	29/28/32/33		640	640	640		0	0	0
	20/21/29/28		0	720	720			0	0
	19./20		480	480	800		0	320	320
	18/19		320	320	320		0	0	0
	7/18		560	560	560		0	0	0
T15NR3E	12/7		880	880	1040		0	160	160
	1/12		240	240	240		0	0	0
	2/1		640	640	640		0	0	0
T16NR3E	35/2		400	240	400		-160	160	0
	26/35		720	640	800		-80	160	80
	27/26		560	400	400		-160	0	-160
	28/27		1200	1200	1200		0	0	0
	27/28		400	400	400		0	0	0
	22/27		320	320	480		0	160	160
	21/22		240	240	320		0	80	80
	20/21		240	240	240		0	0	0
	17/20		480	480	480		0	0	0

Channel widths were measured along section lines, and generally are not perpendicular to the trend of the river and are greater than true channel widths. Channel widths were surveyed by Drummond in 1892 (BLM archives), shortly after the large flood of 1891. Subsequent channel widths were interpreted from historical aerial photographs.

Table 5-2
Extreme Changes in Flood Channel Width on the Verde River

LOCATION	CHANNEL WIDTH (ft)				CHANGE IN WIDTH (ft)			
Verde Valley	**1892**	**1954**	**1972**	**1980**	**1892 to 1954**	**1954 to 1972**	**1972 to 1980**	**Net Change**
T13NR5E								
Sec 26	n.d.	240	240	800	n.d.	0	560	560
Sec. 22	n.d.	360	360	800	n.d.	0	440	440
Sec. 6	1360	640	640	1040	-720	0	400	-320
T14NR5E								
Sec. 30	1680	320	1200	880	-1360	880	-320	-800
T14NR4E								
Sec. 25	1680	1040	1760	1760	-640	720	0	80
Sec. 24	1040	1280	960	1120	240	-320	160	80
Sec. 2	n.d.	880	320	880	n.d.	-560	560	0
T15NR4E								
Sec. 19	n.d.	320	320	800	n.d.	0	480	480
T16NR3E								
Sec. 35	n.d.	480	680	960	n.d.	200	280	480
Sec. 28	n.d.	640	800	960	n.d.	160	160	320
Sec. 21	n.d.	640	420	480	n.d.	-220	60	-160
Sec. 8	n.d.	1200	320	800	n.d.	-880	480	-400
Sec. 8/7	n.d.	880	240	450	n.d.	-640	210	-430
Lower Verde River	**1911**	**1953**	**1972**	**1980**	**1911 to 1953**	**1953 to 1972**	**1972 to 1980**	**Net Change**
T3NR7E								
Sec. 19	1840	1200	1200	1840	-640	0	640	0
Sec. 18	2640	2400	1040	2400	-240	-1360	1360	-240
Sec. 5/6	1600	1280	400	1280	-320	-880	880	-320
T4NR7E								
Sec. 31	2640	2240	1040	1600	-400	-1200	560	-1040
Sec. 18/17	2560	2400	900	2400	-160	-1500	1500	-160
Sec. 5		1000	400	1000		-600	600	0
T5NR7E								
Sec. 30/29		3200	560	3200		-2640	2640	0
~Sec. 8		320	400	640		80	240	320

"Net change" refers to the difference in channel width between the earliest record and 1980 for any particular site. Channels were generally widest around 1900 (shortly after the large flood of 1891), and narrowed through 1972 at most localities. Channel widths increased again during the floods of 1978 and/or 1980.

It is likely that the Verde River effectively reclaimed much of its flood channel during the floods of 1978 and 1980. The Verde River generally followed the same course in 1980 as it had in 1892, although the position of the flood channel changed somewhat during this interval (Figure 5-3d). The width of the flood channel in 1980 generally was somewhat narrower than in 1892 (Table 5-1; Table 5-2).

Changes in channel width during this century were more dramatic along the lower Verde River. The land survey of 1911 (Farmer, 1911) shows a wide flood channel (Figure 5-5; Table 5-3). The flood channel narrowed somewhat between 1911 and 1953 and locations of channel margins shifted in a few localities (Figure 5-5a). By 1972, however, after an interval of 20 years without large floods, the flood channel was 1000 ft or more narrower at a number of localities (Figure 5-5b). The floods of 1978 and 1980 generally reoccupied the same flood channels that existed in 1953, so the net changes in channel widths between 1953 and 1980 were not great (Table 5-3). The net changes in channel width between 1911 and 1980 generally were modest, although the 1911 channel was somewhat wider on balance. At several localities, such as at the confluence with Sycamore Creek and in Section 31, T4N, R7E, fairly significant changes in channel position have occurred since the time of statehood.

Low-Flow Channels. Cadastral surveys from the 1870's record evidence of a continuous low-flow channel throughout Verde Valley that was very similar to the modern low-flow channel of the Verde River. Surveys conducted by Foster in 1873 and 1877 documented a through-going stream about two feet deep and 50 to 100 feet wide with a sandy bottom. It is not clear from the survey notes whether this low-flow channel was within a well-defined flood channel. The Verde River of the 1870's was described as "a beautiful stream of clear, pure water with an average width of 100 links (66 ft) and an average depth of 3 feet" (Foster, 1877; see Table 5-4). The banks of the low-flow channel were estimated to be 3 ft (consistent with the depth estimate). Cottonwoods, willows, and mesquite lined much of the river bank. The low-flow channel clearly existed within a much broader geologic floodplain, described in the survey as bottomland with large amounts of fine farming and grazing land (Foster, 1873). A significant amount of irrigated farming was underway in the bottomlands by 1873-77. The land surveys of the 1870's did not describe marshy land adjacent to the Verde River mentioned in some historical accounts, nor did they document any areas where the low-flow channel was ill-defined. A resurvey conducted in 1916 in the Camp Verde area records wetted channels about 200 to 400 ft wide, and in a number of places the surveying team could not directly survey across the river because it was too swift and deep (Richards, 1916). It may be that 1916 was an unusually wet winter, resulting in increased flow in the Verde River relative to 1873 and 1877.

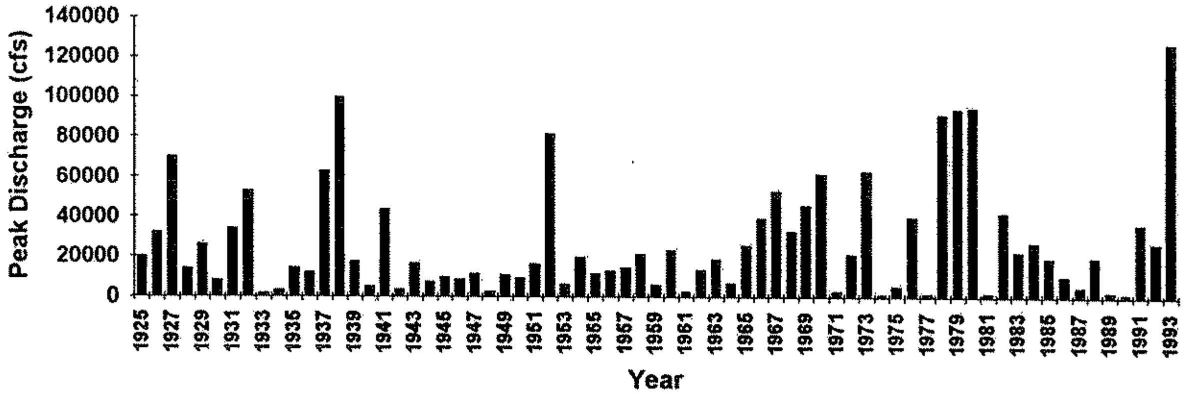

Figure 5-4a. Annual maximum flood series on the Verde River below Tangle Creek (above Horseshoe Reservoir). Data are from Garrett and Gellenbeck (1991), Chris Smith (USGS Tucson), and Charlie Ester (SRP Phoenix).

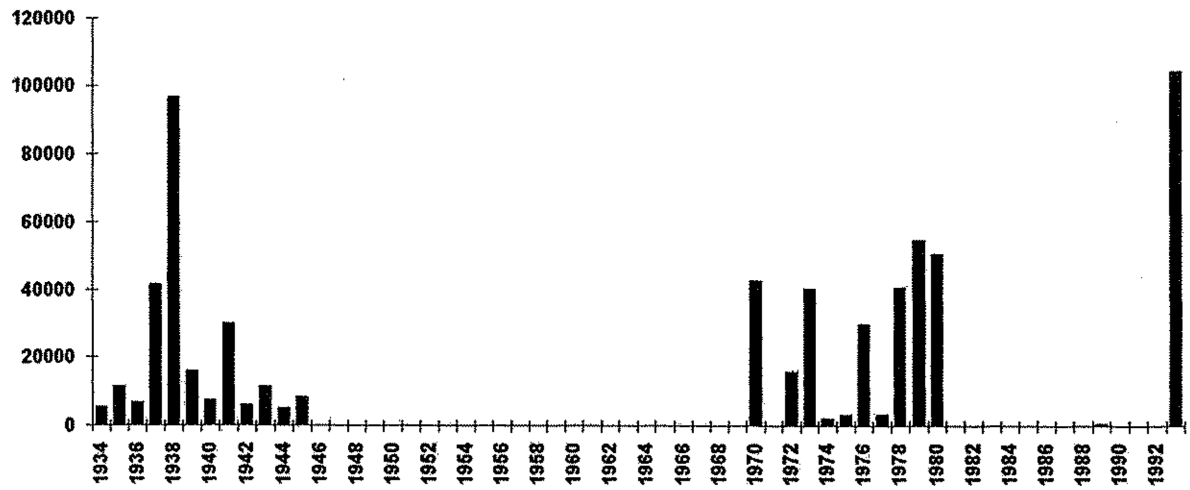

Figure 5-4b. Annual Maximum flood series on the Verde River near (1934-1945, 1989-1993) and below (1970-1980 Camp Verde.

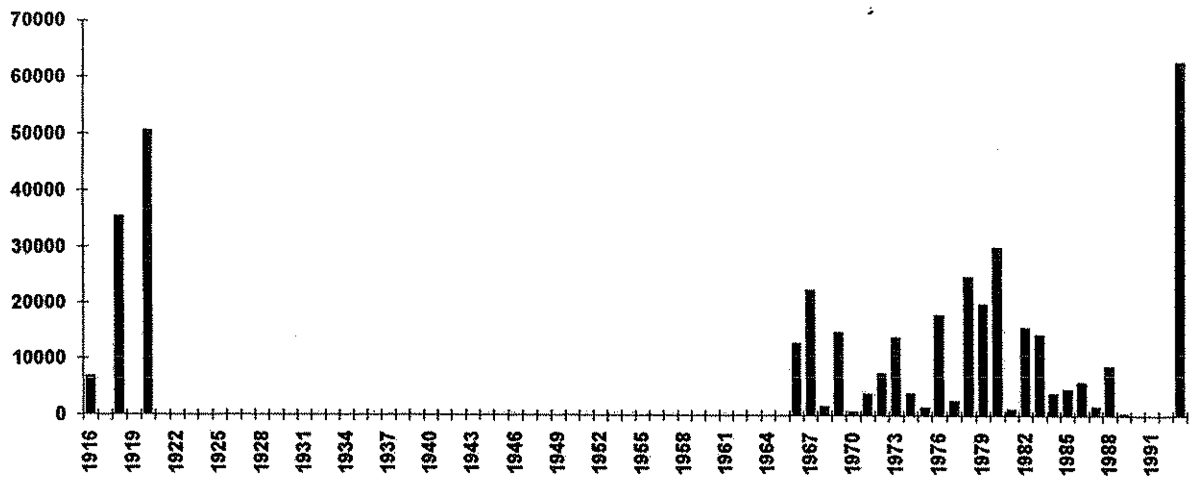

Figure 5-4c. Annual maximum flood series on the Verde River at Clarkdale.

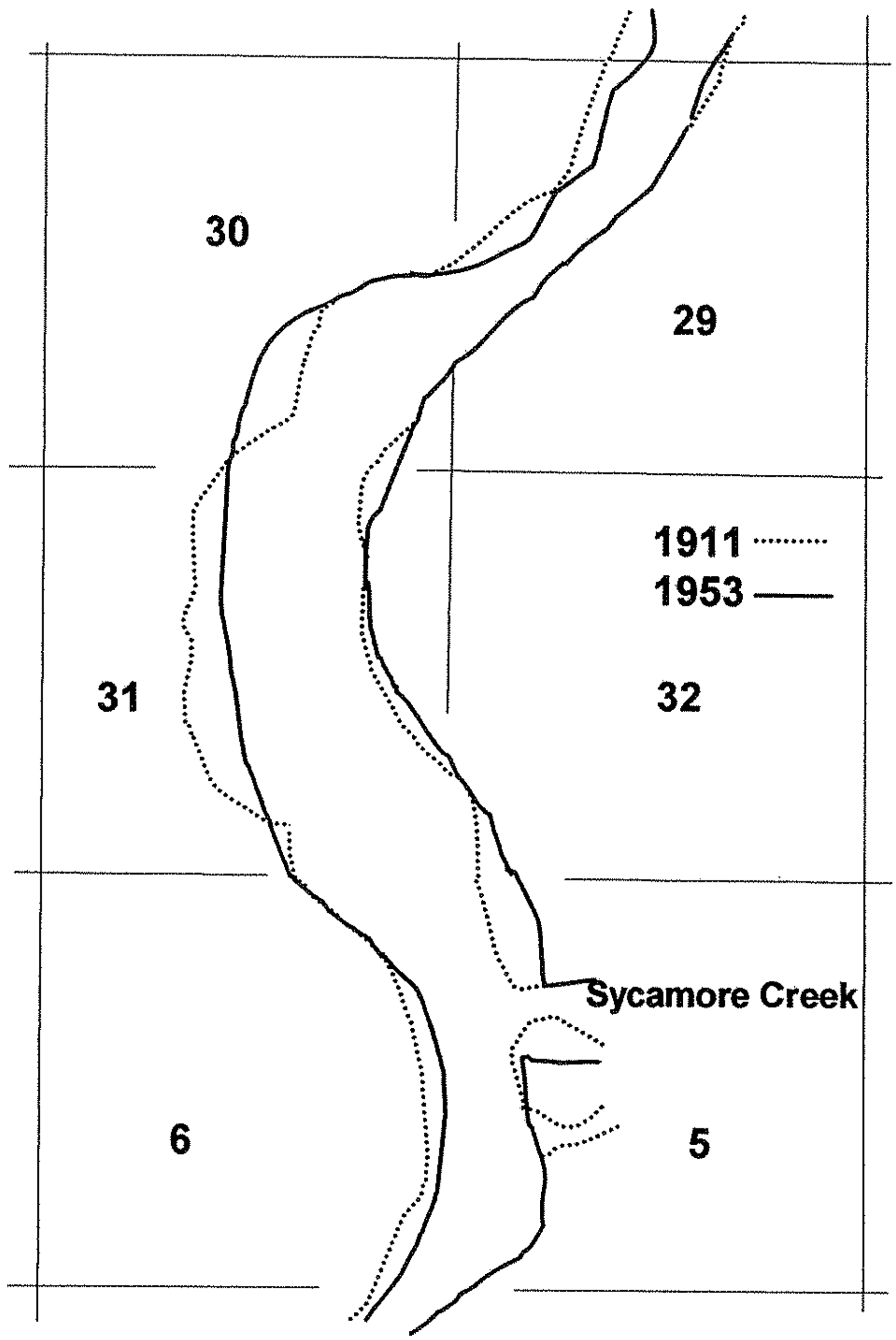

Figure 5-5a. Changes in the position and width of the flood channel of the lower Verde River between 1911 and 1953. This reach, located near Ft. McDowell and the confluence with Sycamore Creek, is about 10 miles upstream from the Salt River.

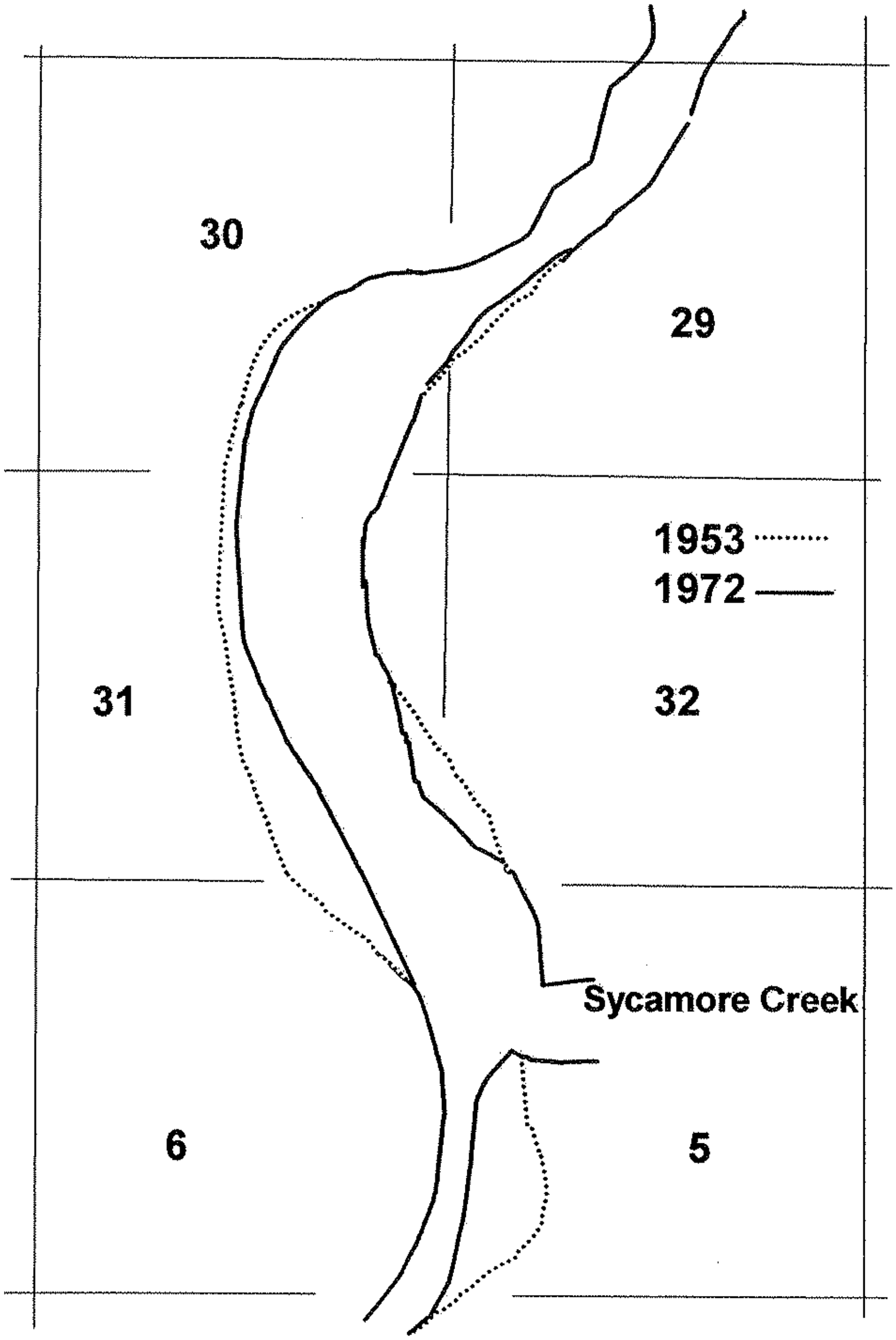

Figure 5-5b. Changes in the position and width of the flood channel of the lower Verde River near Sycamore Creek between 1953 and 1972.

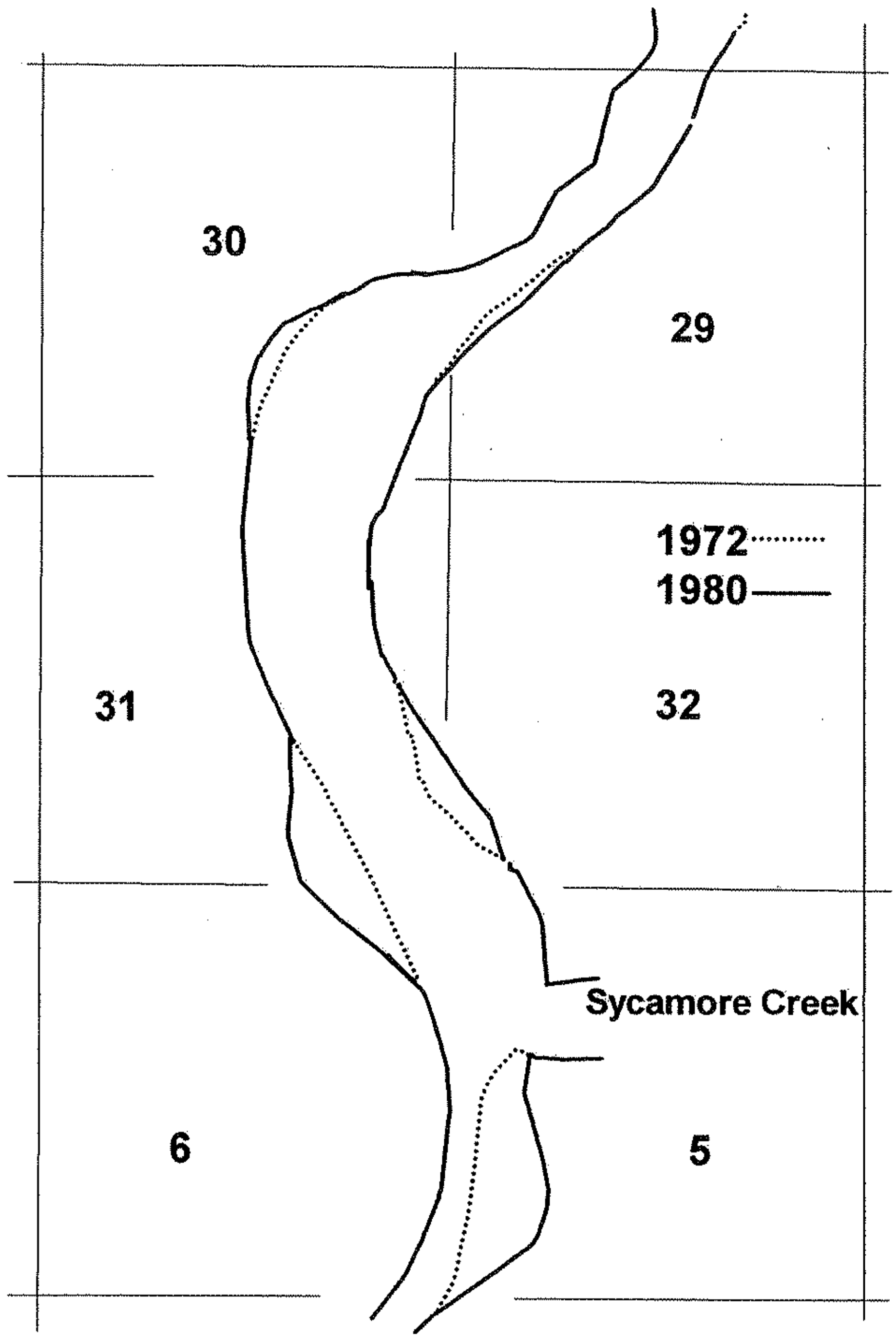

Figure 5-5c. Changes in the position and width of the flood channel of the lower Verde River near Sycamore Creek between 1972 and 1980.

