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Arizona Stream Navigability Study for the San Pedro River:

Gila River Confluence to the Mexican Border

Prepared by

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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 San Pedro River as of the time of statehood, from its confluence with the Gila River to the Mexico border. Information presented in this report is intended to provide data to the Arizona Navigable Stream Adjudication Commission (ANSAC) from which ANSAC will make a decision regarding the navigability of the San Pedro River. This report does not make a recommendation or conclusion regarding title navigability of the San Pedro River.

The report consists of several related parts. First, archaeological information for the San Pedro 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 statehood are discussed with respect to river uses, modes of transportation, and river conditions. 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.

The original San Pedro River Stream Navigability Study was performed by CH2M HILL, Inc. and SWCA Environmental Consultants, Inc., in cooperation with the Arizona Geological Survey (AZGS). The study was completed under contracts #A3-0061 and #A3-0061-001 for the Arizona State Land Department on behalf of ANSAC. Project staff included V. Ottosawa-Chatupron, P.E., Ph.D., Arizona State Land Department, Project Manager; J. Fuller, CH2M HILL team leader, hydrologist, and geomorphologist; R. Borkan, SWCA team leader; D. Gilpin, SWCA, historian; M. Cederholm, SWCA, GIS specialist; P. Pearthree, AZGS team leader; G. Huckleberry, geomorphologist. 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 1993 CH2M HILL report were completed in 1997 by JE Fuller/ Hydrology & Geomorphology, Inc.under contract #97-NROE0002 with the ASLD. This report was revised again in 2004 by JE Fuller/Hydrology & Geomorphology, Inc. under contract #LDA-04-0564.

Executive Summary

CH2M HILL, in cooperation with SWCA Environmental Consultants 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). In 1997 and 2004, JE Fuller/ Hydrology & Geomorphology, Inc. was retained to revise the CH2M HILL report following amendments made to streambed legislation in 1994 and 2000. ANSAC will use information provided in this report, in conjunction with information presented by others, to make a decision of navigability or non-navigability for the San Pedro River to the Arizona Legislature. This report provides information on the San Pedro River between the Gila River confluence and the Mexico border.

The basic approach to this study was to develop a database of information to be used by ANSAC in making a recommendation 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 on the San Pedro River. For the latter task, public officials from every community, town, city, and county 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 at the time of statehood, but also provide information on whether river conditions could have supported certain types of navigation. SWCA historians prepared a 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. 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 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 San Pedro River and were entered in a GIS database. Land use data included existing title records from county assessors 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, supplements 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. The archaeological record of the San Pedro River suggests that prehistoric river uses included water supply, flood irrigation, and exploitation of the diverse environment found along the river. Environmentally and archaeologically, the river may be divided into two segments: the lower San Pedro River which extends from the Gila River confluence to the town of Benson; and the upper San Pedro River which extends from Benson to the headwaters. Prehistoric settlement patterns and lifeways reflect the different micro-environments and proximity to differing cultural cores in these two reaches. Human occupation began about 9500 B.C., where early occupants used the perennial river as a water source, as well as for the biotic diversity that it enhanced. Agricultural practices primarily consisted of dry farming on the floodplain terraces and floodwater farming in the floodplain. River-irrigated farming was supplemented by dry farming techniques and hunting/gathering. Some evidence of prehistoric irrigation has been found along the lower San Pedro in the Sonoran desert region of the river, though evidence of prehistoric canals is scant. Prehistoric settlements were small compared to the complex culture which existed concurrently on the Lower Salt River below the Verde River confluence, and on the Gila River below Safford.

The modern history of the San Pedro River is as well documented as that of any stream in Arizona. Classic studies of arroyo processes documented in studies such as Hastings and Turner's (1965) *The Changing Mile*, compiled historic data for the San Pedro River. These studies indicate that prior to about 1890, the San Pedro River was an irregularly flowing stream, marshy in places, free-flowing in other places, entrenched or subsurface in still other places. Moreover, the flow of the stream varied throughout the year. Published and archival accounts of the history of the San Pedro River suggest that the river was used for irrigation agriculture and milling of ore mined in the nearby mountain foothills.

Historically, the San Pedro River valley was a significant transportation route through southern Arizona because of the river's reliable water source. However, travel was along the river rather than on it. The search of archival and historical documentation on the San Pedro River found no published accounts of boating on the San Pedro River. In fact, although

Cooke in 1846, and Powell in 1849 made no attempt to boat the San Pedro River, both expeditions built boats later in their travels to float the Gila River. Other historic accounts suggest that early explorers, travelers, and settlers did not consider the stream to be boatable. An undocumented account of a ferry operated near Pomerene, is the only evidence for boating on the San Pedro River found during this study.

By 1890, the San Pedro River was a highly variable stream, both seasonally and along its length. In some areas, it was primarily a marsh with no discernible bed. In other areas it was a flowing stream several feet wide and as much as one foot deep, but a few miles away, surface water might not be present at all. In a few places, the stream flowed through arroyo cuts as much as 10 feet deep. Historical accounts of the river also indicate that some reaches changed from wet to dry over the course of the season. Some time around 1890, arroyo cutting significantly changed the character of the San Pedro River. Both the upper and lower reaches of the San Pedro River experienced channel entrenchment and widening during the last half of the 19th century and the first half of the 20th century. By 1912, most of the San Pedro River had already experienced entrenchment. In the upper San Pedro Valley, the river generally consisted of a small braided stream with a baseflow of less than 10 cfs flowing between vertical banks 130 to 260 feet wide. In the lower San Pedro Valley, the river also had a small braided channel that flowed between vertical banks, but intermittent reaches were common below Redington, and the channel banks were commonly wider than 330 feet.

Analysis of the hydrology of the San Pedro River reveals that portions of the river between Hereford and St. David are currently perennial, and probably were perennial as of statehood as well. The rest of the river is presently intermittent or ephemeral, except for a number of short reaches near areas of shallow bedrock. Some of these currently intermittent reaches may have experienced perennial, or longer duration intermittent flow at statehood, but groundwater withdrawal and slightly drier climatic conditions have reduced average flow rates. Hydraulic ratings of average flow rates indicate that average and median flow depths for the entire study reach are generally less than one foot. This estimates is supported by historical and modern observations of flow conditions in the river. Flow rates which would result in greater flow depths generally occur during floods or brief periods of higher flow.

No documented historical accounts of boating on the San Pedro River were uncovered, although anecdotal evidence of a ferry operated on the San Pedro River at Pomerene at some time prior to statehood was discovered, but not confirmed. Historical accounts of early explorers of Arizona who traveled the San Pedro River, did so on foot or by horseback and wagon. In some cases, these travelers built boats upon reaching the Gila River after walking or riding along the San Pedro River. In recent history, most of the San Pedro River has been canoed, kayaked, or rafted during summer high flows. Some of these boating trips are very opportunistic, where boaters drive to a launching point on likely rain days, and "put in" the water if rainy weather conditions favor runoff. The San Pedro River is not generally considered a recreational or commercial boating stream.

Currently, private land owners hold title to most of the land along the San Pedro River. The Bureau of Land Management and the State of Arizona are the second largest land owners. Other important title holders include the San Carlos Indian Community and the Nature

Conservancy. Land uses along the San Pedro River include grazing, agriculture (orchards and miscellaneous crops), residential, and mining. Most of the river is undeveloped.

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Chapter 1
Introduction

CH2M HILL, in cooperation with SWCA Environmental Consultants 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 CH2M HILL team to make a determination whether the San Pedro River should be classified as navigable or non-navigable.

In this chapter, the following topics are presented for the San Pedro 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 San Pedro 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

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

role, and act as technical support staff for ANSAC. The original San Pedro River navigability report was prepared on behalf of ASLD under the provisions of HB 2594.

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 1997 revision of the CH2M HILL San Pedro River 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 2004 revision of the original CH2M HILL San Pedro River 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.

Limit of Study

The report presents evidence of past and existing river conditions and uses for the San Pedro River from the confluence with the Gila River to the Mexican border (Figure 1-1). This report provides factual information for the study area collected from existing data sources. Where necessary or relevant, information from outside the study limits was considered as a supplement to the existing data base. No new analyses or technical evaluations were completed as part of this study. Furthermore, no interpretation of the data collect was made with respect to the title navigability of the San Pedro River. A recommendation regarding title 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 San Pedro 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 already 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.