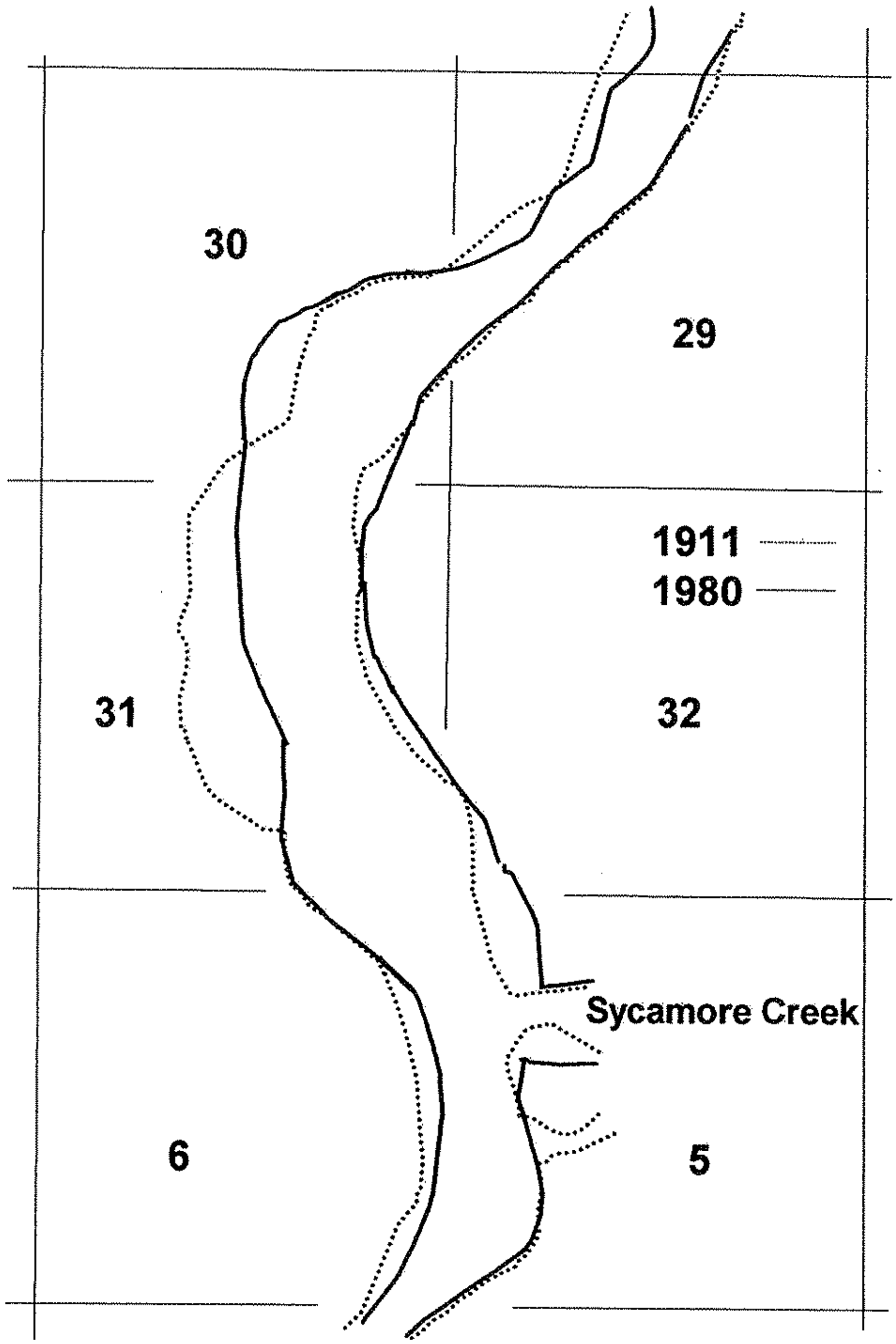

Figure 5-5d. Net changes in the position and width of the flood channel of the lower Verde River near Sycamore Creek between 1911 and 1980.

Table 5-3
Changes in Widths of Flood Channels of the Lower Verde River Below Bartlett Dam

LOCATION		CHANNEL WIDTH (ft)				NET CHANGE (ft)			
Township	**Section Line**	**1911**	**1953**	**1972**	**1980**	**1911 to 1953**	**1953 to 1972**	**1972 to 1980**	**Net Change**
T3NR7E	32/5	n.d.	800	800	1040			240	240
	31/32	n.d.	1200	1200	1680			480	480
	30/29/31/32	1280	1840	1840	1840	560	0	0	560
	20/19/30/29	1680	1520	1520	1520	-160	0	0	-160
	18/19	1920	1920	1920	2160	0	0	240	240
	7 to 18	2400	2400	960	2400	0	-1440	1440	0
	6/5/7/8	1280	1040	720	1120	-240	-320	400	-160
T4NR7E	31/32/6/5	2320	2880	2000	2880	560	-880	880	560
	30/31	1920	1920	1920	1920	0	0	0	0
	29/30	1360	1120	1120	1120	-240	0	0	-240
	20/29	1520	960	960	960	-560	0	0	-560
	17/20	1920	2160	1520	2160	240	-640	640	240
	7/8/18/17	2480	2480	1200	2480	0	-1280	1280	0
	5 to 8	1040	1040	880	1040	0	-160	160	0
T5NR7E	32/5	n.d.	800	800	800		0	0	0
	29/32	n.d.	1280	1280	1280		0	0	0
	19/20/30/29	n.d.	4800	1760	4800		-3040	3040	0

Channel widths were measured along section lines, and generally are perpendicular to the trend of the river and are not true channel widths. Channel widths were surveyed by Farmer in 1911 (BLM archives). Subsequent channel widths were interpreted from historical aerial photographs.

Table 5-4
Low-Flow Channel Widths of the Verde River in the 1870s and 1972

Quadrangle	Township	Section Line	Channel Width 1873-76 Chains	(ft)	Modern (ft)
Cornville (1968)	T14NR4E	2/11	0.90	59	120
		3/2	0.90	59	80
		4/3	1.20	79	80
	T15NR4E	33/4	1.00	66	80
		21/28	1.00	66	80
		20/21	1.25	83	120
		19/20	0.70	46	80
		18/19	0.70	46	80
		17/18	0.80	53	80
		18/17	0.65	43	80
		7/18	0.75	50	60
	T15NR3E	1/12	0.90	59	20
		2/1	1.00	66	80
	T16NR3E	35/2	1.00	66	80
		26/35	1.10	73	60
Clarkdale (1973)		28/27	0.65	43	100
		22/27	1.10	73	80
		21/22	2.00	132	80
		20/21	1.10	73	240
		17/20	1.00	66	80
		17/7	1.10	73	120
		7/8	0.90	59	60
		8/9	1.00	66	80
		8N	0.80	53	80

1870s channel widths from cadastral surveys. Surveys noted channel conveying water at the time of the survey, equivalent to the modern low-flow or channels. Channel widths from 1972 from 1:24,000-scale orthophotoquads.

The low-flow channel along the lower Verde River documented in 1911 was shallow and somewhat wider than the low-flow channel in Verde Valley. The land survey of 1911 recorded a wetted channel ranging from about 180 to 360 ft. wide and 1 to 4 ft. deep (Farmer, 1911). This low-flow channel was within a much larger flood channel. The flood channel evidently was obvious, as it was the primary channel noted in the survey data and notes, and was fringed with cottonwoods and mesquite.

Positions of low-flow channels clearly have changed substantially through the past century. Substantial changes in the positions of the banks of flood channels have dictated changes in the areas within which the low-flow channels can flow. In addition, the positions of low-flow channels have changed after floods in reaches where the flood channel has remained fairly stable. An example of the extent of change in low-flow channel positions in Verde Valley is shown in Figure 5-6. In this area, many substantial changes in channel position occurred between the original survey in 1877 and 1950. Several large floods occurred during this period, as was noted above, and changes in flood-channel positions probably occurred as well. In the Clarkdale area, human activity likely significantly altered the position of the low-flow channel as well. Changes in position of low-flow channels between 1950 and 1970 were very limited, but the floods of 1978 and 1980 probably caused some changes in channel position.

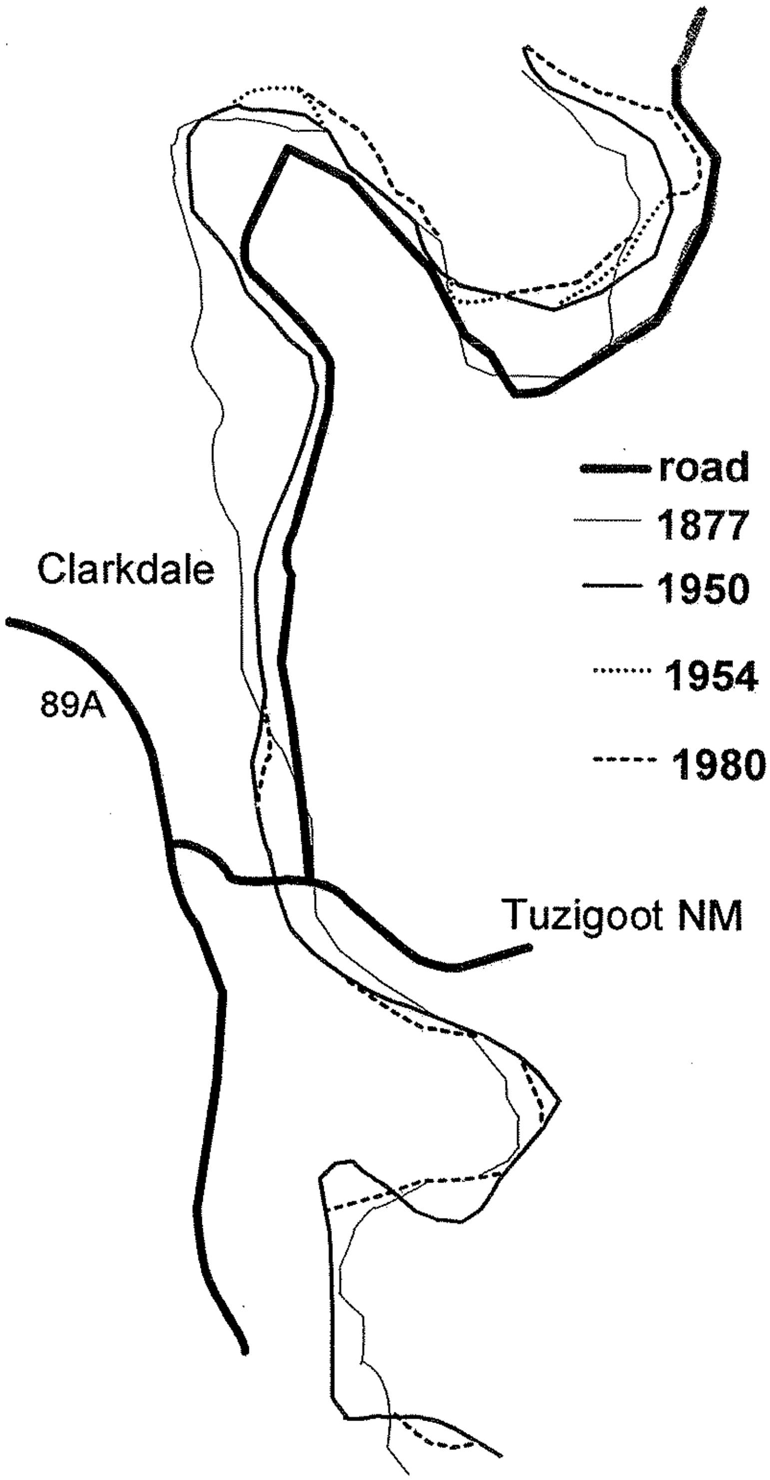

Figure 5-6. Historical changes in low-flow channel positions in the Clarkdale-Tuzigoot area.

Ordinary Highwater Mark

Where channel conditions have not significantly changed since statehood, the limits of the ordinary highwater mark can be mapped using the current USGS topographic maps for the river. Where changes have occurred, and are not due to avulsions or are not man-made, ordinary highwater limits follow the existing channel geometry. The ordinary highwater mark was identified by topographic characteristics, slope changes at the channel margin, and vegetation changes visible on aerial photographs. In canyon reaches the lateral extent of the ordinary highwater mark is very similar to the lateral extent of the floodplain due to confinement by the terraces.

Conclusions

Regional physiography and geology of the Verde River exert a strong influence on the extent and character of its floodplain. The Verde River flows through some of the most rugged country in Arizona. During the past several million years, the Verde River has downcut hundreds of feet, occasionally leaving terrace deposits behind as a record of former valley floors. Because of this long-term downcutting, the Verde River is confined within a steep, narrow valley along much of its length. In these confined reaches, the floodplain is limited in extent, and the potential for changes in channel positions is also limited. The potential for changes in channel form and position is greater in Verde Valley and along the lower Verde River, where the floodplain is relatively broad.

The general form of low-flow channels of the Verde River is quite similar along its length. Low-flow channels typically are 50 to 200 ft wide, and they wind through a much larger flood channel. The flood channel has well-defined banks in some places, but has no obvious banks in other areas. The width of flood channels varies substantially, from about 200 ft to 3200 ft wide. The width of the flood channel depends in large part on the character and width of the geologic floodplain, which is controlled by the erodibility of underlying rock units.

The character and position of Verde River channels during the historical period was investigated in Verde Valley and along the lower Verde River. Several generations of historical aerial photographs indicate that low-flow channels have shifted positions in many reaches, but the larger-scale features of the flood channel are fairly consistent. Modest changes in positions of flood-channel banks and total widths have occurred in many places, but other reaches exhibit little or no change during the past few decades. In most areas, the large floods of 1978 or 1980 occupied the same flood channels that were evident in 1953-54. Historical land surveys in the Camp Verde area and along the lower Verde River reveal that the general form of the flood channels of the Verde River have not changed substantially since statehood. Low-flow channels have shifted position to a greater degree than the larger flood channels. The size and general form of low-flow channels in Verde Valley, however, was about the same in the 1870's as it is today.

Chapter 6
Verde River Land Use

Introduction

This chapter summarizes land uses along the Verde River study reach between the Gila River Confluence and the headwaters, as they relate to the ASLD Stream Navigability Study. Specific data collected for this study included:

- Land Ownership
- Land Leases
- Existing Uses
- Wildlife and Recreation Classifications

Data Sources

The Verde River Valley includes public and private land in Maricopa and Yavapai Counties. Data describing for Verde River land ownership and land use information for the Maricopa County portion of the river was obtained from the Flood Control District of Maricopa County (FCDMC). Information for the Yavapai County portion of the river was obtained from the Yavapai County Assessor's Office. Land ownership/management and riparian data were obtained from Arizona Game and Fish ALRIS GIS database. In addition, leasing data was collected from ASLD (mining and other uses), BLM (agriculture and mining), and the U.S. Forest Service (grazing). Wildlife, riparian, and recreational classifications were obtained from Arizona State Parks and the U.S. Fish and Wildlife Service. Data were not updated after the original CH2M HILL study in 1993.

Methodology

The primary work product for the land use assessment is a GIS for the Verde River study reach. Geographical Information Systems combine the spatial characteristics of digital mapping with the resource information library capabilities of a database. Through a GIS, information such as land ownership (title), biological and hydrologic characteristics, land use, or other descriptive information can be tied to specific parcels or river reaches. Arizona State Agencies are currently in the process of preparing a GIS for the entire state. The state's GIS is called ALRIS. Technical details regarding creation of the Verde River GIS are summarized in Appendix I.

The land ownership GIS for the Verde River was digitized from assessor maps using ALRIS LAND tiles as base maps. Some gaps in the land ownership data base for the Verde River remain, for several reasons. First, there were areas of conflict regarding river alignment, and in areas where "meander land" was delineated in assessor maps that were used as the guide for digitizing parcels. Second, there were certain areas, notably subdivisions, where assessors' maps lacked reference points, making digitizing impossible. These discrepancies can be resolved in the future, when Yavapai County's parcel GIS is completed and made available.

The land ownership GIS also contains land use data for private parcels along the river. Entered values, based on State of Arizona property use codes, have been converted to the standard table of values which has been adopted for this project (Appendix I). Ownership and use data for the Maricopa County portions of the Verde River were obtained from the FCDMC.

Draft and final riparian GIS data for the Verde River were received from AZGF. Data corresponding to 13 USGS quadangles are in draft form, and five quadrangles are in final form. All data were converted to ALRIS-compatible coordinates and compiled into "Draft" vs. "Final" GIS layers suitable for plotting.

Ordinary highwater marks for the Verde River were digitized from lines drafted onto USGS 7.5-minute quandrangle maps. Gaging stations were also digitized where encountered on the base maps. Since the ordinary highwater mark maps were not available until after the completion of the land ownership/use GIS, they were not used as a guide in digitizing parcels.

Plots of GIS land use, ownership, and ordinary highwater mark information for the Verde River are included in Appendix I. The Verde River GIS plots included in Appendix I include:

- Land Ownership
- Ordinary Highwater Mark
- Land Use

Land Use and Ownership

Land ownership, or current title, information was obtained from assessors' records as described above. A summary of Verde River land ownership and use information based on these data are shown in Tables 6-1 and 6-2. The majority of land along the Verde River is publicly held, although private land makes up the bulk of the property in the Verde Valley area between Camp Verde and Clarkdale. Land uses include grazing, residential, agricultural, and unclassified land. Portions of the Verde River have been designated as Wild and Scenic, or as boatable stream by various public agencies. Three Indian communities also claim portions of the reach. Riparian data are summarized in Table 6-3.

Table 6-1 Verde River Land Ownership.	
Owner	**Acres**
Tonto National Forest[1]	12,038
Private	3,166
Prescott National Forest	3,266
Ft. McDowell Indian Community	2,525
Coconino National Forest	1,060
State	365
Salt River Pima Maricopa Indian Community	135
Yavapai Apache Indian Community	81

Table 6-2 Verde River Land Use.	
Land Use	**Acres**
Grazing	918
Residential	897
Misc. Developed	341
Unknown/Unclassified	323
Misc. Undeveloped	211
Crops/Orchards	165
Misc. Agricultural	123
Retail/Wholesale/Warehouse	8
Municipal/County	1
Misc. Commercial	1
Mineral/Mining	< 1

[1] NOTE: Acreage in the Tonto National Forest includes all land area under Bartlett and Horseshoe Reservoirs.

Table 6-3 Verde River Riparian Data		
Description	**Acres**	
	Draft	**Final**
Forested: Riparian or Palustrine	897	1,002
Scrub Shrub: Riparian or Palustrine	550	1,603
Emergent: Palustrine	29	11
Unconsolidated Bottom or Shore	2,364	3,197
Aquatic or Stream Bed	68	107

Chapter 7
Hydrology of the Verde River

Introduction

The hydrology of the Verde River has not changed significantly since 1912. Gage records indicate that stream conditions and average flow rates have not markedly changed over the past 80 years. This chapter presents hydrologic information for the Verde River intended to supplement and support historical accounts of river conditions and river uses at the time of statehood. Three types of information are presented:

- Historical Flow Records (Pre-Statehood).
- Modern Flow Records (Post-Statehood).
- Hydraulic Rating Curves.

Supplemental information on flood frequency, irrigation, and boating are also presented.

Stream Reaches

The Verde River can broken into three reaches based on environmental, archeological, and geomorphic characteristics. These reaches are: the upper, middle and lower Verde (Figure 7-1). The upper Verde River encompasses the area from its headwaters in Chino Valley to Sycamore Canyon southeast of Perkinsville. The upper Verde River is characterized by steep, narrow, bedrock canyons, a narrow riparian corridor, and springs which provide perennial baseflow. The middle Verde River extends from Sycamore Canyon through Cottonwood, Clarkdale, and Camp Verde to the confluence with Fossil Creek. The middle Verde River includes the most densely urbanized portion of the river, the richest historical record, the broadest floodplain area, and a history of irrigation diversions for agriculture. The lower Verde River extends from Fossil Creek to the Salt River confluence. The lower Verde River is characterized by a cobble- and gravel-bedded channel formed over shallow or exposed bedrock, Sonoran desert vegetation, and flow alteration by construction of Horseshoe and Bartlett Dams.

Data Sources

Hydrologic data were derived primarily from published stream gage records of the U.S. Geological Survey (cf. USGS, 1954), historical accounts of the Verde River (cf. Clarke, 1954), and other reports on the hydrology of the Verde River (cf. Sullivan and Richardson, 1993).

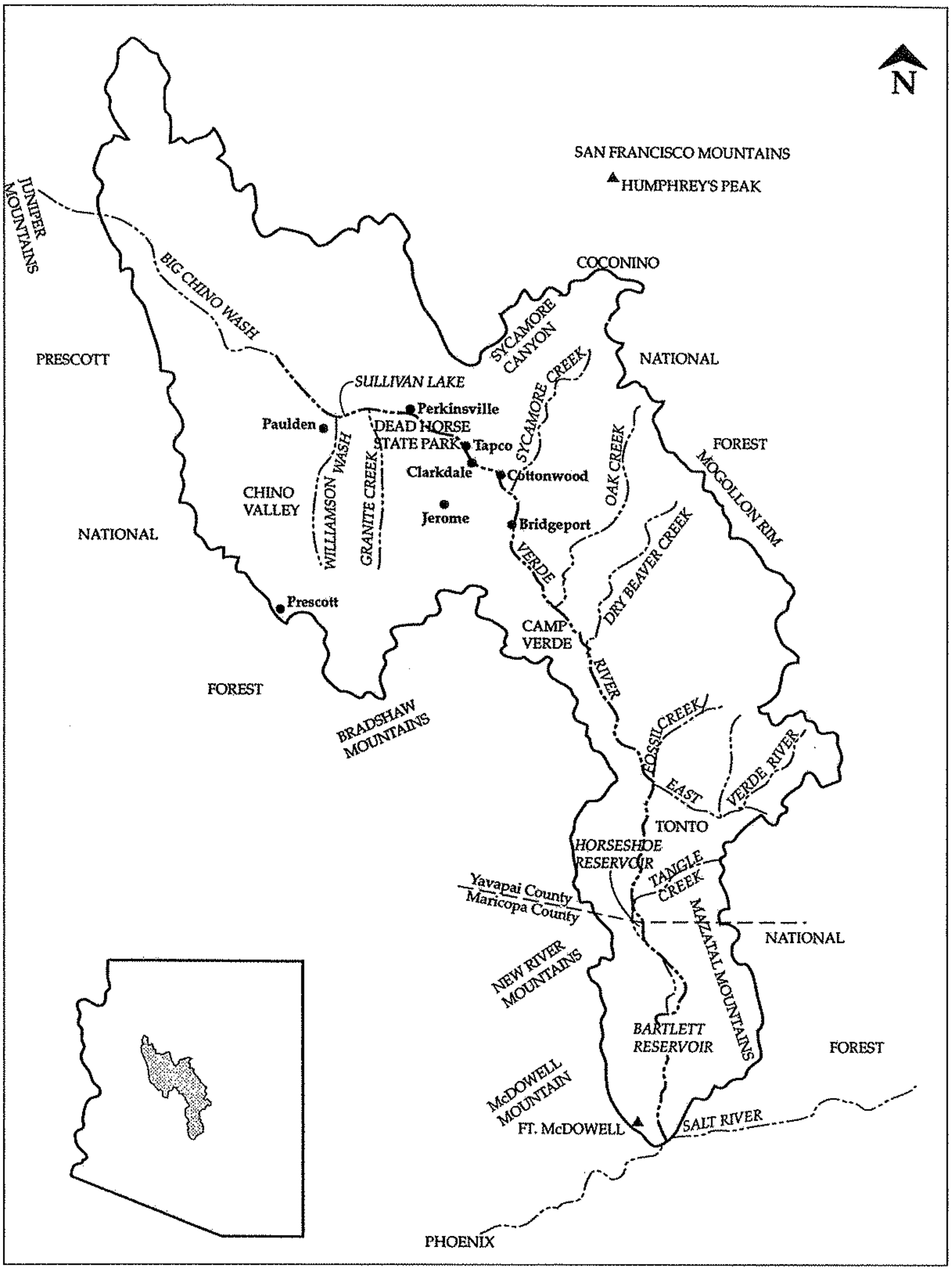

Figure 7-1. Verde River Watershed Map

Hydrologic Setting

The Verde River flows generally east and south through Yavapai and Maricopa Counties in north-central Arizona, before joining the Salt River several miles upstream of Granite Reef Dam east of Phoenix (Figure 7-1). The river, which drains a total of 6,188 mi^2 at the Salt River confluence, heads at the confluence of Williamson Wash and Big Chino Wash at Sullivan Lake near the community of Paulden in northern Yavapai County. The watershed ranges in elevation from about 12,633 feet at Humphrey's Peak to about 1,335 feet at the mouth of the river. The maximum elevation of the river itself is 4,366 at the Sullivan Lake outlet. The Verde River watershed is bounded by the Mogollon Rim and San Francisco Peaks to the north, the Juniper, Bradshaw, and New River Mountains to the west, and the Mazatzal Mountains to the east.

The primary source area for runoff in the Verde River is the Mogollon Rim where precipitation infiltrates permeable bedrock units and becomes ground water. These bedrock units have been eroded and exposed by the Verde River and its tributaries, resulting in ground water discharge from springs into the river (Sullivan and Richardson, 1993). Perennial flow in the Verde River begins at the confluence with Granite Creek, and is sustained by springs and perennial tributaries. Major perennial tributaries include Granite Creek, Sycamore Creek, Oak Creek, Beaver Creek, West Clear Creek, Fossil Creek, and the East Verde River. These tributaries generally drain the area north and east of the Verde River away from the Mogollon Rim. Other major tributaries include intermittent or ephemeral streams with large drainage areas such as Williamson Wash, Big Chino Wash and Partridge Creek.

While discharge from springs provides a reliable base flow in the river, Verde River runoff has a bimodal frequency distribution which reflects seasonal precipitation rates in Arizona (Table 12). The highest average monthly runoff occurs between January and April, in response to snowmelt. Snowmelt runoff may be supplemented (or caused) by rain from cyclonic storms originating over the Pacific Ocean. These winter storms are generally more regional in extent, have relatively long duration, and can generate significant flow volumes. A second period of increased runoff occurs in August and September during summer "monsoon" rainfall. Monsoon storms are caused by tropical moisture entering Arizona from the southeast. These storms produce more localized, intense rains which produce flash floods with high peak flow rates on tributaries to the Verde River. Summer monsoons generally do not produce large peak flows on the main stem of the Verde River, but do increase average late summer monthly flow rates from early summer rates.

The climate the Verde River Basin is also influenced by topographic affects from the Mogollon Rim and the Black Hills. Orographic precipitation occurs as moisture-laden air masses rise and cool while passing the ranges. Average precipitation depths shown in Tables 12 and 13 illustrate these affects. Along the Mogollon Rim, annual precipitation varies from 18 to 26 inches, with 40 to 85 inches occurring as snowfall. The Black Hills near Jerome receive upwards of 18 inches of precipitation with an average of 25 inches of snowfall (Owen-Joyce and Bell, 1983). Precipitation rates do not impact the low flow discharges of the Verde River as much as for other Arizona Rivers (Smith and Stockton, 1981) because of steady outflow from springs. Precipitation does strongly influence average and high flow discharge rates in the Verde River.

Table 7-1
Climatic Data for Verde River Watershed

Average Annual Statistic	Granite Reef 1938-1967 elev.=1,325 ft.	Cottonwood 1949-1977 elev.=3,314 ft.	Prescott 1936-1965 elev.=5,410 ft.
Precipitation (in)	8.9	11.8	18.2
Max. Temperature	86	78	70
Min. Temperature	54	45	37

Vegetation in the Verde River watershed ranges from pine-oak woodlands on the Mogollon Rim and upper elevation areas, to Sonoran Desert Scrub along the lower Verde River. Significant portions of the watershed upstream of Sullivan Lake are grassland transitioning to chaparral and juniper-pinyon woodland at higher elevations. Along the river itself, deciduous riparian woodland and emergent marshland communities are found (Sullivan and Richardson, 1993). The extent of marshland in the central Verde River was drastically reduced during the period preceding and surrounding statehood.

The hydrology of the Verde River is also impacted by irrigation diversions and return flow, ground water pumping, evapotranspiration, ground water-surface water interactions (Owens-Joyce and Bell, 1983), reservoir impoundments, and watershed impacts including grazing, timber, and fire.

Table 7-2 Monthly Climatic Variation in the Verde River Watershed. Precipitation (Inches) and Temperature (°F)			
Month	**Granite Reef 1938-1967 elev.=1,325 ft.**	**Cottonwood 1949-1977 elev.=3,314 ft**	**Prescott 1936-1965 elev.=5,410 ft.**
January	1.0	0.8	1.7
February	0.8	0.8	1.7
March	0.9	0.9	1.5
April	0.4	0.5	0.9
May	0.1	0.4	0.4
June	0.1	0.5	0.5
July	0.8	1.9	2.7
August	1.5	2.2	3.4
September	0.8	1.1	1.6
October	0.5	1.0	1.1
November	.7	0.7	1.0
December	1.3	1.0	1.9
Annual	8.9	11.8	18.2
* indicates precipitation may occur as snow			
Aver. Max & Min Temperature	86 54	78 45	70 37

Statehood/Pre-Statehood Hydrology

The earliest historical and archeological records of the Verde River indicate the presence of reliable, perennial flow in all three reaches of the river. Limited systematic data from the period around statehood also support the hypothesis of perennial flow in the river.

Streamflow measurements. The USGS has operated at least six stream gages on the Verde River during various periods over the past 100 years. The Verde River near McDowell and Verde River near Camp Verde (aka "at Childs, near Camp Verde) gages are the only stations operated prior to statehood.

The McDowell gage[1] was established in August 1888, and was operated or maintained by the USGS, BUREC, Arizona Canal Company, Hudson Reservoir Company, and Salt River Valley Water Users' Association at various periods between 1888 and 1950. After closure of Bartlett Dam in February 1939, flow in the river was partially controlled by operation of the upstream reservoirs. Gage data from the year of statehood is summarized in Table 7-3 below. No discharge calculations are reported for individual days in February 1912 including February 14th, although an isolated discharge calculation of 269 cfs (stage = 8.02 ft.) is reported for February 16, 1912 (USGS, 1914). Average monthly streamflow records for this and other gages indicate that February 1912 experience discharge rates well below the long-term average rates. By comparison, the average discharge for March 1912 was 1,466 cfs; for April 1912 the rate was 2,037 cfs.

Table 7-3
Verde River Streamflow Measurements, 1912 (cfs)

Time Period	McDowell		Near Camp Verde	
	Flow on Given Date	Long-term Average Flow	Flow on Given Date	Long-term Average Flow
1912	621	781	n.a.	470
February 1912	300	2,121	200[b]	1,100
February 14, 1912	269[a]	n.a.	200[b]	n.a.

[a] Measurement for 2/16/12
[b] Estimate from stage measurement, not reported by USGS
NOTE: Near Camp Verde Station also published as at Childs near Camp Verde Station.

The USGS gage station near Camp Verde was established February 1911 and was operated until December 1912. The station was later operated from 1934 to 1945. Discharges were not computed from most stage readings taken in 1912. However, a gage height of 5.2 ft listed for October 12, 1912 is reported as corresponding to discharge of 200 cfs. The gage height measured on February 14, 1912 was also 5.2 feet. Long-term average discharge rates shown in Table 7-3 were computed from the 1934 to 1945 period of record.

Other stream gages established near the time of statehood include a station near Clarkdale, first operated in June 1915, and a station at (not near) Camp Verde initiated in January December, 1912. The near Clarkdale gage, located four miles downstream of Sycamore Canyon, February flows from 1916 to 1921 averaged 700 cfs, and annual flows averaged 270 cfs. Streamflows measured did not include irrigation diversions for about 3,800 acres irrigated above the gage (by 1947). The Verde River at Camp Verde gage averaged 1,109 cfs in the month of February during between 1913 and 1920; annual flows averaged 435 cfs.

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[1] The Verde River(VR) - McDowell gage also known as: (1) VR below Bartlett Dam; (2) VR 1 mile above Salt River; (3) VR at mouth; (4) VR above Salt River; (5) VR at McDowell; (6) VR at McDowell near Lehi; (7) VR near McDowell; (8) VR above Camp Creek, near McDowell; in various USGS and USRS reports and documents.

None of the four USGS stations cited reported any periods of zero flow during the period around statehood.

Other streamflow measurements in the Verde River were made to establish water rights. For example, Hancock reports (1914) that the first permanent water (about 2 cfs) in Verde River occurs at mouth of Granite Creek, and that one mile downstream springs bring total to 22 cfs. Hancock reports that 5,058 acres were irrigated from 25 canals in 1914 between Granite Creek and the Salt River, and that 602,565 miners inches (~15,000 cfs)[2] of Verde River flow were appropriated in Yavapai County. Irrigation diversions in 1914 averaged a total of about 120 cfs diverted from the river upstream of Fossil Creek.

Average discharge rates from streamflow stations operated around the time of statehood compare well to long-term average flow rates based on the entire (modern) period of record, except at the Clarkdale station. For the near Clarkdale station, flow rates from 1915 to 1921 are well above the average rates estimated by including the period from 1966 to 1989 (See Table 7-9). Therefore, while the month of February 1912 experience flows well below the long-term average flow rates, gage records for the extended period around statehood are representative of mean flow conditions at statehood.

Historical Descriptions of River Flow. Historical descriptions of flow in the Verde River date back to the early Spanish explorers in the late 1500's. They described the river as "large and copious" (Bartlett, 1942), a "large river, carrying a great volume of water" (Hammond and Ray, 1966), and "a river much larger [than Beaver Creek and Oak Creek]" (Bartlett, 1942). The first American explorers trapped beaver on the Verde (cf Byrkit, 1978). Early Anglo residents along the Verde River lived near Fort McDowell or in the Verde Valley. In the Verde Valley the river was described a "marshy...having a rich alluvial bottom...". Elsewhere, the Verde River was described as "extremely narrow, ... a canon with rugged...hills on either side" (cf. Surgeon General, 1870; Fish, 1974). Near Fort McDowell, the river was "well confined, with bottom lands free from marshes" (Surgeon General, 1870). Marshy conditions in the Verde Valley were apparently destroyed around 1890 for as yet unknown reasons (See section on Verde River Geology).

Alternatively, some early residents of the Verde Valley claim that the Verde River was "dry enough to step across...[and that they] could drive across Verde River in flood...there were no bridges... no need for them" (cf. Young, 1987; Jordan, 1987). These and other historical accounts of the river are described in more detailed elsewhere for this study.

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[2] Includes irrigation return flows to river and uses that return flow to river (e.g. mills).

Summary. Stream gage records from the period around statehood confirm historical accounts of perennial flow in the Verde River, and allow quantification of historical accounts of streamflow conditions. Gage records indicate that downstream of Granite Creek the Verde River has no months of zero flow. Gage data also indicate that periods of peak runoff occur during winter and spring snowmelt. Irrigation records show that significant diversions of streamflow for agriculture, particularly in the Verde Valley.

Post-Statehood Hydrology

Better documentation of streamflow and channel conditions is available for the period after Arizona statehood. Streamflow records are available from USGS gaging stations and from other hydrologic analyses of the Verde River. The upper and middle Verde River reaches remain free flowing streams with essentially the same hydrologic conditions as were present at statehood. Reservoir impoundments at Horseshoe and Bartlett Dams have altered the natural flow regime on the lower Verde from conditions at statehood.

Gage Records. USGS stream gage records are available for nine stations on the Verde River, not including tributaries (Table 7-4). Sufficient data to develop statistical streamflow summaries are available for five of these stations (Tables 16 and 17). Streamflow statistics were not available for the Verde River McDowell station, although Atshul (1987) reports an "expected daily flow" of 968 cfs for that station.

Table 7-4
Verde River USGS Streamflow Gaging Stations

Station Name	Period of Record	Location
Near Paulden	10/1963 - 9/1991	10 mi. d/s Sullivan Lake
Near Clarkdale	6/1915 - 6/1921; 12/1965 - 9/1991	4 mi. N Clarkdale
At Camp Verde	1/1913 - 3/1920	1 mi. N Camp Verde
Near Camp Verde	10/1934 - 9/1945; 10/1988 - 9/1991	9 mi. SE Camp Verde
Near Camp Verde, at Childs	2/1911 - 12/1912; 10/1914 - 9/1917	18 mi. SE Camp Verde
Below East Verde River	7/1934 - 4/1941	2 mi. d/s East Verde River
Below Tangle Creek	9/1945 - 9/1991	9 mi. u/s Horseshoe Dam
Above Bartlett Reservoir	10/1939 - 12/1946	5 mi. d/s Horseshoe Dam
McDowell	8/1888 - 9/1950	1 mi. u/s Salt River

Flow Duration Curves. A flow-duration curve shows the percentage of time (frequency) during some time period studied that a specified rate of flow was equaled or exceeded. The curve also provides a useful method for analyzing the availability and variability of streamflow. That is, the slope of a flow-duration curve is a good indication of the capacity of a basin to store water. Storage of water in alluvium or bedrock aquifers tends to lower the variability of the flow by reducing the peak flows and spreading the same volume of runoff over a longer time period. A steeply sloping flow duration curve indicates high variability in flow rates and small amounts of natural storage, and gently sloping curve indicates a low variability, which is characteristic of a consistent component of base flow per unit drainage area (Owen-Joyce and Bell, 1983). Flow duration curves for the upper Verde River are steeply sloped for flood flow rates, and gently sloped for lower rates of flow. Stations at Clarkdale and Paulden have more reliable base flow with less fluctuation below the 80 and 95 percent durations. The Camp Verde record is more steeply sloping indicating lesser rates of base flow.

Table 7-5
Verde River Streamflow Statistics (cfs).

Gage	Average Annual[a]	90% Flow Rate	50% Flow Rate	10% Flow Rate
Paulden	42	31	25	22
Clarkdale	192	236	85	70
Camp Verde	439	837	189	84
Tangle Creek	559	917	238	120
McDowell	781	n.a.	968(?)[a]	n.a.

[a] See Atshul, 1987

Average Flow Rates. Monthly and average annual flow rates at Verde River gage stations are shown in Table 7-6. Floods with high peaks tend to skew the average as indicated by flow rates shown in Table 7-5. However, average flow rates are useful for showing spatial and temporal variation of streamflow during the year at various locations in the study area.

Table 7-6 Average Flow Rates, Verde River (cfs).					
Month	**Paulden 1963-89**	**Clarkdale 1916,18-20; 1966-89**	**Camp Verde 1934-45, 89**	**Tangle Creek 1946-89**	**McDowell 1889-1939**
January	40	154	324	655	1048
February	92	444	1030	1060	2121
March	79	528	1570	1460	1942
April	35	197	815	878	1017
May	25	91	139	219	288
June	24	76	84	134	142
July	26	110	114	181	283
August	31	103	220	334	526
September	42	109	265	271	455
October	33	128	221	353	329
November	27	143	212	383	465
December	48	229	321	803	761
Annual	42	192	439	559	781

Sources: USGS (1954; 1991) Flow records for McDowell station after 1939 not used due to regulation by Bartlett Dam.

Base Flow. Base flow, or dry-weather flow, is the non-flood component of streamflow. Owen-Joyce and Bell (1983) examined daily flow records to estimate base flow rates at three Verde River stations, as summarized in Table 7-7. Rivers generally do not flow below base flow rates.

Table 7-7 Verde River Base Flow (cfs)			
Season	**Paulden**	**Clarkdale**	**Camp Verde**
Winter	22	75	200
Summer	22	72	60
2-Year, 7-Day Low Flow	21	68	66
2-Year, 30-Day Low Flow	22	70	76

Source: After figure 4 in Owen-Joyce and Bell, 1983

General Information. Numerous other investigations of the hydrology of the Verde River have been conducted. Some of the findings of these studies include:

- The Corps of Engineers reports a perennial discharge rate from Clarkdale to Bridgeport of 200 cfs (1976), and 100 cfs at Camp Verde (1978).

- The Verde River is a gaining stream, with only a few short losing reaches. From Cottonwood to West Clear Creek, the stream is gaining. From West Clear Creek to Fossil Creek the stream is not gaining or losing (Owens-Joyce and Bell,1983).

- Evapotranspiration loses from the Verde River between Paulden and West Clear Creek average 35,000 acre-feet per year (48 cfs). Other losses in the middle Verde reach include 8,000 acre-feet per year (11 cfs) of ground water withdrawal (Owen-Joyce and Bell, 1983).

- SLA, Inc. (1985) reported at dominant discharge of 11,000 cfs near Dead Horse State Park in the Cottonwood/Clarkdale area. Some investigators believe that the dominant discharge is the flow rate responsible for shaping the stream channel. SLA estimated that the Verde River at 11,000 cfs would have a velocity of 5 to 8 fps, a depth of 4 to 10 feet, and a topwidth of 400 to 500 feet.

Hayden's (1940) description of irrigation practices illustrates the hydrologic impacts of diversions on the Verde River in June and July of 1940, as well as the complexity of reconstructing streamflow along a river with irrigation diversions. June and July are typically the months of lowest average discharge[3]. At Sycamore Canyon, upstream of most diversions, the Verde River carried 75 cfs. At Tapco, only 10-15 cfs remained in the river, and at Clarkdale 20 cfs flowed in the river with 20 cfs diverted to canals. Just downstream, the Hickey Ditch diverted 20 cfs and the Cottonwood Ditch took 45 cfs from the river, indicating the presence of springs and/or return flows. In the 35 miles to Clear Creek, 184 cfs was taken out of the river, with 25 cfs inflow from Oak Creek (no inflow occurred at Beaver and Clear Creeks). Downstream of Clear Creek, the Verde River carried 50 cfs. Hayden computed a 143 cfs excess of streamflow, with a total of 234 cfs of natural flow, accounting for irrigation return flows.

No reports were uncovered that indicated that modern stream gage records were not representative of stream conditions at statehood.

Comparison of Modern and Historical Record. The hydrology of the three Verde River reaches has remained substantially unchanged since statehood, except for the reach downstream of Horseshoe and Bartlett Reservoirs. Comparison of flow rates summarized in Tables 14 and 17 indicate no significant change in mean monthly or annual flow rates since statehood. Other evidence of hydrologic similarity includes:

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[3] Gage data from June, 1940 indicate June experienced slightly above average flows, while July had slightly below average flows.

- Detailed analysis of tree-ring records indicate that the Verde River gage records are representative of long-term average annual flow rates, although the period from 1905 to 1920 was one of wettest periods in the record (Smith and Stockton, 1981).

- Discharge from springs insulates low-flows in the Verde River from the affects of climatic variations (Smith and Stockton, 1981).

- In upper Verde River, no appreciable declines in ground water levels have been measured (Owen-Joyce and Bell, 1983).

- The Verde River ground water system is still in equilibrium; no change in winter base flow were found, particularly in the reach upstream of Clarkdale (Owen-Joyce and Bell, 1983).

- SLA, Inc. (1985) cites a report by Malone (1984) which claims that in-stream sand and gravel mining began in the Verde River as early as 1910. This and other floodplain activities such as irrigation predate 1912.

Hydraulic Rating Curves

Hydraulic rating curves relate stream discharge to flow depth, width, and velocity. Two sources of information were used to develop rating curves for the Verde River: (1) historical measurements of stream stage, velocity, and discharge taken around the time of statehood by the USGS; and (2) recent streamflow characteristics recorded by USGS field personnel working at stream gage stations still in operation. The location of rating curve reaches (Tables 19 to 24) and a typical Verde River low flow rating curve is shown in Figure 7-2.

Historical streamflow data were available from the Clarkdale (1915-1918), Camp Verde (1912-1920), and McDowell (1905 to 1909) stations. To reconstruct rating curves from stage, velocity, and discharge readings from the period of record closest to statehood was tabulated. Stream stage was then related to average stream depth. Finally, other streamflow parameters such as topwidth and velocity were estimated using Manning's equation[4], assuming a rectangular channel. Rating curves were then developed and compared to monthly and annual streamflow statistics.

Recent stream gage measurements were available for the Tangle Creek (2/76 to 8/93), Camp Verde (10/88 to 7/93) and Paulden (8/84 to 8/93) gages. Field measurements of stream width, velocity, topwidth, and velocity were entered into a data base and a rating curve was

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[4] Manning's equation: $Q = 1.49\ A/n\ R^{0.67}\ S^{0.5}$; where: Q = Discharge, cfs; A = Flow Area, ft^2; n = roughness coefficient; R = hydraulic radius, ft.; S = channel slope, ft/ft.

fit to the data. Hydraulic characteristics for monthly and average annual flow rates were then obtained from the rating curve.

Summaries of the data from the rating curves for each station are shown in Tables 19 to 25, and are depicted graphically in Figure 7-2. These data are intended to be representative of the following reaches:

- Upper Verde River: Paulden (Table 7-8, Recent Data)
- Middle Verde River: Clarkdale (Table 7-9, Historical Data); Camp Verde (Table 7-10, Recent Data; Table 7-11, Historical Data)
- Lower Verde River: Tangle Creek (Table 7-12, Recent Data); McDowell (Table 7-12, Historical Data)

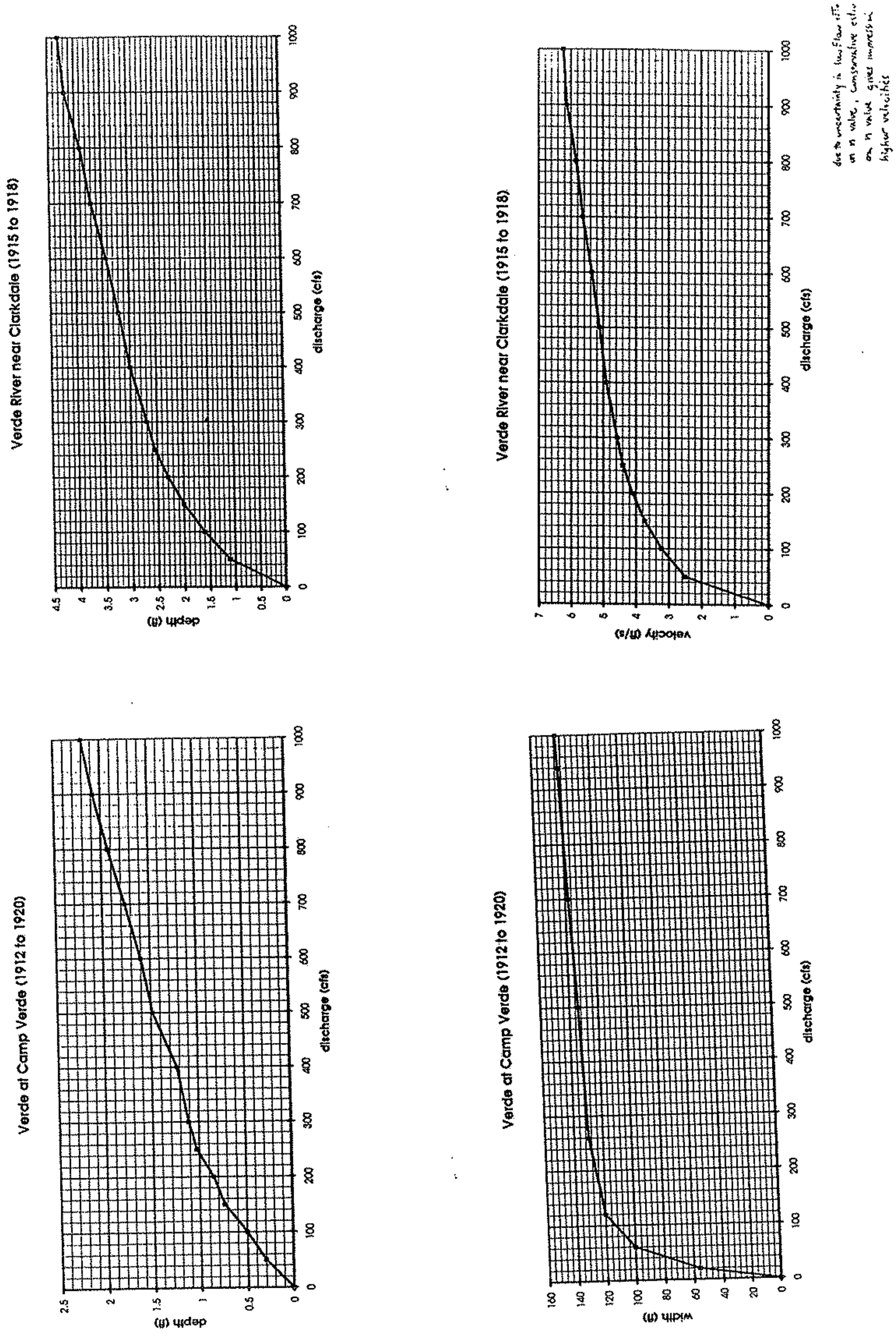
Verde River near Clarkdale (1915 to 1918)
depth (ft)
discharge (cfs)
Verde River near Clarkdale (1915 to 1918)
velocity (ft/s)
discharge (cfs)
Verde at Camp Verde (1912 to 1920)
depth (ft)
discharge (cfs)
Verde at Camp Verde (1912 to 1920)
width (ft)
discharge (cfs)

Figure 7-2.