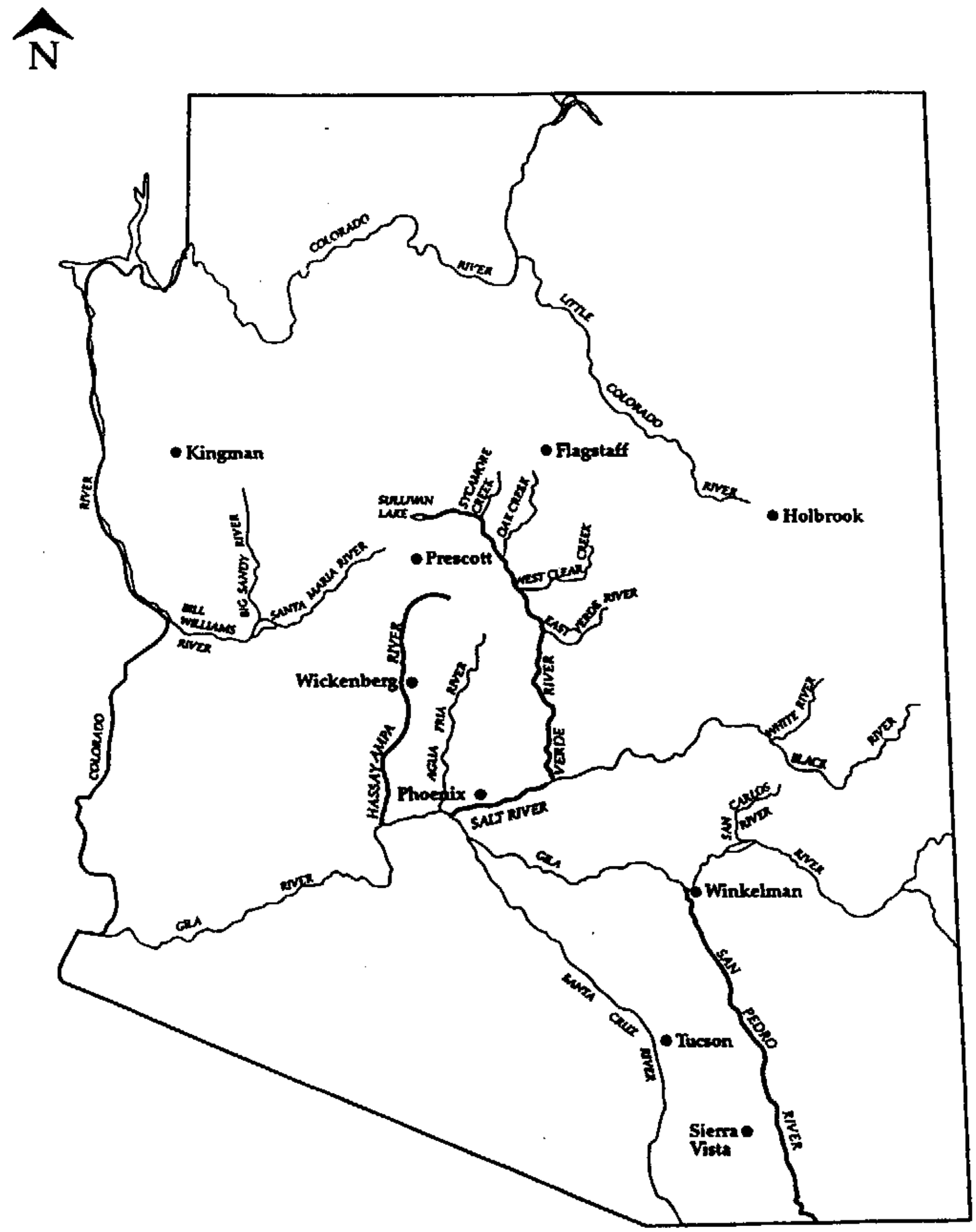

Figure 1-1

General Location Map for Arizona Stream Navigability Studies

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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 at 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 at 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 rivers were 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 on the four rivers. For this task, public officials from communities, towns, cities, and counties located along the San Pedro 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, officials 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 Sierra Vista 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. The 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 rivers 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 rivers. City directories, Sanborne fire insurance maps, and General Land Office (GLO) maps were also consulted to identify businesses located near the rivers. 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 San Pedro 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 rivers. 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, paleoenvironment, 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 at the time of statehood, and also provide information on whether river conditions could have supported navigation. SWCA historians prepared a report 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. 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. Historical information on the San Pedro River is summarized in Chapter 3 and Appendixes B, C, H and I.