Table 7-8a Verde River: Near Paulden, Gage 09503700 Average Hydraulic Characteristics				
Month	**Flow Rate (cfs)**	**Average Depth (ft)**	**Velocity (ft/sec)**	**Topwidth (ft)**
January	40	1.1	1.6	26
February	92	1.6	2.5	27
March	79	1.5	2.3	26
April	35	1.1	1.5	25
May	25	0.9	1.2	25
June	24	0.9	1.2	25
July	26	0.9	1.2	25
August	31	1.0	1.4	25
September	42	1.2	1.7	26
October	33	1.1	1.4	25
November	27	0.9	1.2	25
December	48	1.2	1.8	26
Annual	42	1.2	1.7	26

Table 7-8b Verde River: Near Paulden, Gage 09503700 Flow Duration Hydraulic Characteristics				
Flow Period	**Flow Rate (cfs)**	**Average Depth (ft)**	**Velocity (ft/sec)**	**Topwidth (ft)**
Average Annual Flow	42	1.2	1.7	26
90% Flow	22	0.8	1.0	25
50% Flow	25	0.9	1.2	25
10% Flow	31	1.0	1.4	25

Table 7-9a Verde River at Clarkdale Average Hydraulic Characteristics, 1915 to 1918				
Month	**Flow Rate (cfs)**	**Average Depth (ft)**	**Velocity (ft/sec)**	**Topwidth (ft)**
January	154	2.0	3.8	20
February	444	3.1	5.0	29
March	528	3.3	5.2	31
April	197	2.3	4.1	21
May	91	1.5	3.1	19
June	76	1.4	2.8	19
July	110	1.7	3.3	20
August	103	1.6	3.2	19
September	109	1.7	3.3	20
October	128	1.8	3.5	20
November	143	1.9	3.7	20
December	229	2.5	4.3	22
Annual	192	2.2	4.0	21
NOTE: Average flow rates from entire period of record.				

Table 7-9b Verde River near Clarkdale, 1915 to 1918 Flow Duration Hydraulic Characteristics				
Flow Period	**Flow Rate (cfs)**	**Average Depth (ft)**	**Velocity (ft/sec)**	**Topwidth (ft)**
Average Annual Flow	192	2.2	4.0	21
90% Flow	236	2.5	4.3	22
50% Flow	85	1.5	3.1	19
10% Flow	70	1.4	2.8	19
NOTE: Flow duration statistics from entire period of record.				

Table 7-10a Verde River: Near Camp Verde, Gage 09506000 Average Hydraulic Characteristics				
Month	**Flow Rate (cfs)**	**Average Depth (ft)**	**Velocity (ft/sec)**	**Topwidth (ft)**
January	324	1.8	1.0	155
February	1030	2.9	2.0	170
March	1570	3.5	2.7	175
April	815	2.5	1.8	170
May	139	1.4	0.6	140
June	84	1.2	0.4	120
July	114	1.3	0.5	130
August	220	1.6	0.8	145
September	265	1.7	0.9	155
October	221	1.6	0.8	145
November	212	1.6	0.8	145
December	321	1.8	1.0	155
Annual	439	2.0	1.3	165
NOTE: See Table 4 for location of this Gage relative to VR at Camp Verde Gage				

Table 7-10b Verde River: Near Camp Verde, Gage 09506000 Flow Duration Hydraulic Characteristics				
Flow Period	**Flow Rate (cfs)**	**Average Depth (ft)**	**Velocity (ft/sec)**	**Topwidth (ft)**
Average Annual Flow	439	2.0	1.3	165
90% Flow	84	1.2	0.4	120
50% Flow	189	1.5	0.7	145
10% Flow	837	2.6	1.9	170

Table 11a
Verde River: at Camp Verde
Average Hydraulic Characteristics, 1912 to 1920

Month	Flow Rate (cfs)	Average Depth (ft)	Velocity (ft/sec)	Topwidth (ft)
January	324	1.1	2.7	130
February	1030	2.3	5.4	145
March	1570	>2.5	>6.0	150
April	815	1.9	4.8	140
May	139	0.7	1.4	120
June	84	0.4	0.9	110
July	114	0.6	1.2	115
August	220	0.9	2.0	130
September	265	1.0	2.4	130
October	221	0.9	2.0	130
November	212	0.9	2.0	125
December	321	1.1	2.7	130
Annual	439	1.8	3.3	130

NOTES: Average flow rates from entire period of record. See Table 7-4 for location of this Gage relative to VR near Camp Verde Gage

Table 11b
Verde River: at Camp Verde
Flow Duration Hydraulic Characteristics, 1912 to 1920

Flow Period	Flow Rate (cfs)	Average Depth (ft)	Velocity (ft/sec)	Topwidth (ft)
Average Annual Flow	439	1.8	3.3	130
90% Flow	84	0.4	0.9	110
50% Flow	189	0.8	1.7	125
10% Flow	837	1.9	4.8	140

NOTE: Flow duration statistics from entire period of record.

Table 7-12a Verde River: Below Tangle Creek, Gage 095085000 Average Hydraulic Characteristics				
Month	**Flow Rate (cfs)**	**Average Depth (ft)**	**Velocity (ft/sec)**	**Topwidth (ft)**
January	655	1.1	2.6	125
February	1060	1.3	3.0	175
March	1460	1.4	3.2	200
April	878	1.2	2.8	140
May	219	0.9	2.0	61
June	134	0.8	1.6	44
July	181	0.8	1.8	54
August	334	0.9	2.2	80
September	271	0.9	2.1	70
October	353	0.9	2.3	83
November	383	0.9	2.3	88
December	803	1.2	2.8	135
Annual	559	1.1	2.5	120

Table 7-12b Verde River: Below Tangle Creek, Gage 095085000 Flow Duration Hydraulic Characteristics				
Flow Period	**Flow Rate (cfs)**	**Average Depth (ft)**	**Velocity (ft/sec)**	**Topwidth (ft)**
Average Annual Flow	559	1.1	2.5	120
90% Flow	120	0.8	1.6	40
50% Flow	238	0.9	2.0	65
10% Flow	917	1.3	2.9	150

Table 7-13 Verde River at McDowell Average Hydraulic Characteristics, 1905 to 1909				
Month	**Flow Rate (cfs)**	**Average Depth (ft)**	**Velocity (ft/sec)**	**Topwidth (ft)**
January	1048	>3.5	7.0	48
February	2121	> 4	> 7	50
March	1942	> 4	> 7	50
April	1017	3.6	7.0	48
May	288	2.1	5.0	28
June	142	1.7	4.4	19
July	283	2.1	5.0	28
August	526	2.4	5.6	39
September	455	2.3	5.4	35
October	329	2.1	5.1	30
November	465	2.3	5.4	36
December	761	2.8	6.0	45
Annual	781	2.8	6.1	46

Summary. Rating curves derived from both historical and modern gage data indicate that typical channel depths range about one to three feet, and channel velocities are generally less than 7 feet per second. Rating curves were developed to minimize depth estimates and maximize velocity estimates, therefore are conservative with respect to determining boating requirements.

Floods

Flood data are available from Flood Insurance Studies and from USGS gage records. Large floods occurred in the years preceding statehood, reported causing channel erosion which resulted in channelization of the middle Verde River, and elimination of swampy marshland.

Flood Recurrence Intervals. Flood discharge rates at various key concentration points are listed in Table 7-14. Flow rates obtained from Flood Insurance Studies (FIS, 1976; 1978) are correspond fairly well to flood flow rates determined by the USGS (1991) using stream gage records.

Table 7-14 Summary of Verde River Flood Discharge Rates (cfs)							
Location	**Area (mi^2)**	**Q2**	**Q5**	**Q10**	**Q50**	**Q100**	**Q500**
Paulden	2,148	1,330	4,050	7,310	20,800	30,300	-
Clarkdale	3,139	6,580	16,800	26,400	54,500	69,000	-
Cottonwood	3,272	-	-	22,362	52,015	69,699	124,971
Rt. 89a	3,275	-	-	27,000	54,000	68,000	106,000
d/s Oak Ck.	3,817	-	-	40,000	81,000	101,000	160,000
d/s Beaver Ck	4,336	-	-	43,000	94,000	123,000	220,000
Camp Verde	4,645	11100	25600	40700	96600	133000	-
Tangle Creek	5494	16000	39400	61300	128000	164000	-

[a] Source: FEMA, 1992
[b] Source: USGS, 1991

Historic Floods. The largest floods recorded at USGS gaging stations are summarized in Table 7-15. The floods of 1891 and 1993 were probably the largest floods in the past 150 years, the period since Arizona was settled by Anglos. Except at the Paulden station, the largest floods occurred during winter-type storms. Historical records indicate large floods also occurred in 1868, 1874, 1880, 1888, 1891, and 1905 (cf Dobyns, 1978).

Table 7-15 Dates and Discharges of Large Gaged Verde River Floods (cfs)		
Station	**Discharge**	**Date**
Paulden	15,700	2-20-1980
Clarkdale	50,600	2-21-1920
	35,500	3-8-1918
Camp Verde	97,000	3-3-1938
	41,700	2-7-1937
Tangle Creek	150,000	2-24-1891
	100,000	3-4-1938
	96,000	11-27-1905
McDowell	>150,000	2-24-1891

Flood Hydraulics. Limited flood hydraulics data are available from Flood Insurance Studies for the Verde River, since much of the Verde River flows on public land. Flood studies have been completed for all of the Verde Valley area, a reach within the middle Verde River. Flood depths, of course, are not limiting with respect to boating. In the Verde Valley, velocities for the 100-year flood average about 8 feet per second (fps), and range from about 4 fps to 19 fps. Higher velocities typically occur in constricted reaches, such as under bridges. Lower velocities typically occur upstream of constrictions and in relatively wider, shallower reaches. The average velocities reported do not exceed federal maximum recommended velocities for floating-type boats such as canoes. However, other river conditions during floods, such as floating debris, could indeed making boating hazardous.

Irrigation

Irrigation has been practiced on the Verde River since prehistoric times. Several reports published from 1890 to 1914 describe in detail irrigation works along the river. Hancock (1914) describes irrigation diversions along the entire Verde River at the time of statehood (Table 7-16). In 1914, 25 diversions diverted more than 121 cfs for more than 5,000 acres of farm land between Perkinsville and the Salt River. Diversions lowered measured streamflow, depleted stream resources (Hayden, 1940) and may have contributed to channelization of the middle Verde River. By 1980, about 30 irrigation diversions existed in the upper and middle Verde, providing water for about 7,800 acres. Near Cottonwood and Camp Verde, these diversions took more than half the ordinary flow of the Verde River, and all or portions of the flow several tributaries, including West Clear Creek (Owen-Joyce and Bell, 1983). Similarity of modern and historical irrigation rates give further evidence of the hydrologic similarity of the statehood and modern periods.

Table 7-16 Historical Irrigation Diversions on the Verde River (cfs)				
Diversion	**Capacity**	**Normal Diversion Rate**	**Construction Date**	**Approximate Location**
Campbell	3	3	1874	
Perkins	2	2	1864	Perkinsville
Alvarez	1	1	1901	
Thorbeck	2	2	1880	Sycamore Ck
Duff	4	1	1879	
Sullivan	2	1	1896	
E. Jordan	4	4	1882	
W. Jordan	2	1	1880	
Humbert	1	1	1898	Clarkdale
Allen	9	5	1898	
Hickey	6	5	1874	
Cottonwood	31	25	1874	Cottonwood
O.K.	33	26	1875	
Central Verde	15	0	1875	
Verde	29	25	1868	
Eureka	13	12	1893	
Enterprise	4	0	1892	
Eman	6	6	1895	Camp Verde
Newman	2	0	1870	
Starks	1	0	1913	
Asher	-	-	1895	Ft. McDowell

Source: Hancock, 1914 (see also Straud and Prathan, 1899)

Note: Does not include diversion from springs, tributaries to Verde, or pumping from Verde

Climate Change

Consideration of climatic changes during the few past century places is useful when discussing the hydrology of the Verde River for several reasons. First, climatic data indicates whether modern streamgage records are representative of the long-term river conditions. Second, climatic data reveal that the period surrounding statehood was one of the wettest periods in the past millenium. Third, climatic data help interpret current streamflow characteristics relative to conditions as of statehood.

The BUREC began direct measurement of streamflow on the Salt-Verde system in late 1888 at the Arizona Dam irrigation diversion, and has since been continued to the present time by the USGS at several upstream locations. Smith and Stockton (1981) and Graybill (1989) used tree-ring[5] records to extend gage records to 740 A.D.; Dean et al (1985), and Euler et al (1979) used tree-rings, pollen data, and alluvial sedimentation patterns to estimate periods of increased/decreased moisture to 600 A.D. Smith and Stockton's interpretation of the tree-ring record indicates the following:

- The period from 1905-1920 (Arizona statehood) was the wettest period since 1580 in the Verde River watershed.
- The period from 1900 to 1979 (Verde River gage record) had an average annual flow volume slightly greater than the 400 year mean annual volume.
- The period from 1932-1977 on the Verde River had below average annual runoff. This period corresponds to the majority of the gage record of most Arizona stream gages.
- Base flow in the Verde River is controlled by springs, rather than climatic factors. Low precipitation does not generally affect discharge from springs.
- Irrigation diversions impact Verde River streamflows.

Dean's and Euler's paleoenvironmental studies determined that there were no radical differences in the prehistoric Arizona climate compared to the modern climate. Other tree-ring studies by Stockton (1975) elsewhere on the Colorado Plateau also found that the early 1900's was an unusually "wet" period.

Other conclusions can be reached from consideration of climatic data for the Verde River. First, Arizona's climate at statehood was somewhat, but not drastically different from existing or pre-statehood conditions. The same basic climatic patterns applied. Summers were warm and relatively dry with intense, late summer monsoonal rainfall. Winters were cool, with less

[5] Tree ring studies assume the thickness of the individual annual rings are related to discharge. Wet year (high average annual flow) give rise to thicker rings. Individual tree rings can be readily matched to specific years. Smith and Stockton's data was calibrated using recent gage data and recent tree ring records.

intense Pacific frontal storms bringing snow to higher elevations and rain to lower elevations. However, subtle differences in rainfall and temperature patterns around the time of statehood may have resulted in higher average streamflow. These differences included:

- Generally higher precipitation and streamflow volumes
- More frequent intense monsoonal rainfall
- Cooler average temperatures, with warmer summers and cooler winters

Therefore, the period surrounding statehood was probably subject to higher than average streamflow, indicating that streams may have been more likely to have been navigable at statehood, than during other, less "wet" periods of Arizona history.[6] It is noted that some of Arizona's largest floods, in terms of both volume and peak flow rate, occurred in the twenty years prior to statehood.

Second, stream gage records must be used cautiously to adequately predict the natural, long-term average discharge rates. Tree-ring records indicate that the average annual flow rates on the Verde River between 1900 and 1980 are just slightly above the average annual flow rates for the past 400 years. Gage records from 1905 to 1920 may predict average flow conditions well above long-term average rates, but may accurately reflect conditions at statehood. Gage records with the majority of years of record in the 1940's and 1950's may predict average flow conditions below the long-term average, and well below the wetter conditions at statehood. Of course, stream gage data must also be filtered to account for human impacts on streamflow, such as reservoirs and irrigation diversions. *In general, use of the existing stream gage database will probably result in prediction of flow rates less than those that existed at statehood.*

Third, changes in climatic conditions may have in fact altered stream conditions that would have affected navigability on some Arizona streams. For the Verde River, climatic variation has little affect on low flow conditions due to steady base flow from springs and geologic control (bedrock) for much of the river. In the more densely populated, alluvial reaches of the Verde Valley urbanization may obscure climatic impacts. However, climatic records indicate that higher than average flow in the Verde River probably occurred around the time of statehood, making navigation more possible at statehood than during other periods of history.

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[6] Human impacts such as reservoir construction, ground water withdrawal, etc., have tended to lessen average stream discharge rates obscuring climatic affects on some Arizona streams.

Summary

The hydrology of the Verde River has not substantially changed since 1912. Flow rates, channel conditions, stream geomorphology, ground water conditions, and river uses are similar to conditions at statehood. At statehood, the Verde River was used for boating, fishing, trapping, irrigation and water supply. With the possible exception of trapping, these uses continue on the Verde River today. Data from USGS gage records indicate that the Verde River was and is perennial, with a low flow controlled by steady discharge from springs and ground water. High flow periods on the river typically occur from January to April, and have average monthly flow rates in excess of 1,000 cfs. Winter flows currently support several types of commercial/recreational boating operations.

Chapter 8
Boating on the Verde River

Introduction

The objective of this chapter is to provide information federal boating criteria and the types of boating which have occurred historically in Arizona. Several types of information are presented including:

- Federal navigability criteria
- Historical accounts of boating
- Modern boating records

Historical and modern accounts of boating are presented for the Verde River. Additional information on boating the Verde River was presented in Chapters 3 and 7 of this report. Information on boating other Arizona rivers is presented in Appendix H.

Federal Criteria for Navigability

The federal government has not yet published universally applicable criteria to explicitly define title navigability. Rather, specific agencies use criteria defining title navigability that have been developed at the state level based primarily on case law. These criteria vary somewhat from state to state. However, some federal agencies have formally described stream conditions which favor various types of boating. One such description was developed by an intergovernmental task force, the Instream Flow Group, to quantify instream flow needs for certain recreational activities including boating (US Fish and Wildlife, 1978). The US Department of the Interior independently developed boating standards (Cortell and Associates, 1977). These federal criteria, summarized in Tables 8-1 and 8-2, were developed primarily for recreational boating, not necessarily for commercial boating. Minimum stream conditions required are summarized in Table 8-1. Minimum and maximum conditions are summarized in Table 8-2.

Table 8-1
Minimum Required Stream Width and Depth for Recreation Craft

Type of Craft	Depth (ft.)	Width (ft.)
Canoe, Kayak	0.5	4
Raft, Drift Boat, Row Boat	1.0	6
Tube	1.0	4
Power Boat	3.0	6
Source: US Fish and Wildlife, 1978		

Table 8-2 Minimum and Maximum Conditions for Recreational Water Boating						
Type of Boat	Minimum Condition			Maximum Condition		
	Width	Depth	Velocity	Width	epth	Velocity
Canoe, Kayak	25 ft.	3-6 in.	5 fps	-	-	15 fps
Raft, Drift Boat	50 ft.	1 ft.	5 fps	-	-	15 fps
Low Power Boating	25 ft.	1 ft.	-	-	-	10 fps
Tube	25 ft.	1 ft.	1 fps	-		10 fps
Source: Cortell and Associates, 1977						

Some Arizona boaters surveyed for this study did not agree with the minimum velocity criteria given in Table 8-2. They argue that since boats can be used on lakes and ponds which have no measurable (zero) velocity, no real minimum velocity exists, except perhaps for tubing. Minimum velocities in Table 8-2 are probably intended to indicate what stream conditions are most typically considered "fun." Similarly, minimum width conditions listed in Table 8-2 probably do not represent the minimum possible conditions for use of a watercourse.

The Bureau of Land Management (BLM) apparently has adopted a "narrow" definition of navigability (Rosenkrance, 1992). BLM criteria to determine title navigability include:

- The original condition of waterway at date of statehood is used
- Use by small, flat bottom sport boats or canoes is not navigation
- Navigation must occur at times other than seasonal floods
- Unaccessible streams are not navigable
- Long obstructions such as bars makes upstream segments unnavigable

No documentation of application of these guidelines by the BLM in Arizona was uncovered, although BLM apparently did not consider the Salt River navigable at statehood, due to the closure of Roosevelt Dam (BLM, 1964). Other federal agencies have stated that the Salt and Verde are non-navigable streams, as discussed below, although specific criteria which formed the technical bases of these decisions are lacking.

Historical Accounts of Boating

Boats were in use during the period around statehood. Newspaper stories, contemporary reports, anecdotal information, and oral histories all provide evidence of boating on Arizona rivers. Documented uses of boats included:

- Travel
- Ferries
- Recreation
- Mail Delivery
- Flood Rescues
- Transport of Goods

Several accounts of floating logs down Arizona rivers are also documented. Review of historical records of boating gives the general impression is that there was no shortage of boats in the Salt River Valley. Whenever a boat was needed to cross a flooded river, even during the period of early exploration, boats were borrowed from local residents, used and returned. The presence of boats in arid regions like Phoenix, Tempe, and the Verde Valley, despite there being no nearby lakes, argues for use of boats on the rivers.

Some documentation of boating on the Verde is also available. Historical accounts are of course concentrated in reaches with settlements, particularly the lower Verde near Fort McDowell and the Verde Valley. Boats were used on the Verde River beginning near the time Fort Verde was established in the 1860's. Historical accounts of boat use on the Verde River include:

- Fort Verde personnel (IO Report, 1878) and civilians (Jordan, 1987) kept boat(s) to reach other side of river during periods of high flow

- Boats or rafts used to transport rock in building rock dam near Perkinsville in June 1899 (Willard, undated)

- Boats used in the Verde Valley from 1910 to 1920 needed to be emptied of cargo to pass the rapids downstream of Camp Verde

- Boats were used for recreational purposes, such as hunting, prior to statehood.

Historical accounts of Verde River boating are generally concentrated in river reaches with settlements, particularly the lower Verde near Fort McDowell and the Verde Valley near Camp Verde. The types of boats used included canvas canoes, a steel boat, skiffs, and flat-bottomed boats. Information presented in Table 8-3 summarizes probable stream characteristics required to support use of the type of boats available as of statehood. The criteria for canoes available as of the time of statehood are not substantially different from criteria for canoes available today. Reaches boated historically extend from Perkinsville to the Salt River confluence, the reach most frequently boated today.

Table 8-3
Flow Requirements for Pre-1940 Canoeing

Boat Type	Depth
Flat Bottomed (Wood or Canvas)	4 in.
Round Bottomed (Wood or Canvas)	6 in.

Source: Slingluff, J., 1987

It is noted that for all of the instances of boat use on the Verde River the boaters traveled downstream or across the river. No evidence of boating in the upstream direction was found. Furthermore, several accounts of taking boats upstream by wagon after or before boating were discovered. Most boating on the Verde River apparently was occurred during spring, but was not exclusively limited to the wetter months or to periods of seasonal floods.

Historical Accounts of Fish

Although the presence of fish in a river does not necessarily indicate that boatable conditions exist, existence of certain species does provide some information about flow conditions. Archeological evidence indicates that the same species found in Arizona rivers in prehistoric times were also present around the time of statehood (James, 1992). Change in fish species distributions did not occur in most rivers until the 1940's (Minkley, 1993). Some of the species found in the Verde River included very large fish such as squawfish (aka Salt River Salmon, Colorado River Salmon) some of which grow to over three feet long, razorback sucker, and flannelmouth sucker. The latter fish tend to indicate "big river" conditions (Minkley, 1993), by Arizona standards. Fishing remains a popular pastime on the Verde River today.

Modern Accounts of Boating

Some Arizona rivers are still boated in modern times. While modern boat use of a river may not provide definitive proof of susceptibility of a stream to navigation at statehood, it is strong evidence that is readily available for consideration. Boat-making technology has improved[1] since the times of statehood, with use of inflatable rafts, inflatable and hard-shell kayaks becoming one of the preferred modes of travel. However, while canoe technology has changed to make these boats more durable, the depth of water required for canoeing has not substantially changed. In addition, flow rates on Arizona rivers have generally declined since 1912. Therefore, modern use of a river reach by canoes probably indicates that canoes could have been used as of the time of statehood.

The Central Arizona Paddlers Club (CAPD), an organization of boaters, conducted a survey of their members to determine what rivers had been boated. With 20 percent of members responding to their survey, CAPD reports that all of the Verde River downstream of Perkinsville has been boated in recent years (Central Arizona Paddlers Club, 1992). CH2M HILL informally polled CAPD members willing to be interviewed to determine flow conditions at the time various rivers were boated. A brief summary of the CAPD poll showing reaches and flow data is presented in Table 8-4. More detailed information on the CAPD survey is provided in Appendix H.

The Verde River is the most frequently canoed, rafted, and kayaked river of the four rivers under consideration for navigability studies by CH2M HILL. The U.S. Forest Service even permits several commercial rafting operations on the Verde River. Most boating of the Verde occurs during winter months and during spring runoff, although Slingluff (1990) published a

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[1] One enterprising Arizonan redesigned a motorboat to be able to travel in shallow water only 2.5 inches deep (Ariz. Days and Ways, 1960). The news article describing the boat mentions that the driver cracked the boat's hull while traveling 35 miles per hour in an ankle deep stream.

boating guide to the Verde River which states that the river can be boated from several miles upstream of Perkinsville to the Salt River, at flows as low as 50 cfs (1993). Some published stories of river trips on the Verde describe difficulties in travel (cf Gerke, 1959). Why these boaters had problems, while CAPD boaters frequently boat the same reaches without trouble is unexplained, but is probably related to the experience and skill of the boater. The Arizona State Parks Department (1989) mapped the Verde River from Perkinsville to the Salt River as a boatable stream. A boating guide to the southwest does not list the Verde River, though the upper Salt River is described (Anderson, 1982).

Table 8-4
Central Arizona Boaters Club
Survey Results: Selected Reaches Boated

River	Reach	Date mo-yr	Flow (cfs)	Depth (ft)	Width (ft)	Craft	Portage (%)
Verde	Morgan Ranch to Perkinsville	10-89	30	0.5-1	< 15	Canoe	1
	Morgan Ranch to Salt River	10-88	< 50	> 0.5	> 10	Canoe	1
	Horseshoe to Needlerock	3-92	20,000	> 10	300	Kayak	0

Navigability Decisions

Some limited information on formal decisions of navigability in Arizona were uncovered. These include, but are by no means limited to:

- BLM (1957; 1967). BLM refers to the Verde River as "non-navigable" in two land disputes.
- BUREC (1935). The Verde River is not navigable because it is "too small and flashy to justify any serious claim that it is navigable in the vicinity of [Bartlett Dam]." (See also Davidson, 1973)
- Arizona Attorney General (1981). For State v. Superior Companies et al, the State claims that "we will not be able to establish, by any credible evidence, that the Verde River was navigable at the time of statehood." A hand written note adds that "any other stance could prove very embarrassing." The author of the hand written note is not known.

Summary

Some Arizona rivers were used for boating and transport of materials around or prior to the time of statehood. Hydrologic conditions in the Verde River would meet federal standards for recreational boating during most of the year. No evidence of boating up the Verde River, or use of large machine-powered boats was found. No significant commercial boating industries were developed on the Verde River as of 1912, though isolated cases of commercial use of the river were found. In addition, portions of the Verde River are currently boated for recreational purposes most of the year and by commercial operations at certain times of the year.

Chapter 9
Conclusions

This report documented the archaeology, history, geology, and hydrology of the Verde River. The archaeological record of the Verde River Valley provides information on prehistoric uses of the Verde River, settlement patterns in the region with respect to the river, and paleoenvironmental information which describes long-term flow characteristics of the river. This information may be used to help reconstruction the "ordinary and natural" conditions of the Verde River. Archaeological evidence indicates that the Verde River has provided accessible, permanent water to the Verde Valley area since the region was first inhabited. The river provided water for irrigation and has been a communication and trade route among various cultures since prehistoric times, although no evidence of prehistoric boating has been documented. Prehistoric irrigation canal systems have been mapped in three areas along the river: the Perkinsville valley, near Horseshoe Reservoir, and near Fort McDowell. The upper and middle Verde River appear to have contained the largest canal systems, based largely on the size of the floodplain and first terraces, although those in the lower Verde are the best documented. Most of the lower Verde River canals were less than one mile in length, with numerous secondary canals measuring less than 1,300 feet in length. The lower Verde River canal systems often occur in conjunction with other water control features, such as check dams, terraces, and rock alignments associated with dry land farming. Irrigation systems along the Verde River may be limited in size compared to prehistoric irrigation systems on the Salt and Gila Rivers due to the heavy flow rates of the Verde River. High average and annual flows may have eliminated the need for long canals and may have eliminated the need for any irrigation at all in some reaches.

The recorded history of the Verde River extends back to Spanish expeditions to Indian mines near the Verde Valley in the late 1500s and early 1600s. Thereafter, the Verde River seems to have been bypassed by European colonists and left to the Yavapai and Apaches for almost two centuries. Fur trappers from the United States began to trap along the Verde River in the 1820s. The United States military established garrisons along the Verde River during the Civil War, with Camp Lincoln (aka Fort Verde) established in 1864, and Camp McDowell established in 1865. Mining and farming of the region also began in the 1860s. Throughout the late 19th century, the Verde River Valley was a center for irrigated farming. Around 1890, forts along the Verde River were abandoned. In 1909, a hydroelectric plant was constructed on the Verde River at Childs. The Santa Fe railroad constructed a line from Drake to Clarkdale in 1911. In the 1930s and 1940s, Bartlett Dam and Horseshoe Dam were constructed on the Verde River.

Reliable flow in the perennial Verde River was a major factor in historical development of the Verde River Valley. The earliest settlers used the river for irrigation of crops grown to supply nearby military establishments and mining camps. The river also served as a source of water for domestic and commercial use, such as hydroelectric power. Early descriptions of the Verde River include accounts of perennially flowing water, beaver and fish populations, and frequent floods. Floods caused dramatic increases in water levels in the river, eroded channel banks, damaged irrigation structures, and sometimes lasted for significant periods of time. Large floods which occurred prior to statehood apparently played an important role in removing marshy stream conditions in the middle Verde River which were described by early residents.

Historical accounts of boating on the Verde River do exist, though the vast majority of transportation in the region by horses, mule trains, wagons, and railroad. Overland transportation was often difficult, especially during rainy periods. Published accounts of boating prior to 1912 exist for those portions of the Verde River that are best documented historically--that is, the middle Verde River Valley above Camp Verde and the lower Verde River below Fort McDowell. Long-time residents and historians of the Verde Valley generally can provide accounts of boats being used on the river for commercial and recreational purposes, though most were surprised that the river was under consideration as a navigable stream.

Review of geological and hydrologic records of the Verde River support conclusions drawn from historical and archaeological data. Regional physiography and geology of the Verde River exert a strong influence on the extent and character of its floodplain. The Verde River flows through some of the most rugged country in Arizona. During the past several million years, the Verde River has downcut hundreds of feet, occasionally leaving terrace deposits behind as a record of former valley floors. Because of this long-term downcutting, the Verde River is confined within a steep, narrow valley along much of its length. In these confined reaches, the floodplain is limited in extent, and historical changes in channel positions have also been limited. The potential for channel changes is greatest in Verde Valley and along the lower Verde River, where the floodplain is relatively broad.

The general form of low-flow channels of the Verde River is quite similar along its entire length. Low-flow channels typically are 50 to 200 ft wide, winding through a larger flood channel. The flood channel has well-defined banks in some places, but has no obvious banks in other areas. The width of flood channels varies substantially, from about 200 ft to 3200 ft wide. The width of the flood channel depends in large part on the character and width of the geologic floodplain, which is controlled by the erodibility of underlying rock units. Areas inundated during large floods typically include low terraces and vegetated slackwater areas. In confined canyon reaches, the entire canyon bottom is inundated during large floods.

The character and position of Verde River channels during the historical period, according to evidence seen in historical aerial photographs, indicate that low-flow channels have shifted positions in many reaches, but the larger-scale features of the flood channel have been fairly consistent. Modest changes in positions of flood-channel banks and total widths have occurred in many places, but other reaches exhibit little or no change during the past few decades. In most areas, the large floods of 1978 or 1980 occupied the same flood channels that were evident in 1953-54. Historical land surveys in the Camp Verde area and along the lower Verde River reveal that the general form of the flood channels of the Verde River have not changed substantially since statehood. Low-flow channels have shifted position to a greater degree than the larger flood channels. The size and general form of low-flow channels in Verde Valley, however, was about the same in the 1870's as it is today.

The hydrology of the Verde River, upstream of Horseshoe Reservoir, also has not changed since 1912. Flow rates, channel conditions, stream geomorphology, ground water conditions, and river uses are similar to conditions as of statehood. Around 1912, the Verde River was used for boating, fishing, trapping, irrigation and water supply. With the possible exception of trapping, these uses continue on the Verde River today. Data from USGS gage records indicate that the Verde River was and is perennial, with a base flow discharge controlled by nearly constant outflow from springs and ground water. High flow periods on the river typically occur from January to April, and have average monthly flow rates in excess of 1,000 cfs. Winter flows currently support several types of commercial/recreational boating operations.

Some Arizona rivers were used for boating and transport of materials around or prior to the time of statehood. Hydraulic conditions in the Verde River would meet federal standards for recreational boating during most of the year, though no evidence of boating up the Verde River, or use of large machine-powered boats was found. No evidence of sustained commercial boating industries was found for the Verde River as of 1912, though isolated cases of commercial use of the river were found. Portions of the Verde River are currently boated for recreational purposes most of the year and by commercial operations at certain times of the year.

The Verde River was used for some types of boating as of the time of statehood. The river also was susceptible to a variety of types of boating during that time period, according to historical information. Additional interpretation by ANSAC of H.B. 2594 is required to determine whether these uses or potential uses constitute navigability.

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Letter and map illustrating Roosevelt Reservoir, construction costs; irrigable lands, Salt River Valley Canal, and canals.

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Navigation

Arizona Citizen, 1-1874

Arizona Citizen, 2-28-1874

Describes Hayden's ferry at Salt River in Tempe.

Arizona Citizen, 3-1874

Arizona Citizen, 5-3-1884

Man nearly drowns in Salt River after falling off ferry which broke from cable.

Arizona Gazette, 4-14-1884

Mail boat capsizes on Salt River near Tempe after collision with ferry.

Arizona Gazette, 6-3-1885

18x5 flatboat taken from Eddy's Ranch in Salt River Canyon to Phoenix. Arrived 6-5-1885 valley. "Undisputed conclusion is that logs can be floated" from uplands to valley.

Arizona Gazette, 6-5-1885

Flatboat arrives in valley, Lacy reports that boat was "tied up a Grand Canal Dam. See 6-3 and 6-8/1885 AZ Gazette Articles.

Arizona Gazette, 6-8-1885, "The Box Canyon"

Article corrects statement in 6-5-1885 paper stating recent flatboat trip was first from Salt River Canyon to Phoenix. Had been navigated 8 years earlier.

Arizona Gazette, 4/21/1888

Biggest boat yet launched on Salt River on 4/20/1888.

Arizona Republic, 2-1-1898 "The South Side"

Haws & Finch Ferry (See Finch Autobiography) in readiness.

Arizona Republic, 3-30-05

Flood rescue in boat. Also on 1-15-05.

Arizona Republic, 12-9-1905

Boat used to travel from Granite Reef dam to the Consolidated canal heading. Boat capsized twice. Visit of Reclamation VIP's.

Arizona Republic, 8-22-1912

Arizona Republic, 4-18-1941

Boats used on flooding Salt to ferry workers to salvage aviation tower.

Arizona Republic, 12-22-1985

Recent article by Earl Zarbin describing historical attempts at navigation on Salt River in 1873-1885 by C.W. Hayden and William Burch. Hayden trips with canoe and logs failed in Salt River Canyon. Burch trip successful, sailed 18x5 flatboat into Tempe, and contracted to deliver 1,000 railroad ties.

Arizona Sentinel, 1-25-1879

References a "skiff" which sailed from Phoenix to Yuma with only one portage. Skiff draws less than 2 ft. water.

Chiras, Dan
1987 Arizona's Salt River. River Runner, May. p. 30-35.

Describes recent Salt River raft trips through Salt River Canyon.

City of Phoenix
1993 Report on Navigability of Salt River. Prepared under direction of City Attorney by Jerry Coffman.

Phoenix Daily Herald, 2-15-1883

N. Wilcox and Dr. Anderson canoed from Ft. McDowell (to Phoenix) using river to Grand Canal, then canal to Phoenix - took 1.5 days.

Phoenix Gazette, 3-8-41, "Hay Day of Salt River Ferries Recalled by Boat Trip"

(Prescott) Weekly Miner, 6-21-1873

Describes canoe trip completed on Salt River. Floated logs on Salt River for 200 miles.

SRPMIC v. Arizona Sand & Rock
1976 Statement of fact for No. CIV 72-376, Salt River Pima Maricopa Indian Community v. Arizona Sand & Rock, filed March 30, 1976.

Document alledgedly signed by Court which states that Salt is not and never was navigable.

Tempe News, 3-27-1897

Ferry operates on Salt River in Tempe.

Tombstone Daily Prospector, 1-24-1889

Large ferry on Salt at Maricopa crossing was floated down river to Gila Crossing. Navigated 40 miles downstream of Phoenix, until snagged and capsized in 15 ft/sec waters, and was damaged.

U.S. Bureau of Land Management
1964 Memorandum from Director, BLM to Southwest District, Arizona dated May 15, 1964 regarding Salt River boundary.

Memo (p. 2) states that Salt was non-navigable at statehood due to Roosevelt reservoir.

Weekly Arizona Miner, 5-3-1873

Five tons of wheat shipped by L. Vandermark and W. Kilgore via boat from Tempe to Phoenix on Salt River and Swilling's Ditch on or about April 28, 1873. "Salt River is navigable for small craft..."

Maps

Unknown????
1912 Map of Salt River Reservation giving acreage under cultivation.

Wilson, E.D., R.T. Moore, and H.W. Pierce
1957 Geologic Map of Maricopa County, Arizona. Arizona Bureau of Mines, University of Arizona.

Flood Control District of Maricopa County

List of reports and maps held at the Flood Control District of Maricopa County. Information is filed in several locations including:

- Hydrology Library - Open Access
- Floodplain Management Maps - See Ron Nevitt, Floodplain Manager
- Central Filing - Near Reception Area
- Miscellaneous Information - See Dave Johnson, Chief Hydrologist

Hydrology Library

The library has books, maps, computer printouts, and photographs generally organized by river and subject. There was no index. Most information pertains to Maricopa County. Information was formerly organized by watershed. Pertinent information included:

Arizona State University, College of Engineering Studies
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Burgess & Niple, Inc.
1988 Salt River Floodplain Delineation Study, Country Club to Granite Reef Dam. October. Report to FCDMC.

Camp, Dresser, and McKee, Inc.
1981 Slat-Gila Interim Flood Control Works: Gillespie Dam to Agua Fria River. June. Report to FCDMC.

CRSS Civil Engineers, Inc.
1992 Preliminary Technical Data Notebook: Salt River Channelization Floodplain Delineation Study, 48th Street to Southern Pacific Railroad Salt River Bridge. March. Report to FCDMC.

CRSS Commercial Group
1990 Salt River Hydraulic Design: Grade Control #4 to McClintock Drive Bridge. April. Report to FCDMC.

FCDMC
undated Flooding Events, Index of Photographs and Newspaper Articles. Unpublished document prepared by FCDMC staff.

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U.S. Army Corps of Engineers
1972 Floodplain Information: Hassayampa River, Wickenberg Area. April.

Photographs
- West Side Aerial Photographs, 2 Volumes: Hassayampa River and Walnut Grove Dam. FCDMC Library.

- Salt River Aerial Photographs, Country Club to 59th. Undated. Located in FCDMC Library flat file #3.7

1978 Salt River Flood Photographs, Granite Reef to El Mirage Area, 1"=500', December. FCDMC Library.

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1988 Hassayampa River Aerial Photographs, 1:21120. FCDMC Library.

Topographic Mapping
1984 Salt River near 67th Avenue. Located in FCDMC Library Box file #B1.6.

Floodplain Management Maps

Cella Barr Associates
1988 Hassayampa River Flood Insurance Restudy. Maps prepared for FCDMC, 1"=400', 2 ft. contour interval.

U.S. Army Corps of Engineers
1984 Salt River, Central Avenue to 115th Avenue. Prepared for FCDMC. February.

Central Files

General Information - filed by subject

Salt River

Drawer #5

- 1964 Salt River: Proposed Low Flow Channel Location

Drawer #16

- 1951 Gila/Salt River Plan & Profile, Gillespie to Granite Reef
- 1960 Salt River Ownership Map
- 1965 Salt River Flood - Mapped on USGS Quadrangles
- 1970 Map of Channel Alignment
- 1978 Salt River Outfall Channel Bridge
- 1978 Salt River Lowflow Channel

Drawer #17

- 1959 Salt River Bottom Land Use
- 1962 Salt River Topography, Country Club area
- 1964 Salt River Low Flow Channel
- 1966 Salt River Water Surface Profile
- 1979 Salt River Alignment
- 1980 Salt River Aerial Photography - Mylar

Drawer #18

- 1973 Salt River Pilot Channel
- 1980 Salt River Flooding, Aerial Photographs
- 1982 Salt River Low Flow Clearing Project, Photographs

Drawer #56

- \- Salt River Topographic Map, Granite Reef to Confluence

Drawer #59

- 1964 Hassayampa River Aerials

Drawer #61

- 1951 Gila/Salt Rivers, Gillespie Dam to Granite Reef Dam, Plan and Profile

Drawer #63

- 1959 Salt River Aerials
- 1964 Salt River Aerials

Drawer #66

- 1965-66 Salt River Flood Aerial Photographs

Miscellaneous Files

Salt River, Mill Avenue to Hayden - File 17
Salt River, Photographs - File 63
Salt River, Channel Information - File 16
Salt River, Topographic Mapping - File 57
Salt River, Country Club to 59th Avenue - File 16
Salt River, Gillespie to Granite Reef, Topography -File 16
Salt River, Map of Channel Bottom - File 1
Salt River, Low Flow Channel Aligment - File 17
Hassayampa River, Photographs - File 59
Hassayampa River, Survey of Centerline and Elevation (8-23-71) - File 33

Miscellaneous Information

Mapping - See Joe Tram/Hydrologist III

1903 Topographic Map of the Salt River Valley, Arizona prepared by A.P. Davis and R.W. Hawley. 5 ft. contour interval Gila River to Arizona Dam (Granite Reef Dam). Reproducible Mylar.

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1954 Base Map of Tonto National Forest (Verde & Salt Rivers).

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Rivers Files: Hassayampa - Miscellaneous, Hydrology, Sand and Gravel.
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Special Projects Files: Historical Floods - Newspaper Accounts, 1884-1959.

- R.G. Willson, 1949, "State's Worst Disaster Wipes Out Work Camp" Arizona Days and Ways: Arizona Republic, October 2, 1949. Account of Walnut Grove Dam failure on Hassayampa River.

- Arizona Republican, 1891. "Waters Subsiding" & "Crossing the River" describes several boat crossings at Tempe in flood with 6 foot standing waves. Ferries operational within few days of flood peak. February 21-22, 1891.

Photographs - See Jan Opstein/Hydrologist II

Hassayampa River

- 1964, 1:12,000
- 1966, scale not indicated
- 1971, County Line to Confluence, 1"=1,000'
- 1978, County Line to Confluence, 1"=1,000'

Salt River

- 1941
- 1962
- 1982, Central Ave. to 115th Ave.

City of Phoenix - Floodplain Section

Information held at the City of Phoenix Street Transportation Department - Floodplain Management Section (Engineering). Does not include information prepared by City Attorney for their Salt River Study. Information from Floodplain Management is located in three main groupings:

- Drainage Study File Cabinets - Filed by River
- Flood Control Index - See attached list
- Non-project File - See attached list

Specific references held at the City of Phoenix which may contain information relating to the navigability studies include:

Advance Transportation Planning Team

1978 Salt River Bridges Concept Study, Report by City of Phoenix. August.

Halpenny, L.C.

1966 Flow in the Salt River in Relation to the Safety of the Central Avenue Bridges, Phoenix, Arizona: A Progress Report. Report by Water Development Corporation. February. Reports that Salt River was "permanent" (perennial) at Central Avenue in 1912, until 1920's.

U.S. Army Corps of Engineers

1957 Interim Report on Survey for Flood Control: Gila and Salt Rivers, Gillespie Dam to McDowell Dam Site, Arizona. USACOE Los Angeles District, C.T. Newton. December.

1967 Water-Resources Development by the U.S. Army Corps of Engineers in Arizona. Report by USACOE, Los Angeles District. January 1, 1967. Describes potential shallow draft navigation on inland waterways for recreation.

Appendix C
Note on Verde River Historical Sources

Note on Verde River Sources

The primary libraries for historical research in Arizona are (1) the Arizona State Library and Archives, (2) the Arizona Historical Society libraries in Tucson and Phoenix, (3) the University of Arizona Library, especially the special collections, (4) the Hayden Library at Arizona State University, especially the special collections and the Arizona Historical Foundation, which maintains an office in the Hayden Library. The Salt River Project maintains archives that are important in documenting the history of the Verde and other rivers. The Cline Library at Northern Arizona University and the library of the Museum of Northern Arizona have secondary sources, but with regard to the Verde River, duplicate the holdings of the libraries at the University of Arizona and Arizona State University. It should be noted that the computerized card catalog at the Cline Library at NAU can access the collections of the other university libraries in Arizona. According to Michael Sullivan, the archaeologist with the Heritage Program for the Tonto National Forest, the Forest has some old military records from the Verde River area, as well as the journal of Joseph Pratt Allyn, one of the first district judges, who traveled down the Verde (on horseback, however).

Secondary sources that provide general overviews on regional history include the Arizona Historical Foundation's (1963) history of McDowell Mountain Regional Park, Brogdon's (1952) history of Jerome, and Mawn's (1979) history of Phoenix. Walker and Bufkin's (1986) *Historical Atlas of Arizona* provides a general history of the state, illustrated with maps. Barnes (1988) and Granger (1984, 1985) give background information on the history of Arizona place names. The Bureau of Reclamation (1976), Byrkit (1988), Chamberlain (1975), Hanson (1965), Trimble (1986), and Wagoner (1975) are other secondary studies with pertinent information.

The history of the Verde specifically has been the subject of numerous secondary studies: Byrkit's (1984) article on the Verde in Bartlett's (1984) encyclopedia of American rivers, Byrkit's (1978) article on the history of the Verde, Munson's (1981) article on the history of the Verde, Parker's (1949a, 1949b) popular history of the Verde, Pierson's (1957) history of Camp Verde, and one study on navigability of the Verde River (Research Management West 1987). Descriptions of the Verde River for planning and recreation oftentimes have historical information (for example, SCORP 1989; Slingluff 1990; Taylor and Jackson 1916; Turney 1901; USDAFS 1982, 1990; Verde River Corridor Project Steering Committee 1991; and Whitmore et al. 1991). Similarly, studies of the prehistoric archaeology of the Verde are often include discussions of the history of the area and can therefore be sources of historical data (see for example, Fish 1974; Gladwin 1930; Hagenstad 1969; McNider et al. 1989; Mindeleff 1896; Minckley and Alger 1968; Morris 1928). Ayres and Stone (1984), (Hackbarth 1992), and Stein (1984) are studies of the historical archaeology along the river.