Oral History

Ethnographic data, or the recollections of individuals with personal knowledge of historical conditions, supplement 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 San Pedro River. Names of potential interviewees were obtained from historical societies, public agencies, and private organizations contacted during the agency contact task. A total of 25 interviews were conducted for the San Pedro River, and are summarized in Chapter 4 and Appendix D.

Hydrology/Hydraulics

Hydrologic/hydraulic information is a key source of information regarding susceptibility of the San Pedro River to navigation. These data include estimates of flow depths, width, velocity, and average flow conditions at statehood, based on the available records. CH2M HILL evaluated information collected during agency contact and literature search tasks. Literature, stream gauge records, topographic maps, aerial photographs, and other data were used to develop an estimate of natural stream flow conditions at statehood, as well as for existing stream conditions. Depth, velocity, and top width rating curves for existing and for (near) statehood channel conditions were developed from historical gauging records. Estimates of 2-, 5-, 10-, 50-, 100-year, and average annual flow rates were obtained from gauge data. Flow duration curves and average monthly flow rates were also summarized. Finally, technical memorandums were prepared which discuss the role of climate change on stream flow (Chapter 7, Appendix E), irrigation (Chapter 7), modern boating activities (Chapter 8, Appendix F), and recreational navigation criteria (Chapter 8, Appendix F) on stream navigability.

Geomorphology

Geomorphic data provide information on river stability, river conditions at statehood, and the nature of river changes since statehood. A summary of the geology and geomorphology of the San Pedro River was prepared. These summaries were based on literature and other information collected during agency contact and the literature search. The objectives of these summaries were to estimate channel positions at 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 high water mark. A summary of geologic information is presented in Chapter 5.

Land Use

Land use data were compiled for the San Pedro River and entered in a GIS database. Land use data included existing title owner records from county assessors offices, and state and federal land leasing records from 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. Other data collected for the San Pedro River, such as ordinary high water mark limits, floodplain limits, and hydrologic data were also entered into the GIS. 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 1997 or 2004 revisions of the original CH2M HILL report.

Conclusion

The following chapters of this report describe historical uses of the San Pedro River as well as the types of activities to which the San Pedro 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 San Pedro 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 San Pedro River will be summarized (Chapter 8). Finally, appendixes which provide additional data on topics related to the San Pedro River study are attached.

Chapter 2
Archaeology of the San Pedro Valley

Introduction

The San Pedro River Valley is divided environmentally and archaeologically into two segments: the lower San Pedro River, from the mouth of the river near Winkelman to approximately the town of Benson; and the upper San Pedro River, from the Benson area to the headwaters of the river. This division is due to the difference in biotic life zones, the Sonoran and Chihuahuan desert zones, and prehistoric settlement that resulted from lifeways based on different environments and varying proximity to multiple cultural cores, such as Hohokam, Salado, and San Simon Mogollon.

A discussion of past archaeological projects in the San Pedro River Valley is presented below to describe the nature and amount of work that has been accomplished. This is followed by a brief summary of prehistoric culture history of the Valley, prehistoric use of the river, and environmental reconstructions of the river valley for the prehistoric time period.

Archaeological Projects

Archaeological exploration of the San Pedro River region (Figure 2-1) began in 1880 when Bandelier, under the auspices of the Archeological Institute of America, conducted a reconnaissance of much of the Southwest (Table 2-1). Although he did not inspect the area east of the San Pedro River Valley, doubting that it would hold important traces of prehistoric occupation, he did survey the San Pedro River Valley, because it contained perennial water, an enticement to prehistoric settlement. During his survey, he described the ruins of Tres Alamos and Babocomari (Bandelier 1892). Frank Russell, collecting for the Bureau of American Ethnology, spent some time in the area as well. He did not publish his observations (Sauer and Brand 1930:417), although he did briefly describe some ruins along the river in his account of the Pima (Russell 1908, cited in Bronitsky and Merritt 1986:41). Two large, important surveys were conducted in the late 1920's; one was sponsored by Gila Pueblo and reported by Gladwin and Gladwin (1935), and the other one was conducted by Sauer and Brand (1930) of the University of California at Berkeley. The Gila Pueblo survey covered much of southeastern Arizona and the lower San Pedro River, in particular, as far south as Benson, and was focused on determining the eastern extent of Hohokam influence in the Southwest. The Sauer and Brand survey concentrated on recording sites and collecting representative artifacts, especially decorated ceramics, from areas peripheral to culture cores.