Information on Native American use of the Verde Valley can be found in Basso (1983), Gifford (1936), Khera (1978), Khera and Mariella (1983), Schroeder (1952, 1974), Simmons (1984), Stein (1981, 1984), and U.S. Congress (1990). Spanish exploration of the Verde is discussed in Bartlett (1942), Bolton (1932), Colton (1940), de Espejo (1966), Farfán (1908, 1953), Hammond and Rey (1929, 1953, 1966), Pérez de Luxán (1966), and Wyllys (1931).

Cleland (1950) and Weber (1971) are general secondary sources on the fur trade in the Southwest. Hafen (1965) is a ten-volume compendium of biographical sketches of individual mountain men. Biographies of trappers who explored the Verde include Carson (n.d., 1935), Carter (1965), Hall (1929), Hill (1923a, 1923b), Parkhill (1965), Sabin (1935), and Wilson (1965).

Foreman (1941), Sitgreaves (1853), Wheeler (1872), and Whipple (1856, 1941) recount military exploration of the Verde. The Surgeon General's (1870) report on military posts contains descriptions of Fort Verde and Fort McDowell. The history of Fort Verde is discussed in Eason (1966) and Pearson (1957). Fort McDowell has been the subject of a number of historical studies (Chamberlain 1975; Huntington 1957; Reed 1977; Stein 1984). The entire reservation was inventoried for archaeological sites by the Arizona State Museum (Canouts 1975). Most of the archives of the Fort McDowell Indian Reservation are in the tribal library there. These archives were used by Stein (1984) for her study of the historical archaeology of the Fort McDowell Indian Reservation, but she found the state library and archives and the state university libraries equally important. Corbusier (1968) and Summerhayes (1908, 1911) are firsthand accounts of life at these posts.

Reminiscences and local history can be found in Goddard (1984), Groseta (1984), Palmer (1979), Simmons (editor, 1984), and the Verde Valley Pioneers Association (1954, 1972). Wahman (1971, 1983) discusses the history of railroading along the Verde.

Several other historical studies have focused on the dams constructed along the river (Introcaso 1990; Jackson and Fraser 1991; Salt River Project 1966).

A number of early histories and boosters' descriptions of Arizona (Adams 1930; Bancroft 1889; Farish 1915; Hamilton 1884; Hodge 1877; McClintock 1916; Wallace W. Elliot & Co. 1884; Woodruff 1912) might be considered primary sources. For example, Hamilton (1884), Hodge (1877), and Wallace W. Elliot & Co. (1884) are promotional literature that might be expected to publicize navigability of the rivers if it was at all feasible, but none of these volumes does. Hamilton (1884) has 14 pages of advertisements in the back, including ads for stagecoaches, but none for railroads or river transportation.

Newspapers proved to be the greatest source of accounts of boating on the Salt River, but contained little on boating on the Verde. Newspapers are on microfilm at the State Library and Archives (as well as at the libraries of the University of Arizona and Arizona State University). The State Library and Archives has a listing of all of the newspapers published in the state. Earl Zarbin has examined Arizona newspapers published between 1859 and 1918 and compiled an index of articles relating to water in Arizona (Zarbin n.d.). Mary Lu Moore, historian with the State Attorney General's Office has a copy of this index.

General Land Office maps, located in the State Library and Archives, were made between 1872 and 1920. Maps were not made for national forests, Indian reservations, or land grants. These maps provide information on activities along the river--including stores, houses, farms, ranches, dams, irrigation ditches, fields, roads, trails, an Indian camp, a church, a cemetery, a mine, and other sites-

-during the period around the time of statehood. The maps showing the Verde River did not illustrate any sites associated with boating.

Sanborn Fire Insurance Maps were produced for most of the communities along the river and can be found in the special collections of the Hayden Library at Arizona State University and the Library at Northern Arizona University. Like GLO maps, Sanborn Fire Insurance Maps provide information on activities along the river, but in the case of the Verde River did no illustrate any sites associated with boating.

Many of the museums and libraries around the state maintain collections of photographs. Among the most extensive are those of the libraries of the state universities, the state historical societies, the state library and archives, and the Salt River Project, mentioned above. The Arizona Historical Foundation has a separate catalog of photographs in its collection.

Appendix D
Oral History Summaries

THIS IS A GENERAL SAMPLE LETTER SENT OUT TO INDIVIDUALS AND INSTITUTIONS.

June 15, 1993

Hanna J. Cortner
Water Resources Research Center
350 North Campbell
Tucson, Arizona 85721

Dear Ms. Cortner:

SWCA, Inc. Environmental Consultants has received a contract from the Arizona State Land Department to conduct a study of historical uses of the San Pedro, Hassayampa, Salt and Verde Rivers at the time of Statehood (1912). The specific objective of the study is to determine whether or not the rivers were navigable in 1912. The beds of rivers that were navigable at the time of Statehood are held in trust by the state.

We would like to know if you have any knowledge of photographs, diaries, manuscripts, or any other information on uses of these rivers at the time around 1912. We would be particularly interested in knowing about commercial uses of the river, including boating, ferries, mills, dams and reservoirs, irrigation agriculture, water diversions, hydraulic mining, and recreation.

If you have any information, or would like more information from us, you may contact Dennis Gilpin, Historical Archaeologist, in our Flagstaff office (602) 774-5500.

Sincerely,

Javier F. Torres
Ethnographer/Archaeologist

KEY TOPICS AND QUESTIONS FOR INTERVIEWS

(1) Do you know of any use of the river for transportation or commerce? Recreational boating? Ferries? Floating logs? (It may be helpful to explain navigibility with the example that in Oregon, streams that were used seasonally to float logs to the sawmill have been considered navigible.)

(2) Was irrigation practiced along the river? What areas were irrigated? How reliable was the stream flow, both seasonally and year to year?

(3) What were the principal means of transportation in the area? Railroads? Stage and liveries? Highways?

(4) Are there fish in the river? What species?

(5) How has the river changed historically?

(6) Do your have or know of any photographs, diaries, letters, or journals that would describe or illustrate use of the river? (If they have anything like this, it should be donated to a local or state museum or historical society, so that it is formally archived and documented.)

(7) Do you know anyone else we should contact?

LIST OF HISTORICAL SOCIETIES, AND SUMMARY OF MUSEUMS AND PERSONNEL CONTACTED

4-14-93

Buckeye Valley Historical and Archaeological Museum
116 Highway 85 East
Buckeye, AZ 85326
Tel: 602-386-4333

The Buckeye Valley Historical and Archaeological Museum's records indicate extensive use of the Hassayampa for canals and irrigation. The museum, according to Michael Sullivan, has some canal company reports that mention the building of sand dams across the Hassayampa to let water out of the canals. He suggested contacting the Buckeye Irrigation Company in Buckeye (602-386-2196) and the Roosevelt Irrigation District (602-386-2946). The museum has early Buckeye Irrigation Company records but Sullivan said that the Buckeye Irrigation Company might know more about it. He also said that there is an Old Settlers Reunion on May 5 at Palo Verde (which is in part of the canal system). He feels this might be a good place to get information from some of the oldtimers--they like to reminisce a lot. He also said that *History of the Buckeye Canal* by I. H. Parkman is a good summary of water in the Hassayampa area. Parkman is a native of the area. NOTE: Michael Sullivan is the archaeologist with the Heritage Program for the Tonto National Forest. He told me that the Forest has some old military records from the Verde River area, as well as, the journal of Joseph Pratt Allyn, one of the first district judges, who traveled down the Verde (on horseback, however).

4-26-93

Camp Verde Historical Society
P.O. Box 1184
Camp Verde, AZ 86322
Tel: 602-567-9560 or 567-3489

The Camp Verde Historical Society does not have information on navigation use of the Verde River. Betty Tome, historian for the Society, said she doesn't have any knowledge on navigation of the Verde River, and suggested we talk to Bob Munson who works at Fort Verde. She mentioned that at one point the soldiers at Fort Verde used a boat for fishing, but that beyond this information she had nothing for us on navigation. What the Camp Verde Historical Society has in their archives is passed down to them from Fort Verde. What information she does have on the river is on settlement of the area, and river use for irrigation.

4-23-93

National Archives Federal Records Center
Diane Dixon, Director
#24000 Avila Road
Laguna Niguel, CA 92677
Tel: 714-643-4241

Suzanne Dewberry, administrator, mentioned that there is a lot of material in the archives, and that nobody but herself knows them better, and she does not know of anything on the subject. She mentioned that there are 24,000 feet of paper in those archives and that and index does not exist, and the archives inventory is not computerized. She suggested contacting Bob Trennert and a Mr. Fontana, who retired from Arizona State University. She mentioned also contacting Mr. William Creech in Washington, D.C. to find out about coast guard ships plying the rivers in Arizona. Mr. Creech would know if anyone should, she said, because he should know about the Revenue Cutter Service of the Old Coast Guard (202-501-5395). She said that she would send us a Finding Aid which is an aid to figuring out what articles we want copied. There are records of the BLM and other federal agencies dating back to 1880s or so.

4-26-93

Contacted Angie Vandereedt (Washington, D.C., National Archives of the Old Coast Guard, 202-501-5395), who takes care of Old Coast Guard Records with William Creech. Ms. Vandereedt said that she will look into the issue of navigation on Arizona Rivers. From this information index compiled we can pick what we want copied and send for it.

5-3-93

Angie Vandereedt replied that she could not find any evidence of navigability for any of the four Arizona Rivers.

4-20-93

Scottsdale Historical Society
Thelma Holveck, Historian
3839 Civic Center Plaza
P.O. Box 143
Scottsdale, AZ 85252
Tel: 602-945-6650

Scottsdale Historical Museum
Joann Hanley, Secretary
Tom Lennon, President
Tel: 602-945-4499

Neither the Scottsdale Historical Society or the Scottsdale Historical Museum have any information on river navigation. Thelma Holveck, historian for the Society, mentioned she does not know of anything on navigation in the Salt River. She mentioned that from Granite Reef Dam to the Tempe-Mesa-Phoenix area the river would have not been navigable because normally there is not enough water in the Salt. A lot of it, she said, runs underground. In 1912 she said there would not have been enough water anyway. As far as the Verde River is concerned she said there could have been navigation, but again this was only guesswork. Ms. Holveck suggested I talk to Marshall Trimble, Southwest Historian, who works at Scottsdale Community College (SCC switchboard 602-423-6000). Joann Hanley of the museum said she is going to send us a letter stating that the museum does not have any information on navigation, only on canals. Ms. Hanley stated that she was "pretty sure" there was no information in the archives on navigation, because Scottsdale was simply too far from the rivers. Regarding other information, such as diaries, newspapers, journals, and photos Ms. Hanley said that what they have in the archives only goes back to 1950s.

8-12-93

Tempe Historical Museum
809 E. Southern Avenue
Tempe, Arizona 85282
Tel: 602-350-5100

Talked to Scott Soliday, research historian. He said that they had quite a bit of information on the Salt River. This information includes data on sand and gravel businesses and Hayden's Ferry. They have references from the *Tempe Daily* and old photographs of Hayden's Ferry. He has seen a reference to an article in the *Mesa Free Press* of 1890 or 1891 that discusses the Verde. The article discusses Mr. A. J. Chandler who was building the Consolidated Canal and had logs or sawn timber from the dismantled Ft. McDowell floated down the Verde to use for constructing the canal head gates. He also said that the information they have on the Salt is organized according to subject so that data pertaining to rivers would probably be easily accessible.

6-14-93

Julio Betancourt
US Geological Survey-Tucson
Water Resources District Office
602-670-6821

Mr. Betancourt was brief about his knowledge about the rivers. He does not have any knowledge about the Hassayampa, Verde or Salt. His knowledge covers the southern part of the state and its rivers. He basically is not too familiar with historical uses of any of the rivers in that part of the state. His area of expertise is in biological processes. He mentioned he did a study on the Santa Cruz and the San Pedro rivers, and will send a copy of the report on the San Pedro to SWCA, but he doesn't think the San Pedro was used for navigation.

4-27-93

Don Bufkin
Arizona Historical Society
949 E. Second Street
Tucson, Arizona 85719
Tel: 602-628-5774 or 298-1705 (h)

Mr. Bufkin, former employee of the Arizona Historical Society in Tucson, retired, mentioned he had done a consulting job in Pinal County and talked about his study on the Santa Cruz River. He mentioned that the San Pedro River is basically similar to the Santa Cruz, but that he did not know much on the four rivers being investigated. He suggested contacting Mr. Bob Trennert to get more information, and mentioned a former student of his by the last name of McCroskey who did two projects, one on the Verde River and the other on the Salt River. These articles, he believes, may have information which may shed light on this issue. Bob Trennert would know the name of the documents and her full name. He also mentioned that I should talk to Julio Betancourt, who works on Tumanok Hill in Tucson with the USGS. Julio Betancourt and Ray Turner co-authored a article called "The Changing Mile" which covers the changing biota on the Santa Cruz River. As far as navigation is concerned he only mentioned that Hayden's Ferry would have met federal standards for navigation, and that at one point people were moving lumber down the Salt. He said we could contact him later if we needed more information.

4-32-93

Mr. Jim Byrkit
Environmental Sciences Professor
Northern Arizona University
P. O. Box 5694
Flagstaff, Arizona 86011
Tel: 602-523-9333

Mr. Byrkit basically said that the Verde River could not be navigable. He said that he had been consulted in the past about this same issue by David Baron of the Arizona Center for Law in the Public Interest in Tucson (602-327-9547). Mr. Byrkit said that the courts decided the Verde was navigable in a case pursued by Mr. Baron. Mr. Byrkit said that he has not heard or does not know of the Verde ever being navigable for commercial purposes. The only season it can be navigable, that is boating for recreation or white watering, is in February - March. Afterwards it cannot be run because it dries up or because it is dangerous. A lot of people have died in the Verde because they enter the river during flooding. Speaking about the history of the Verde, he said that when the Spaniards and first Anglos entered the area of the Verde they encountered a swamp. Afterwards, with the introduction of cattle, the river environment changed, and it might have been navigable afterwards. Nowadays it may be navigable perhaps in a shallow bottomed boat going downstream. Mr. Byrkit said that the river was used for floating logs to build a lodge called the Verde House Spring Lodge (or something similar) in 1958. Jim Byrkit suggested contacting John Parsons who lives in the Verde Valley by the river, but that his name is not listed in the phone book. Mr. Byrkit said that he studies the river because he likes to know about everything related to the river's watershed, and how everything associated with the river has changed. He grew up in the Verde Valley and developed an attachment to the river at an early age. "The Verde is the last free flowing river in Arizona", he said. Mr. Byrkit suggested consulting a copy of the Verde River Corridor Project Final Report and Plan of Action by Tanna Thornburg and Peggy Tabor of Arizona State Parks (602 542-4174). Mr. Byrkit said that if there were any more questions we could contact him.

7-15-93

Pete Groseta
740 Mingus View Dr.
Cottonwood, AZ 83326
634-2366

He is a ditch boss for an irrigation system along the Verde in Cottonwood. He did not want to give out any information without first checking with the Board of Directors for the irrigation system in that area. He gave me another persons's name, George Kowakalvich, who is the ditch boss for the OK ditch on the middle Verde. Groseta said that if I sent out a letter to him detailing the types of questions that I had, then he could take that to the board, and they could contact us with any pertinent information. I sent a letter out to him.

7-27-93

Louis Hood
Tribal Planner
Ft. McDowell-Apache Indian Community
837-5121

He had been sent a letter requesting information about historical use of the Verde River. He personally doesn't know of any historical use of the river or of any historic documents. He forwarded the letter to the Tribal Chairman, who is going to send it to the BIA so that they could initiate some historic research.

4-9-93

Mary Lu Moore, Historian
Arizona State Attorney General's Office
1275 West Washington
Phoenix, Arizona 85007
Tel: 602-542-1401

Met with Mary Lu Moore to describe proposed program and to develop list of contacts. She provided Earl Zarbin's name, address, and telephone number.

6-14-93

Ms. Moore does not work on navigation issues but on water rights, and has done a good amount of research on water history. She suggested talking to Phil Moreland and Terry O'Sullivan (602 650-0509) of the BLM Arizona District Office because they are doing research into Wild and Scenic Rivers and their environmental impact statements. They are conducting an EIS on the Hassayampa, but only on public lands, but would possibly intersect with state lands. Ms. Moore also said that in the future she will provide SWCA with material the BLM has done in terms of historical research on the Hassayampa River. She also suggested we contact Gail Atcheson of the BLM Phoenix Resource Area Office (602-780-8090). She concluded by saying that if we needed more help we should contact her.

4-14-93

Mr. Bob Munson, Park Manager
Fort Verde Historic Park
P. O. Box 397
Camp Verde, AZ 86322
Tel: 602-567-3275

Bob Munson said that making the Verde River a navigable river was like `trying to make a silk purse out of a sow's ear'. Mr. Munson added that nobody used the river for commercial purposes either prior to or following the territorial period. The mountain men may have used canoes but since most of them were illiterate, there are no written records of them having done so. Regarding the Fort he said that when it was abandoned and then sold in 1899 "the world ended". During the 1880s, the Fort was issued a collapsible boat, because they needed a way to get messages and messengers across the river in times of high water. Other uses the boat had was for fishing, and that there is a photo of the boat at the Fort. Munson said that he heard a rumor that there was a slight possibility that during the late 18th century the Spanish may have run boats on the Salt and the Gila (but that we shouldn't quote him on this). It is more unlikely that the Verde was used for commercial purposes.

4-27-93

Bob Trennert, Historian
Arizona State University
History Department
Tempe. Arizona 85287
Tel: 602-965-6322 or 963-7795

Mr. Trennert did not know much about navigation on either of the rivers. He suggested we talk to Mr. Noel Stowe of the history department in Arizona State University. Mr. Stowe would perhaps know of two students by the name of Janet Burk and Carol Martell who at one point, if he remembers correctly, did a study on the navigation of Arizona rivers. He did not know of Janet Burk's whereabouts, but Carol Martell works part time for the history department Arizona State University. I mentioned that Don Bufkin had mentioned a woman named McCroskey. Mr. Trennert said that maybe she did the study, and that her name was Mona McCroskey. Ms. McCroskey, he said, may have worked at the State Historic Preservation Office and that we should contact Reba Wells who would likely know where she is. He mentioned that he was going to the Annual Arizona Historic Convention in Bullhead City and that he would see if Ms. Wells or Ms. McCroskey or anyone else may know the whereabouts of these people and anything about river navigation. Mr. Trennert said he would call back as soon as he got some more information.

6-14-93 and 7-5-93

Earl Zarbin
3803 E. St. Catherine Ave.
Phoenix, Arizona 85040
Tel: 602-437-2665

Mr. Zarbin sent two letters providing references to boating, ferries, and fish. These references pertained essentially to the Salt and Verde rivers. In his letter of 6-14-93, he cited two accounts of soldiers boating from Fort McDowell to Phoenix. The first article, in the *Arizona Gazette* (February 14, 1883), described the 18-hour trip of North Willcox and Dr. G.E. Andrews in a canvas skiff. The second article, in the *Phoenix Herald* (December 12, 1888), described how Major E.J. Spaulding, the commandant at Fort McDowell, and Captain Hatfield were canoeing down from Fort McDowell, hunting along the way, and while lifting their canoe over the Mesa Dam, Major Spaulding's gun accidentally discharged, killing him.

Appendix E

Verde River Geomorphology

This was not modified in the 2003 revision. The original is on file with the Arizona State Land Department Drainage and Engineering Section.

Appendix F
Verde River Rating Curves

This was not modified in the 2003 revision. The original is on file with the Arizona State Land Department Drainage and Engineering Section.

Appendix G

Arizona Climatic Variation

Arizona Climatic Variation

Introduction

This appendix presents a brief overview of historical variation in Arizona climate with respect to potential navigability of the Salt, Verde, San Pedro, and Hassayampa Rivers. The objective of this overview is to provide information which may help address the following questions:

- Was the climate around the time of Arizona statehood (1912) significantly different from current or pre-statehood conditions?
- Does the period of record for stream gages adequately represent long-term stream discharge rates?
- Have changes or fluctuations in Arizona climate changed streamflow conditions in a manner that would affect navigability?

Methodology

Information presented in this appendix is summarized from published sources. No new analyses o f c limatic d ata were conducted by the author. This summary focuses on climatic affects streamflow. Data from the published studies was derived from: daily precipitation and temperature readings for central and southern Arizona dating to the mid-1800's; stream flow gage records by the U.S. Geological Survey (USGS), U.S. Reclamation Service (BUREC), and others dating to 1888; tree-ring records for the past 400 years; and other more recent regional or national weather data from the National Weather Service (NWS). Cited references have more detailed descriptions of data sources.

Stream Gage Records

Gage names and the periods of record for stream gages used for stream navigability studies of the Salt, Verde, San Pedro, and Hassayampa Rivers are summarized in Table G-1. Only gages with statistically significant periods of record were used. The gage records generally do not account for irrigation diversions or other impoundments that would alter streamflow rates.

Stream Gage	Period of Record (Water Years)
Table G-1 Period of Record for Key Stream Gages Within Study Area	
Salt River	
@ McDowell	1-11/1889; 1901-1911
Granite Reef (Arizona Dam)	
Verde River	
@ McDowell	8-9/1889; 1897-1899; 1901-1936
@ Tangle Creek	1945-present
nr. Camp Verde	1934-1945; 1988-present
@ Camp Verde	1914-1921
nr. Clarkdale	1915-present
nr. Paulden	1963-present
San Pedro River	
@ Palominas	1930-1933; 1935-1940; 1950-1981
nr. Benson	1966-1976
@ Fairbank	1912-1928
@ Charleston	1904-1906; 1913-1926; 1929-1933; 1936-present
nr. Tombstone	1967-1986
nr. Redington	1943-1946; 1950-1978
@ Winkelman	5-8/1890; 1966-1978
Hassayampa River	
@ Walnut Grove/Wagoner	1912-1918
nr. Wickenberg (Box Cyn)	1921-1938; 1946-1982
nr. Morristown	1939-1947; 1964-1989
nr. Arlington	1961-1989

Arizona Climate Change

Climate change is measured by monitoring weather characteristics such as daily, monthly, seasonal, or annual temperature, precipitation, or relative humidity. Although weather records for the period prior to Arizona statehood in 1912 are not as extensive as for the period since statehood, sufficient data exist to give indications of pre-statehood climatic and streamflow conditions.

The BUREC began direct measurement of streamflow on the Salt-Verde system in late 1888 at the Arizona Dam irrigation diversion, and has since been continued to the present time by the USGS at several upstream locations. Smith and Stockton (1981) and Graybill (1989) used tree-ring[1] records to extend gage records to 740 A.D.; Dean et al (1985), and Euler et al (1979) used tree-rings, pollen data, and alluvial sedimentation patterns to estimate periods of increased/decreased moisture to 600 A.D. Tree-ring records may be used to estimate annual

[1] Tree ring studies assume the thickness of the individual annual rings are related to discharge. Wet year (high average annual flow) give rise to thicker rings. Individual tree rings can be readily matched to specific years. Smith and Stockton's data was calibrated using recent gage data and recent tree ring records.

flow volume. Smith and Stockton's interpretation of the tree-ring record indicates the following:

- The period from 1905-1920 (Arizona statehood) was the wettest period since 1580 in both the Salt and Verde River watersheds.

- The period from 1900 to 1979 (Salt River gage record) had an average annual flow volume slightly greater than the 400 year mean annual volume.

- The period from 1940-1977 on the Salt River, and from 1932-1977 on the Verde River had below average annual runoff. This period corresponds to the majority of the gage record of most Arizona stream gages (Table G-1).

- Base flow in the Verde River is controlled by springs, rather than climatic factors. Low precipitation does not generally affect discharge from springs.

- Irrigation diversions impact Verde River streamflows.

Graybill's data also indicate that average flow from 740 -1370 A.D. was somewhat less than twentieth century average flows on the Salt River. However, summer low flows were found to have more predictable average flows during that period. Dean's and Euler's paleoenvironmental studies determined that there were no radical differences in the prehistoric Arizona climate compared to the modern climate.

Other tree-ring studies by Stockton (1975) elsewhere on the Colorado Plateau also found that the early 1900's was an unusually "wet" period. Unfortunately, tree ring data in the Hassayampa River and San Pedro River watersheds have not been analyzed. However, other investigations (c.f. BUREC, 1948) have demonstrated hydrologic similarity between the Hassayampa and Verde Rivers. Therefore, it is assumed that the long-term climatic trends predicted for the Verde River apply to the Hassayampa River.

For the San Pedro River, climatic data older than 1904 streamflow records and 1867 rainfall records are not available. However, the impact of climatic change on the San Pedro River has been extensively studied. Cooke and Reeves (1976) analyzed precipitation records from 1867 to 1960 for southern Arizona and concluded that the:

- Total annual, annual summer, and annual non-summer precipitation volumes did not significantly change from 1867 to 1960, although total precipitation volume varies significantly from year to year.

- Frequency of heavy rains (>1 inch/day) decreased significantly from 1867 to 1900, and decreased slightly thereafter.

- Frequency of light rains (<0.5 inch/day) increased significantly from 1867 to 1900, and increased slightly thereafter.

Hastings and Turner (1965) reach similar conclusions as Cooke and Reeves, and also note a slight increase in average temperature since 1895. Since the heavier rains result in stream runoff, decreasing intense rain events and increasing light rain events probably decreased stream runoff in the San Pedro River. Since the San Pedro is not strongly impacted by snowmelt runoff, increasing the total annual volume of light winter rains did not influence runoff. Finally, the Arizona Department of Water Resources (1991) also reports generally declining flow rates in the San Pedro between 1913 and 1988.

In regional climatic studies, Sellers (1960) recorded a decreasing, but not statistically significant, trend in total annual precipitation averaging about 0.03 inch/year. Thomsen and Eychaner (1991) statistical analysis of 109 years of rainfall records from the Tucson Basin indicated no trend in precipitation. Peterson (1950) demonstrated that total annual precipitation was above average between 1881 and 1884, a period of extensive channel change in southern Arizona. In northern Arizona, Hereford (1984) notes a period of lower than average runoff and precipitation and above average temperature in the 1940's and 1950's when compared to records for the rest of the twentieth century. This drought period affected most of the Rocky Mountain states. Hereford also concludes that beginning in 1900, precipitation abruptly increased until about 1910, at which a progressive decline began that lasted until 1956. Since 1956, average temperatures have cooled somewhat, and discharges increased somewhat. Regional analyses of archeological data have concluded that there were no radical differences in climate that would have affected streamflow (Graybill and Gregory, 1989).

Analysis of national climatic data by Diaz and Quayle (1980) indicates that in the southwest, the period between 1920 and 1954 had warmer winters, cooler summers and less precipitation than the period from 1895 to 1920. These data generally support the observations of Hereford (1984) and Stockton (1975) cited above, and suggest that climatic conditions may have favored higher runoff rates around the period of Arizona statehood.

Conclusions

The affects of climatic variations on potential stream navigability and channel conditions are complex, and cannot always be clearly distinguished from stream changes initiated by man. However, some basic conclusions can be drawn from the studies cited above.

First, Arizona's climate at statehood was not drastically different from existing or pre-statehood conditions. The same basic climatic patterns applied. Summers were warm and relatively dry with intense, late summer monsoonal rainfall. Winters were cool, with less intense Pacific frontal storms bringing snow to higher elevations and rain to lower elevations. However, subtle difference in rainfall and temperature patterns around the time of statehood may have resulted in higher average streamflow. These differences included:

- Generally higher precipitation and streamflow volumes
- More frequent intense monsoonal rainfall
- Cooler average temperatures, with warmer summers and cooler winters

Therefore, the period surrounding statehood was probably subject to higher than average streamflow, indicating that streams may have been more likely to have been navigable at statehood, than during other, less "wet" periods of Arizona history.[2] It is noted that some of Arizona's largest floods, in terms of both volume and peak flow rate, occurred in the twenty years prior to statehood.

Second, stream gage records must be used cautiously to adequately predict the natural, long-term average discharge rates. Tree-ring records indicate that the average annual flow rates on the Salt and Verde Rivers between 1900 and 1980 are just slightly above the average annual flow rates for the past 400 years. Gage records from 1905 to 1920 may predict average flow conditions well above long-term average rates, but may accurately reflect conditions at statehood. G age records with the majority of years of record in the 1940's and 1950's may predict average flow conditions below the long-term average, and well below the wetter conditions at statehood. Of course, stream gage data must also be filtered to account for human impacts on streamflow, such as reservoirs, irrigation diversions, and groundwater withdrawal. *In general, use of the existing stream gage database will probably result in prediction of flow rates less than those that existed at statehood.*

Third, changes in climatic conditions may have in fact altered stream conditions that would have affected navigability on some Arizona streams.

- For the Salt River, climatic changes are almost completely obscured by human impacts on the stream system. These human impacts include construction of reservoirs, irrigation diversion, groundwater withdrawal, channelization, mineral extraction from the river bed, and addition of urban storm waters. Climatic conditions may have contributed to somewhat higher low flow channel stability due to sustained, higher (low) flows. Conversely, extreme floods which occurred in the three decades prior to statehood may have adversely affected channel conditions.

- For the Verde River, climatic variation has little affect on low flow conditions due to steady base flow from springs and geologic control (bedrock) for much of the river. In the more densely populated, alluvial reaches of the Verde Valley urbanization may obscure climatic impacts. However, climatic records indicate that higher than average flow in the Verde River probably occurred around the time of statehood, making navigation more possible at statehood than during other periods of history.

- For the Hassayampa River, like the Verde River, climatic changes probably had minimal impact on whether the Hassayampa River was navigable at statehood. Hassayampa River low flows and channel geometry are probably more controlled by geology (bedrock and springs) and flood hydraulics, than by minor climatic perturbations. Very little evidence of climatically induced channel change was uncovered.

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[2] Human impacts such as reservoir construction, ground water withdrawal, etc., have tended to lessen average stream discharge rates obscuring climatic affects on some Arizona streams.

- For the San Pedro River, climatic changes may have had a more significant impact on potential navigability of certain stream reaches, particularly for the period preceding statehood. Several studies have demonstrated a strong climatic influence on arroyo cutting in the San Pedro River in the late 1800's. Development of arroyos changed reaches of the San Pedro River from cienega's, beaver dam impoundments, and marshlands (which may have been navigable) to sand-bottomed channels with steep vertical banks. However, this arroyo cutting episode is thought have been substantially complete before statehood. Since statehood, the subtle climatic changes that have occurred tend to make the San Pedro River less navigable than at statehood. That is, runoff producing rainfall frequency has decreased. In addition, other factors have reduced average streamflow rates from statehood levels.

Summary

Some data available from which to evaluate climatic conditions at the time of statehood relative to the climate during other periods of Arizona history. These data indicate that the period around statehood favored higher runoff rates in many Arizona streams than in the years preceding or following statehood. Use of modern streamflow records will generally result in estimates of flow rates less than what actually occurred at the time of statehood. In general, however, these minor climatic perturbations have less impact on stream navigability than have human-induced changes to the watersheds and stream channels.

Appendix H
Boating on Arizona Rivers

Boating on Arizona Rivers

Introduction

The exact criteria which define what "navigability" means for Arizona rivers will be established during the streambed adjudication process. The objective of this report is to provide information federal boating criteria and the types of boating which have occurred historically in Arizona. Several types of information are presented including:

- Federal navigability criteria
- Historical accounts of boating
- Modern boating records

Historical and modern accounts of boating are presented only for four Arizona streams: the Salt, Verde, San Pedro, and Hassayampa Rivers.

Federal Criteria for Navigability

The federal government has not yet published universally applicable criteria to explicitly define title navigability. Rather, specific agencies use criteria defining title navigability that have been developed at the state level based on case law. These criteria vary somewhat from state to state. However, some federal agencies have formally described stream conditions which favor various types of boating. One such description was developed by an intergovernmental task force, the Instream Flow Group, to quantify instream flow needs for certain recreational activities, including boating (US Fish and Wildlife, 1978). The US Department of the Interior independently developed their own boating standards (Cortell and Associates, 1977). These federal criteria, summarized in Tables G1 and G2, were developed primarily for recreational boating (transport of people), not necessarily for commercial boating. Minimum stream conditions required are summarized in Table H1. Minimum and maximum conditions are summarized in Table H2.

Table H1
Minimum Required Stream Width and Depth for Recreation Craft

Type of Craft	Depth (ft.)	Width (ft.)
Canoe, Kayak	0.5	4
Raft, Drift Boat, Row Boat	1.0	6
Tube	1.0	4
Power Boat	3.0	6

Source: US Fish and Wildlife, 1978

Table H2 Minimum and Maximum Conditions for Recreational Water Boating						
Type of Boat	Minimum Condition			Maximum Condition		
	Width	Depth	Velocity	Width	Depth	Velocity
Canoe, Kayak	25 ft.	3-6 in.	5 fps	-	-	15 fps
Raft, Drift Boat	50 ft.	1 ft.	5 fps	-	-	15 fps
Low Power Boating	25 ft.	1 ft.	-	-	-	10 fps
Tube	25 ft.	1 ft.	1 fps	-	-	10 fps
Source: Cortell and Associates, 1977						

Some Arizona boaters surveyed for this study did not agree with the minimum velocity criteria given in Table H2. They argue that since boats can be used on lakes and ponds which have no measurable (zero) velocity, no real minimum velocity exists, except perhaps for tubing. Minimum velocities in Table H2 are probably intended to indicate what stream conditions are most typically considered "fun."

The Bureau of Land Management (BLM) apparently has adopted a "narrow" definition of navigability (Rosenkrance, 1992). BLM criteria to determine title navigability include:

- The original condition of waterway at date of statehood is used
- Use by small, flat bottom sport boats or canoes is not navigation
- Navigation must occur at times other than seasonal floods
- Unaccessible streams are not navigable
- Long obstructions such as bars makes upstream segments unnavigable

No documentation of application of these guidelines by the BLM in Arizona was uncovered, although BLM apparently did not consider the Salt River navigable at statehood due to the closure of Roosevelt Dam (BLM, 1964). Other federal agencies have stated that the Salt and Verde are non-navigable stream, as discussed below, although specific criteria which formed the technical bases of these decisions are lacking.

Historical Accounts of Boating

Boats were in use during the period around statehood. Newspaper stories, contemporary reports, anecdotal information, and oral histories all provide evidence of boating on Arizona rivers. Documented uses of boats included:

- Travel
- Ferries
- Recreation

- Mail Delivery
- Flood Rescues
- Transport of Goods

Several accounts of floating logs down Arizona rivers are also documented. Review of historical records of boating gives the general impression is that there was no shortage of boats in the Salt River and Verde Valleys. Whenever a boat was needed to cross a flooded river, even during the period of early exploration, boats were borrowed from local residents, used and returned. The presence of boats in arid regions like Phoenix, Tempe, and the Verde Valley, despite there being no sizable lakes within several days travel, argues for frequent, or necessary, use of boats on the rivers.

The most extensive documentation of historical river boating is for the Salt River. Prior to statehood, before irrigation diversions and closure of dams upstream depleted river flows, at least five ferries were in operation at various locations between Granite Reef Dam and the Gila River. Sixteen episodes of boating, involving portions or the entire study reach, are recorded. A few, but not most of these boating episodes were unsuccessful, though not for lack of streamflow within the study area. Typical problems encountered included snags and sandbars, or narrow canyons on the upper Salt River, above the study reach.

Some documentation of boating on the Verde is also available. Historical accounts are of course concentrated in reaches with settlements, particularly the lower Verde near Fort McDowell and the Verde Valley. Boats used include canvas canoes, a steel boat, a skiff, and a flat-bottomed boat. The boated reach extends from Cottonwood to the Salt River confluence, most of the same reach which is frequently boated today.

No documented historical accounts of boating on the San Pedro and Hassayampa Rivers were uncovered. SWCA ethnographers discovered anecdotal evidence of a ferry operated on the San Pedro River at Pomerene at some time prior to statehood. It is noted that early explorers who travelled the San Pedro on foot, or by horseback and wagon, in some cases built boats upon reaching the Gila River. For the Hassayampa River, the only account of floating comes from a single report describing caskets which were floated downstream after the catastrophic dam failure and flood of 1890.

It is noted that for all of the instances of boat use on the Salt, Verde, San Pedro, and Hassayampa Rivers, the boaters travelled downstream or across the river. No evidence of boating in the upstream direction was found. Furthermore, several accounts of taking boats upstream by wagon after or before boating were discovered. Boating on the Salt and Verde Rivers apparently was not limited to the wetter months or seasonal floods. Several accounts of boating the Salt River during May and June, two months which typically have annual minimum flows. Both attempts to float logs were conceived and executed by Salt River Valley residents during summer months, not winter high flow periods. This fact suggests that the residents assumed the portion of the river they were most familiar with, the study reach, could support log transport during the summer low flow period. Historical accounts of boating on the Verde River are generally limited from early winter to late spring.

The type of boats typically used were flat-bottomed boats, skiffs, or canvas and wooden canoes. Information presented in Table H3 summarizes probable stream characteristic required to support use of the type of boats available at statehood. The criteria for canoes are not substantially different from criteria for canoes available today.

Table H3
Flow Requirements for Pre-1940 Canoeing

Boat Type	Depth
Flat Bottomed (Wood or Canvas)	4 in.
Round Bottomed (Wood or Canvas)	6 in.

Source: Slingluff, J., 1987

Historical Accounts of Fish

Although the presence of fish in a river does not necessarily indicate that boatable conditions exist, existence of certain species do provide some information about flow conditions. Archeological evidence indicates that the same species found in Arizona rivers in prehistoric times were also present around the time of statehood (James, 1992). Change in fish species distributions did not occur in most rivers until the 1940's (Minkley, 1993). Some of the species found in the Salt, Verde, and San Pedro Rivers included very large fish such as squawfish (aka Salt River Salmon, Colorado River Salmon) some of which grow to over three feet long, razorback sucker, and flannelmouth sucker. The latter fish tend to indicate "big river" conditions (Minkley, 1993), by Arizona standards. Very little data are published regarding fish populations on the Hassayampa River, although Arizona Game and Fish has introduced some species in the upper reaches.

Historical accounts of fishing are centered on early explorer routes and settlements. There are numerous accounts of "salmon" runs (actually squawfish) on the Salt and San Pedro Rivers, catching hundreds of fish from the Salt River near Phoenix, fish left to die after canals diverted streamflow in the Salt, fish clogging canals on the San Pedro River, and catching fish with pitchforks for use as fertilizer on irrigated fields. A commercial operation harvested razorback suckers between 1870 and 1910 near Tombstone. Fishing remains a popular pastime on the Verde River today.

Modern Accounts of Boating

Some Arizona rivers are still boated in modern times. While modern boat use of a river may not provide definitive proof of susceptibility of a stream to navigation at statehood, it is evidence that is readily available for consideration. Boat-making technology has improved[1] since the times of statehood, with use of inflatable rafts, inflatable and hard-shell kayaks becoming one of the preferred modes of travel. However, while canoe technology has changed to make these boats more durable, the depth of water required for canoeing has not substantially changed. In addition, flow rates on Arizona rivers have generally declined since 1912. Therefore, modern use of a river reach by canoes probably indicates that canoes could have been used as of the time of statehood.

The Central Arizona Paddlers Club (CAPD), an organization of boaters, recently conducted a survey of their members to determine what rivers had been boated. With 20 percent of members responding the survey indicated that all of the Salt River study reach, all of the Verde River downstream of Perkinsville, and the San Pedro from Palominas to Hereford Road have been boated in recent years (Central Arizona Paddlers Club, 1992). CH2M HILL informally polled CAPD members willing to be interviewed to determine flow conditions at the time various rivers were boated. Data collected in this poll reveal that all of the San Pedro River except the reach from Mammoth to Aravaipa Creek, and Curtis to I-10 have been boated at least once. Although several boaters claimed to have heard of boating portions of the Hassayampa River, no documentation of this was uncovered. A brief summary of the CAPD poll showing reaches and flow data is presented in Table H4.

The Verde River is the most frequently canoed, rafted, and kayaked river of the four rivers under consideration. The U.S. Forest Service even permits several commercial rafting operations on the Verde River. Most boating of the Verde occurs during winter months and during spring runoff, although Slingluff (1990) published a boating guide to the Verde River which states that the river can be boated from several miles upstream of Perkinsville to the Salt River, at flows as low as 50 cfs (1993). Some published stories of river trips on the Verde describe difficulties in travel (cf Gerke, 1959). Why these boaters had problems, while CAPD boaters frequently boat the same reaches without trouble is unexplained. The Arizona State Parks Department (1989) mapped the Verde River from Perkinsville to the Salt River as a boatable stream.

Although the Salt and San Pedro Rivers have been boated, Arizona State Parks Department classified the San Pedro as a hiking or general recreation reaches (1989). Some boaters who have travelled on the San Pedro River described driving to the reach and waiting for summer monsoons to occur before being able to float the stream. Others have attempted to float some reaches merely on base flow. All but one of the boating excursions on the San Pedro River occurred in the month of August, during the monsoon season. The Salt River below Granite

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[1] One enterprising Arizonan redesigned a motorboat to be able to travel in shallow water only 2.5 inches deep (Ariz. Days and Ways, 1960). The news article describing the boat mentions that the driver cracked the boat's hull while traveling 35 miles per hour in an ankle deep stream.

Reef Dam is not mentioned in the Parks publication. The Hassayampa is mentioned only for hiking, even in reaches of perennial flow. A boating guide to the southwest does not list any of the four rivers[2] (Anderson, 1982).

Table H4
Central Arizona Boaters Club
Survey Results: Selected Reaches Boated

River	Reach	Date mo-yr	Flow (cfs)	Depth (ft)	Width (ft)	Craft	Portage (%)
Salt	Granite Reef to McKellips Dr.	1-92	1,000	1-4	30-100	Kayak	0
	Gilbert Rd. to Priest Dr.	4-93	20,000	> 6	< 300	Kayak	0
	Gilbert Rd. to 51st Ave.	5-82	1,000	1-2	< 100	Kayak	0
	Mill Ave. to 115th Ave.	2-92	4,000	3-4	< 1,200	Canoe	0
Verde	Morgan Ranch to Perkinsville	10-89	30	0.5-1	< 15	Canoe	1
	Morgan Ranch to Salt River	10-88	< 50	> 0.5	> 10	Canoe	1
	Horseshoe to Needlerock	3-92	20,000	> 10	300	Kayak	0
San Pedro	Mexican Border to Palominas	8-92	n.a.	< 1	< 15	Kayak	50
	Palominas to Hereford Rd.	8-92	12	< 1	< 10	Kayak	50
	Hereford to Highway 90	1-93	n.a.	< 5	< 40	Rubber Raft	0
	San Pedro Preserve	8?-92	n.a.	n.a.	n.a.	Canoe	n.a.
	I-10 to Mammoth	8-73	200	> 0.5	< 20	Small Raft	5
	Aravaipa Ck. to Hayden	3-79	1,000	1.5	< 120	Canoe	0
Hassayampa	None	-	-	-	-	-	-

2 The upper Salt River is listed as a rafting river, but is not in study reach.

Navigability Decisions

Some limited information on formal decisions of navigability in Arizona were uncovered. These include, but are by no means limited to:

- Court Decisions. The Kent Decree stated that the Salt River was a non-navigable stream (Hurley v. Abbott, 1910). SRPMIC v. Arizona Sand and Rock (1976). A motion filed by attorneys claiming non-navigability of the Salt River was supposedly accepted by the court.

- BLM (1964). BLM apparently did not consider the Salt River navigable at statehood due to the closure of Roosevelt Dam (BLM, 1964).

- BLM (1957; 1967). BLM refers to the Verde River as "non-navigable" in two land disputes.

- BUREC (1935). The Verde River is not navigable because it is "too small and flashy to justify any serious claim that it is navigable in the vicinity of [Bartlett Dam]." (See also Davidson, 1973)

- Arizona Attorney General (1981). For State v. Superior Companies et al, The State claims that "we will not be able to establish, by any credible evidence, that the Verde River was navigable at the time of statehood." A hand written notes adds that "any other stance could prove very embarrassing."

Summary

Some Arizona rivers were used for boating and transport of materials around or prior to the time of statehood (Tables 6 and 7, Main Report). Hydrologic conditions in some of these rivers would meet federal standards for recreational boating. No evidence of boating up rivers, or use of large machine powered boats was found. Certainly no significant commercial boating industries were developed on Arizona rivers by 1912. However, portions of at least three of the rivers are currently boated for recreational purposes at certain times of the year.

Appendix I
Verde River GIS

Verde River GIS Plots

1. Land Ownership GIS & Ordinary Highwater Mark (7 Sheets)
2. Land Use (7 Sheets)

Appendix I.1: Data Formats

INFO (PAT) FILE FORMAT

QUAD	4 C
TOWNSHIP	4 C
RANGE	4 C
SECTION	2 C
COUNTY	2 I
BASELINE	1 I
TRS_SOURCE	2 I
OWNER	2 I
OWN_SOURCE	2 I
STATUS_DAT	8 D
BOOK	3 C
MAP	3 C
PARCEL	4 C
OWN_CODE	12 C

Items QUAD through STATUS_DAT are identical to the corresponding items in ALRIS's LAND library.

OWN_CODE = COUNTY+BOOK+MAP+PARCEL

RELATE FILE FORMAT (Privately owned and some agency lands)

OWN_CODE	12 C
OWNER	40 C
ADDRESS1	40 C
ADDRESS2	40 C
ADDRESS3	40 C
ADDRESS4	40 C
LANDUSE	4 C
STCODE	4 C [State landuse code]

SALTP PAT FORMAT (UNREVISED GIS)

OWNER	2 I
OWN_CODE	12 C
OWNER_C	40 C
ADDRESS1	40 C
ADDRESS2	40 C
LANDUSE	4 C
STCODE	4 C [State landuse code]

RVG AND TNK PAT FORMAT

TYPE	13 C	[National Wetlands Inventory Classification]
MO*	2 I	
YR*	2 I	
QUAD	4 C	
ACRES**	17 N 6	
KEY	4 C	[Simplified version of TYPE]

*Present only in "Final" layers
**Present only in RVG layer

STR PAT FORMAT

TYPE	13 C
QUAD	4 C

SPVEG PAT FORMAT

TYPE	13 C	[Brown and Lowe Digital Classification]
ACRES	17 N 6	
MAP_LABEL*	6 C	
DESCRIP*	32 C	

*Identical to items in ALRIS NATVEG layer.

Land Use Categories and Codes

0000	Unknown / unclassified undeveloped / open space
1000	Agency administered -- unclassified
1010	Wilderness or wildlife refuge
1100	Agricultural -- unclassified or multi-use
1110	Field Crops/Orchards
1120	Grazing/Pasture
1200	Timber sale
1300	Mining Claim
1400	Right-of-Way
1900	Undeveloped privately owned open space
2000	Developed -- unclassified
2100	Residential -- unclassified or multi-use
2110	Single Family
2120	Multi-family
2200	Commercial -- unclassified or multi-use
2210	Office / banking
2220	Retail / wholesale / warehouse
2300	Industrial -- unclassified or multi-use
2310	Mineral/mining

2320 Salvage yards / equipment storage
3000 Municipal / County
3100 Administrative
3200 Field facilities / shops
3300 Parks / recreation / drainage
3400 Water / wastewater treatment plants

Appendix I.2: Data Inventory

Land Ownership/Use GIS (names correspond to ALRIS LAND tiles):

Verde: PPRESE, PSEDONW, PPAYW, PTRW
San Pedro: PNOGE, PFORTHE, PTUCE, PMAME, PMAMW
Hassayampa: PPHXSW, PPHXNW, PBRADW, PPRESW
Salt: SALTP
Gila: GILAP

Relate Files:

Verde: VE_OWN
San Pedro: SP_OWN
Hassayampa: HA_OWN

Riparian Data

Verde Final GIS: FRVG, FTNK, FSTR
San Pedro: SPVEG

SALTP PAT FORMAT (UNREVISED GIS)

OWNER	2 I
OWN_CODE	12 C
OWNER_C	40 C
ADDRESS1	40 C
ADDRESS2	40 C
LANDUSE	4 C
STCODE	4 C [State landuse code]

Appendix J
Photographs of the Modern Verde River

This was not modified in the 2003 revision. The original is on file with the Arizona State Land Department Drainage and Engineering Section.