The earliest site descriptions were provided in the 1930's by Trischka (1933) and Fulton (1934) on Texas Canyon. The Amerind Foundation sponsored excavations at major sites such as Tres Alamos

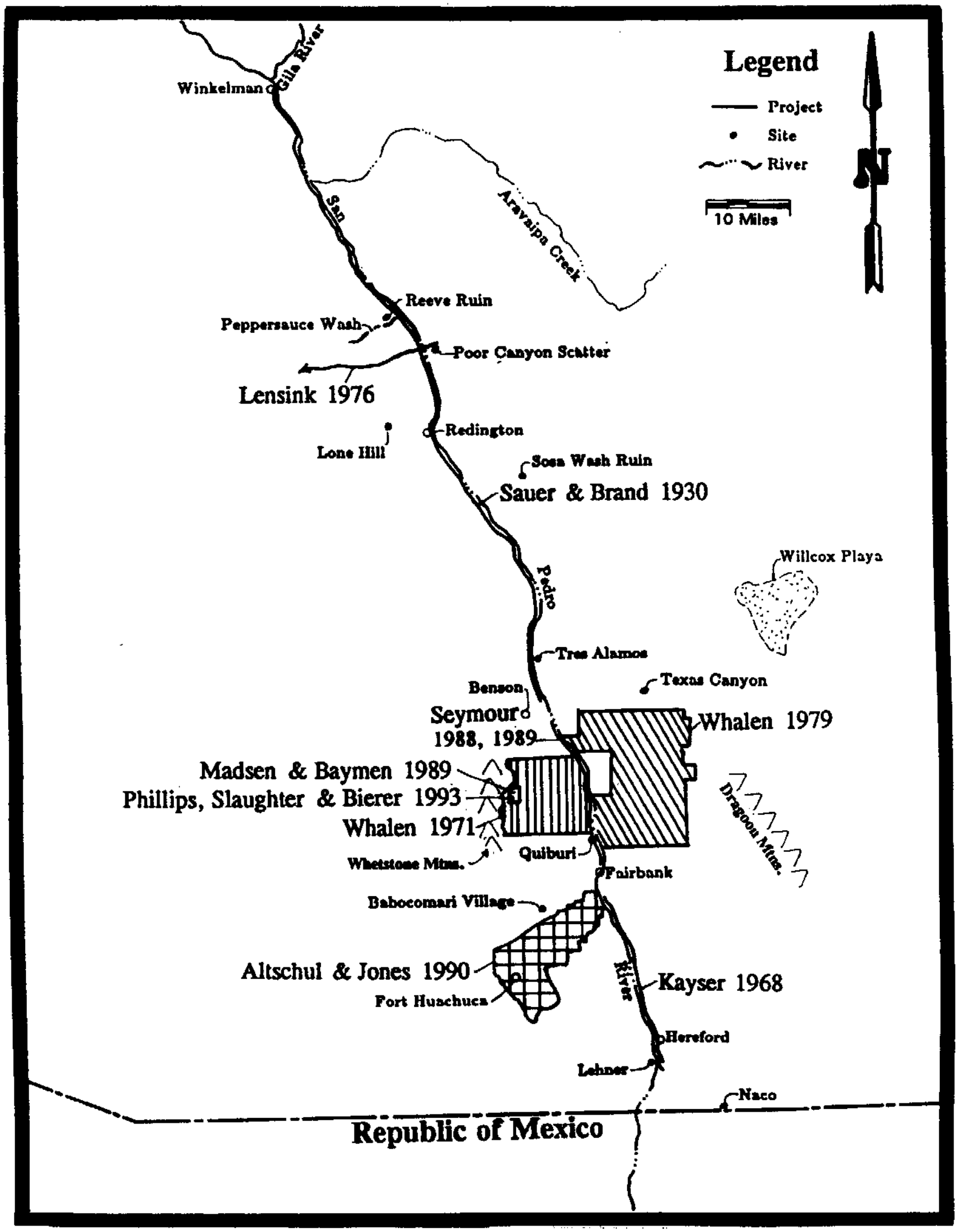


Figure 2-1: San Pedro River Archaeological Site Map

Table 2-1
Archaeological Projects Along the San Pedro River.