Appendix K
Public Comment

This was not modified in the 2003 revision. The original is on file with the Arizona State Land Department Drainage and Engineering Section.

Verde River Glossary

Glossary

Acequia. An irrigation ditch or canal.

Agglomerate. Sedimentary rock type formed of detrital volcanic material explosively ejected from a volcanic vent, with clasts larger than 32 millimeters.

Alluvial. See alluvium.

Alluvial Fan. A large fan-shaped accumulation of sediment; Usually formed where a stream's velocity decreases as it emerges from a narrow canyon onto a flatter plain at the foot of a mountain range.

Alluvial Ground Water. Ground water found in alluvium, as opposed to ground water found in bedrock. See Alluvium and Ground Water.

Alluvial Stream. A stream whose bed and banks are formed in sediment transported by the stream itself; a stream with a non-bedrock channel.

Alluviation. Progressive deposition of sediment, raising the elevation of the depositional surface.

Alluvium. A general term for eroded rock material, including soil, deposited by rivers; loose sediment, often from the recent geologic past.

Amplitude. A characteristic of a river meander describing the distance, perpendicular to the river valley, between opposite river meanders; A meander with high amplitude has broad bends, a river with low amplitude meanders is relatively straight.

Anastomosing. A stream pattern characterized by a net-like or interwoven channel pattern, with individual flow paths better defined or permanent than braided channel flow paths.

Andesite. A volcanic rock type mostly composed of plagioclase (Calcium bearing feldspar minerals) and other mafic (Calcium- or magnesium-bearing) minerals.

Anecdotal. Undocumented evidence or accounting of an event.

Angle of Repose. The maximum slope at which cohensionless soil or sediment material will remain stable.

Apex. The point on an alluvial fan where the stream intersects the mountain front.

Aquifer. A water-bearing bedrock or alluvium layer.

Archeology. The systematic recovery, and scientific study, of material evidence of human life and culture from past ages. The study of antiquity.

Arkose. Rock type, generally sandstone, composed of more than 25 percent silica-feldspar minerals.

Armoring. A stream process by which fine sediments are eroded from the bed or floodplain of a stream, leaving only coarser sediments. The coarser sediments protect the stream bed from further erosion, "armoring" the bed.

Arroyo. A term used in the southwest to describe an entrenched, dry wash.

Artesian. Artesian wells tap surface water that is under suffient pressure to make the wells flow without pumping.

At-Grade Crossing. Road crossing of a stream that goes directly on the stream bed, rather than over a culvert or bridge.

Average Flow. See mean flow.

Avulsion. In geomorphology, an avulsion is the sudden relocation of a stream away from its original flow path, usually due to catastrophic sediment deposition in the original flow path.

Axial Stream. A stream which drains the center of a valley, usually between opposite bajadas formed on parallel mountain fronts.

Bajada. A piedmont comprised of coalescing alluvial fans.

Bar and Swale Channel Form. Channel bars are small islands composed of the larger clasts (particles) of bed load material deposited during high flow and exposed during low flow. Channel swales are the low flow areas located between bars; the low flow thalweg.

Base Flow. Stream discharge which does not fluctuate in response to precipitation. The minimum discharge in a stream.

Base Level. The minimum elevation to which a stream can erode.

Basin and Range. One of three physiographic provinces in Arizona. The Basin and Range is characterized by elongated, parallel mountain ranges trending northwest to southeast, with intervening basins filled by alluvium eroded from the mountains.

Bed Load. The portion of sediment in a stream which is transported by rolling, bouncing, or sliding on the stream bed.

Bedforms. Features formed on channel bottoms by sediment in transport, including dunes, ripples, and antidunes.

Bifurcation. The division of a stream into two or more channels in the downstream direction; a channel split.

Bimodal. A frequency distribution with two peaks is called bimodal.

Bioclimatic. Pertaining to relations of climate to biological or living matter.

Biotic. Having to do with living organisms.

Block Faulting. Large scale fracture of rock units resulting in tilting and uplift, usually to form mountains.

Bottomland. Floodplain.

Braided. A braided stream is one flowing with branching and reuniting channels. May be ephemeral or perennial.

Breccia. A rock unit composed of coarse highly angular fragments.

Cadastral Survey. A land (legal) survey.

Calcalkaline. Basic calcium bearing rock.

Calcareous. Calcium rich.

Caliche. Calcium carbonate ($CaCO_3$) deposited and illuviated in arid region soils cemented into a petrocalcic horizon; often as Stage IV carbonate.

Carbonate Stage. Stage I carbonate is loose disseminated $CaCO_3$ in the soil matrix. Stage II carbonate is thin, discontinuous coatings of $CaCO_3$ on the bottoms of coarse clasts in the soil matrix. Stage III carbonate is continuous coatings of $CaCO_3$ on the majority of coarse clasts in the soil matrix. Stage IV carbonate is replacement of the original soil matrix by a thick, well-cemented layer of $CaCO_3$.

Central Mountain Province. (Transition Zone). One of three physiographic provinces in Arizona, characterized by deeply eroded mountains composed of granitic bedrock.

CFS. Abbreviation for cubic feet per second, a measure of the rate of stream flow.

Channelization. The process of a stream changing from a broad unconcentrated flow path to a more confined, or single flow path.

Check Dam. A small, or temporary dam, usually intended to maintain a desired water elevation in a canal.

Clasts. Rock fragments or other material which has been transported.

Concave Stream Profile. A stream whose slope decreases in the downstream direction appears concave in profile, opposite of convex.

Confluence. The point where two streams join.

Continuous Gage. A type of stream measuring equipment that records water surface elevations continuously throughout a flood, or over a long period of time regardless of flow conditions. Water surface elevations in the stream can be related to discharge rate.

Contraction Scour. A form of river bottom scour frequently occurring at bridges where stream width rapidly decreases causing an increase in stream velocity and/or turbulence.

Control. The river reach or structure which governs stream flow characteristics at a stream gage is called the control. A gage with reliable, consistent stream flow characteristics has "good control."

Cratonic Sequence. A series of rock types deposited in a tectonically stable environment, usually on a continental shelf.

Crenulation Index. The ratio of the topographic contour length to the straight line distance along the arc of the contour. A low crenulation index indicates low relief and a uniform surface.

Crest Stage Gage. A type of stream measuring equipment that records only the highest water surface elevation during a flood or flow event. Water surface elevation can be related to stream discharge rate through use of a rating curve. Also see continuous gage.

Cretaceous. A period of geologic time. See table attached to glossary.

Crystalloblastic. A crystalline texture due to metamorphic recrystallation such that original mineral may have inclusions of minerals formed during metamorphism.

Cyclonic. Arizona weather patterns derived from cyclones originating over the Pacific Ocean are called cyclonic storms.

Degradation. Channel bed erosion resulting in a topographically lower stream bed.

Dendritic Drainage Pattern. A drainage system with tributaries which join at all angles, similar to the branching pattern of a tree. The number of flow paths decrease in the downstream direction.

Desertification. The process of a landscape developing desert characteristics.

Detrital. Detritus is material carried and deposited by wind or water, especially grains of rock particles.

Difluence. See bifurcation. The point of separation of stream channel into two or more channels.

Dike. An thin, flat igneous rock unit which unconformably cuts across other rock units.

Dominant Discharge. The dominant discharge is believed to be the stream flow rate responsible for forming a stream's geometry. This theory is somewhat tenuous when applied to stream in Arizona or bedrock streams.

Dynamic Equilibrium. A natural condition of regular, expected channel change such the stream characteristics are adjusted to the physical conditions of the environment.

Emphemeral Stream. A stream which flows only in direct response to rainfall.

Empirical. Empirical methods are based on experimentally derived equations, rather than theoretically derived equations.

Entrenchment. (Entrench, Entrench) Progressive degradation of a streambed or channel resulting in a topographically lower channel bottom usually with steep or vertical banks; a process associated with arroyo formation.

Equilibrium. Balance. When applied to streams, equilibrium means lack of change.

Erosion. Removal of bedrock or alluvium by water or wind.

Escarpment. A steep bluff, or cliff.

Ethnography. The scientific study of culture.

Euroamerican. North Americans of European descent.

Evaporites. Sedimentary rock types formed by evaporation of water; for example, halite and gypsum.

Evapotranspiration. Losses of water from a stream, lake, or other water body to the atmosphere; includes evaporation (transfer of water molecules from the liquid phase to the gas phase - vapor) and transpiration (transfer of water molecules to the atmosphere by plants, usually through their leaves during the process of photosynthesis).

Facies. A grouping of sediments, rocks, or soils with a common or related origin.

Fanglomerate. Rock and soil material originally deposited as an alluvial fan which has since been transformed into bedrock. Fanglomerates are characterized by a wide range of grain sizes and bedding types.

Faulting. Movement which displaces adjacent rock masses. E.g. offset on the San Andreas Fault in Southern California.

Faunal Remains. Animal bones and other parts that are recovered from archeological contexts.

Feldspar. A potassium bearing silicate mineral.

Felsic. A term applied to potassium feldspar and silica rich rock types.

Feral Salt Cedar. A wild, undomesticated tamarisk tree.

First Terrace. Term used by archaeologists to describe portion of a river floodplain closest to the river. See Terrace.

Flash Floods. Floods which reach their peak discharge rate very quickly are flash floods. In Arizona, the term is often used to describe a flood or flow event moving down a previously dry river channel.

Flexed Inhumation. Burial in a bent position.

Flow Duration Curve. A graph depicting the percent of time a given discharge on a stream is exceeded. For instance, a 10% flow of 20 cfs means that the stream discharge only exceeds 20 cfs, 10 percent of the time; a 90% flow of 1 cfs means that the stream flows at discharges greater than 1 cfs 90 percent of the time; the 50% flow is the median (not average) flow rate.

Fluvial. Relating to stream flow.

Fluvial Geomorphology. The branch of geomorphology relating to streams. See Geomorphology.

Ford. A river crossing; usually, but not necessarily, with shallow flowing water.

Frequency Distribution. A table which presents data in a number of small classes for use in statistical treatments of the data.

Freshets. A flow of water, often a flash flood.

Gaining Stream. A gaining stream increases its flow rate in the downstream direction, usually due inflow of groundwater. See Losing Stream.

Geoclimatic. Pertaining to relations of climate to geological forces or materials.

Geologic Time Scale. See Figure G-1

Geomorphic. Parameters or variables relating to geomorphology.

Geomorphology. A branch of geology concerned with the formation, characteristics, and processes of landforms, including rivers.

Giant Powder. An explosive.

GIS. Geographic Information System. A database which relates information to spatial characteristics of some land area.

Gneiss. A type of metamorphic rock characterized by a lineation of the mineral grains which comprise the rock.

Grabens. Downdropped blocks of rock material bounded by normal faults. See Horsts.

Granite. An intrusive igneous rock consisting of primarily of quartz and alkali feldspar.

Granoblastic. A secondary texture found in metamorphic rock characterized by recrystallization to equigranular size.

Graywacke. A type of sandstone characterized by detrital sand grains in a clay matrix. A dirty hard sandstone.

Ground Water. Water stored or moving beneath the ground surface, usually in pore spaces in alluvium, or voids in bedrock.

Ground Water Decline. Lowering of the elevation or volume of ground water relative to the ground surface.

Ground Water Discharge. Transfer or flow of water from underground sources into surface water; a spring.

Headcutting. A process of channel bed erosion whereby a sharp break in the average channel bed slope moves upstream, rapidly lowering the channel bed elevation.

Headwaters. The point, or area, where a stream originates; or the most upstream point of a stream.

Holocene. The most recent epoch of geologic history, usually the past 10,000 years before present; part of the Pleistocene geologic period.

Horsts. Uplifted blocks of rock material bounded by normal faults. See Grabens.

Hydraulics. The science or technology of the behavior of fluids. Characteristics of stream flow such as depth, velocity, and width.

Hydrology. A branch of engineering concerned with water. In the context of this report, hydrology means the characteristics of water flow.

Igneous. Rocks formed from molten material, e.g. lava or magma.

Immature Vegetative Species/Communities. This term is used by the Soil Conservation Service to describe invasive plant species which are first to colonize a devegetated area. In Maricopa County, these species often include creosote, bursage, and salt cedar. Small, young plants of more stable species may also be included.

Incised Channel. A stream or waterway which has eroded its bed, creating steep or vertical stream banks. An arroyo, or degraded stream channel.

Inhumation. Burial.

Inselbergs. Isolated remnants of bedrock exposed as small hills or buttes in the alluvial plain or pediment.

Instantaneous Flow Rate. Stream discharge at an instant in time, as opposed to a discharge averaged over a period of time (See Mean Flow).

Interfluves. The area between braided flow channels. The area is usually vegetated, in contrast to the sandy channel beds.

Intermittant. A stream which flows only for portions of the year, but has sustained flow for a period after rainfall. See perennial and ephemeral.

Isoclinal. A structural fold of a rock unit with parallel limbs.

Lacustrine. Having to do with lakes. Lacustrine sediments were deposited in a lake.

Listric. Spoon-shaped. A listric fault is a spoon-shaped thrust fault, which curves upward toward a vertical plane.

Losing Stream. A losing stream decreases in discharge in the downstream direction, usually due to loss of stream flow to infiltration to the subsurface.

Ma. Million years before present.

Macrobotanical. Pertaining to large plant remains recovered from archeological contexts.

Mafic. Referring to dark, magnesium-rich minerals.

Manning's Equation. An empirical formula which relates steam velocity or discharge to measurable stream flow characteristics such as depth, flow area, and slope via coefficients.

Mannings Roughness Coefficient. An empirical parameter which describes energy loss in a stream reach, accounting for such factors as turbulence, eddying, and backwater.

Mean Flow. The mean flow of a river is determined by dividing the total runoff volume by the time in which that volume was discharged, i.e. mean annual flow is the average rate at which the average yearly flow volume would be discharged.

Median Flow. The flow rate which is exceeded 50 percent of the time (conversely, the rate is not exceeded 50% of the time).

Metamorphic. Rock type formed by alteration by heat or pressure of other rocks.

Metamorphic Core Complex. A dome of ancient igneous or metamorphic rock with a shell of mylonite.

Metarhyolite. Metamorphosed rhyolite.

Mexican Period. The period from Mexican independence to the Mexican War (1846).

Morphology. The shape or geometric characteristics, especially of a stream, or stream reach.

Mylonitization. The process of forming mylonite, a fine-grained metamorphic rock characterized by mineral grains subjected to milling and brecciation (processes of breaking rocks into fine ground or fractured pieces) by movement along a fault zone. Mylonite is an intensely deformed metamorphic rock.

Navigable. or 'navigable watercourse' means a watercourse, or portion of a reach of a watercourse, that was in existence on February 14, 1912, and that was used or was susceptible to being used, in its ordinary and natural condition, as a highway for commerce, over which trade and travel were or could have been conducted in the customary modes of trade and travel on water."

Oral History. Historical knowledge that is passed on verbally.

Orogeny. The process or event of mountain building, especially by folding and thrusting.

Orographic. Relating to topography. Orographic precipitation is caused by changes in pressure and temperature caused when air masses are forced over topographic features such as mountains.

Ordinary High Water Mark. The line on the shore of a watercourse established by the fluctuations of water and indicated by physical characteristics such as a clear, natural line impressed on the bank, shelving, changes in the character of the soil, destruction of terrestrial vegetation or the presence of litter and debris, or by other appropriate means that consider the characteristics of the surrounding areas. Ordinary high watermark does not mean the line reached by unusual floods.

Oxbow. A crescent shaped lake occupying the abandoned channel of a stream meander that is isolated from the present channel by a meander cutoff and sedimentation.

Paleobotanical. Pertaining to prehistoric plant life.

Paleoclimatic. Pertaining to prehistoric climate conditions.

Paleoenvironmental. Pertaining to prehistoric environments

Paleofaunal. Pertaining to prehistoric animal life.

Paleoflood. Any flood which occurred prior to, or without, human records.

Paleo-Indian. The earliest stage of human occupation on the American continent, characterized by the hunting of big game.

Paleosols. Buried or relict soil layers, not formed during the present climatic conditions or at the existing soil surface.

Pediment. A gently sloped erosion surface composed of bedrock with a thin veneer of alluvium, often formed by mountain front planation.

Perennial Stream. A stream which flows year round, non-zero base flow.

Permanent Water. Perennial stream flow.

Permeable. A rock or soil unit which is permeable will allow water to pass through it.

Petrocalcic. Calcium-rich rock material.

Physiographic Province. A region of similar geology. In Arizona, three physiographic provinces are recognized: the Basin and Range, the Central Highland (Transition Zone), and the Colorado Plateau.

Piedmont. A general term for the sloping land area adjacent to a mountain front.

Pier Scour. A form of channel bed scour caused by the turbulence created by bridge piers.

Placer Mine. A mining operation harvesting minerals from alluvial stream deposits, usually gravel bars along a stream or wash.

Planform. The channel pattern, as viewed from above; map view.

Pleistocene. The most recent geologic period, usually the past 1,000,000 years before present.

Plug. A rounded body of igneous rock material intruded into surround rock units.

Pluton. A body of igneous rock which formed beneath the earth's surface by crystallization of molten material.

Point of Zero Flow. The stage on a rating curve or gage record where no discharge occurs.

Porphyritic. A term describing rock texture in igneous rocks where larger crystals are set in a glassy or fine-grained matrix.

Precambrian. A period of geologic time. See Table G-1 attached to glossary.

Quaternary. A period of geologic time. See Table G-1 attached to glossary.

Rating Curve. A graph which relates stream discharge to some other measurable stream characteristic such as width, depth, or velocity.

Reach. A segment of a stream, usually with uniform characteristics.

Recurrence Interval. (aka Return Period) The average period of time in years within which a given event, usually a flood, will be equalled or exceeded. The 100-year, or 1% chance flood, has a recurrence interval of 100 years.

Regime. The flow and sediment transport characteristics of a stream. A stream reach "in regime" has balanced sediment transport in and out of the reach.

Return Flow. Water discharge to a stream that was originally diverted into irrigation canals. Return flow can either be water not applied to field which bypasses local canal turnouts, or seepage through soil under agricultural fields that returns to the stream.

Rhyolite. An igneous rock type with mineral content equivalent to granite, but with individual mineral grains too small to distinguish with the naked eye.

Riffles. Steeper reaches of a stream, often with coarse bed sediments such as cobbles and boulders which form small rapids.

Riparian. The environment impacted by a river.

Riprap. Rock material used to protect streambanks from erosion.

Runout Distance. The distance a debris flow travels from the mountain front or base of a slope to its resting point.

Salado River. A term used during the Spanish, Mexican, and Territorial periods to refer to the Salt River.

Salt River. Aka Black River, Rio Salinas, Rio Salado

San Francisco River. A term used during the Spanish, Mexican, and Territorial periods to refer to the Verde River.

Scarp. A cliff, embankment, or bluff.

Scour. Removal of stream bed material by flowing water.

Seasonal Exploitation. Use of an area for only a portion of the year, such as gathering native crops during their annual period of ripening.

Secondary Entrenchment. Degradation of a geomorphic surface, usually a stream channel or piedmont below its initial deposition surface, often forming terraces.

Seep. A small, diffuse spring generally of low discharge rate.

Shear Stress. Stress due to forces that tend to cause movement or strain parallel to the direction of the forces.

Sinuous. The "curviness" of the channel planform; the degree of meandering.

Sinuosity. A measure of how sinuous a stream is: the ratio of the length along the thalweg to the length along the stream valley. Always greater than one.

Skiff. A small, light boat.

Slackwater. A low-energy zone in a stream characterized by near-zero velocity and sediment deposition.

Spanish Period. The period from 1540 to Mexican independence.

Spillway. A structure on a dam designed to convey water over or around the dam itself. Often used to discharge floodwater.

Spring. The point where underground sources of water discharge at the surface.

Stage. A term used in stream gaging to describe the elevation of the water surface of a stream relative to some datum (fixed elevation). Stream stage is analagous to stream depth.

Strath Terrace. A stream terrace formed by erosion, rather than deposition.

Stream Capture. A process by which headward erosion on one stream intersects another stream, diverting it into a new flow path and abandoning its former channel.

Stream Gage. A site operated for the purpose of measuring the rate or volume of water discharge in a stream. Accumulated data from a stream gage are called stream gage records.

Stream Order. A geomorphic parameter used to describe the complexity of a drainage system. A first order stream has no tributaries. A third order stream is formed by the confluence of two second order streams. No stream order system specifically for alluvial fans exists.

Stream Power. The ability of a stream (flow) to do work, usually erosion.

Strike-slip Faulting. Tectonic movement along a fault line which is dominantly horizontal, rather than vertical. The San Andreas Fault is a strike-slip fault.

Suspended Load. The part of the total sediment load that moves above the bed load. The weight of the suspended sediment is totally supported by the fluid.

Syntectonic. Occurring in conjunction or concurrently with tectonic activity, usually emplacement of a pluton.

Talus. A loose, steeply sloped accumulation of rock debris deposited at the base of a mountain slope.

Tectonic Forces. Geologic forces generated from within the earth that result in uplift, movement or deformation of part of the earth's crust.

Tectonic. Tectonism. Deformation of the structure of the earth's crust by movement of crustal plates; includes mountain building by vulcanism and faulting.

Terrace. (Bench) A relatively flat geologic or geomorphic surface which parallels a stream and is elevated above the floodplain, and was formed when the river flowed at a higher elevation.

Tertiary. (Capitalized). A period of geologic time. See Table G-1 attached to glossary.

Thalweg. The centerpoint, or low flow channel, of a stream.

Topwidth. The distance across the water surface, perpendicular to the channel, of a flowing stream.

Torrifluvents. A type of soil characterized by stream deposits of gravelly, sandy material, and lack of significant soil horizon development.

Transition Zone. See Central Mountain Province.

Transmission Losses. Reductions in stream flow due to infiltration of water into the stream bed and subsurface.

Trellis Drainage Pattern. A stream pattern where master and tributary channels are aligned at nearly right angles.

Tuff. A rock type formed of compacted volcanic fragments and ash.

U.S. Territorial Period. The period from 1863 to Statehood, in 1912.

Unentrenched. See entrenchment

Verde River. Aka San Francisco River,

Volcanics. Rocks formed by consolidation or crystallization of material deposited by volcanic eruptions.

Wash Load. The part of the sediment load composed of fine particles carried in permanent suspension, and generally not found in the stream bed.

Watershed. The land area draining into a stream, or other body of water.

Water Table. The upper surface of the underground zone of saturation; the plane which represents the elevation of ground water.

Wild Flooding Irrigation. An irrigation technique in which water from the canal is allowed to spread unhampered over the filed, without the use of control devices to direct the water.

Glossary Table
Geologic Time Scale

Era	Period	Epoch	Millions of Years Ago	Significant Geologic Events in Arizona
PHANEROZOIC				
Cenozoic	Quaternary	Holocene	0.01	Change to hotter drier climate.
		Pleistocene	1.8	
	Tertiary	Pliocene	5	
		Miocene	25	
		Oligocene	37	Basin and Range Crustal Extension and Volcanism Mid-Tertiary Orogeny.
		Eocene	55	
		Paleocene	65	
				Laramide Orogeny and Regression.
Mesozoic	Cretaceous		135	Plutonism and Volcanism in Southern Arizona.
	Jurassic		180	
	Triassic		230	
Paleozoic	Permian		275	
	Pennsylvanian		330	
	Mississippian		355	
	Devonian		410	
	Silurian		430	
	Ordovician		500	Regional Uplift and Erosion.
	Cambrian		600	
				Grand Canyon Disturbance.
PRECAMBRIAN				
Proterozoic			1000 1500 2000	Mazatzal Orogeny and Plutonism.
Archeozoic			3000 4500	