Sponsor	Type of Project	Areal Extent	No. of Sites	Reference
Archaeological Institute of America	Reconnaissance (judgmental)	Southwest U.S.	?	Bandelier 1892
University of California, Berkeley	Survey and Collection	San Pedro Valley+	?	Sauer and Brand 1930
Amerind Foundation	Excavation	Excavation (Tres Alamos)	1	Tuthill 1947
Amerind Foundation	Excavation	Excavation (Babocomari Village)	1	DiPeso 1951
Amerind Foundation	Excavation	Excavation (Reeve Ruin)	1	DiPeso 1958
Private Citizens	Excavation	Excavation (Naco)	1	Haury 1953
Arizona State Museum	Excavation	Excavation (Lehner)	1	Haury, Sayles, and Wasley 1959
Arizona State Highway Department	Excavation	Excavation (Peppersauce Wash)	4	Hammack 1971
El Paso Natural Gas Company	Survey	?	2	Lensink 1976
El Paso Natural Gas Company	Collection and Recording	Poor Canyon Scatter	1	Ferg 1977
Arizona Department of Transportation	Excavation	Excavation (Second Canyon Ruin)	1	Franklin 1980
Unknown	Excavation	Excavation (Lone Hill Site)	1	Agenbroad 1970
University of Arizona	Survey	100 square miles	90	Whalen 1971
Organized Research Committee of Southwest Texas State University	Systematic reconnaissance	180 square miles (16½ square miles actually surveyed)	293	Whalen 1979
Trico Electric Cooperative, Inc.	Survey	15.8 miles (Santa Catalina Mountains east across San Pedro River)	7	Breternitz 1978
Bureau of Land Management; Rio Rico Properties; Nature Conservancy; University of Arizona; Arizona State Parks; Mariah Associates, Inc.; Arizona Archaeological and Historical Society	Survey	Between Fairbank and Benson	50+	Seymour 1988, 1989, 1993
Arizona State Parks	Survey	Approximately 3,000 acres (Kartchner Caverns State Park)	13	Madsen and Baymen 1989
Arizona State Parks	Excavation	Excavation (AZ EE:3:28^{+}, ASM)	1	Phillips, Slaughter, and Bierer 1993
Army Corps of Engineers	Sample survey	8,600 acres (Fort Huachuca)	84	Altschul and Jones 1990
National Park Service	Survey	51 square miles (near Charleston)	126	Kayser 1968
U.S. Bureau of Land Management	Survey	Winkelman Bureau of Land Management Administrative Unit	56	Teague 1974

(Tuthill 1947), Babocomari Village (DiPeso 1951), and Reeve Ruin (DiPeso 1958) in efforts to learn more about the Dragoon (Tuthill 1950) and Babocomari cultures, and to establish spatial and temporal boundaries for San Pedro Valley prehistory and history (Bronitsky and Merritt 1986:48). More site-specific information did not become available until the 1970's when contract archaeology, based on federal and state legislation, took an active role in mitigating impacts of urban expansion and improvements to transportation and communication facilities. Of note were the Peppersauce Wash Project (Hammack 1971), that documented small site occupation along the lower San Pedro River, and other Arizona Highway Salvage projects conducted by the Arizona State Museum, such as the 1969-1970 excavations at Second Canyon Ruin (Franklin 1980; Hammack 1970). Archaeological treatment at a pumping station proposed for the West Coast/Mid-Continent Natural Gas Pipeline Project documented a Cochise Culture lithic procurement site, Poor Canyon Scatter, near Redington, Arizona (Ferg 1977; Lensink 1976); systematic investigation of the site contributed to our knowledge of the nature and function of Cochise sites. In 1968 a large survey (51 square miles) was conducted within the proposed Charleston Lake area on the upper San Pedro River, locating 126 sites (Kayser 1968).

Paleo-Indian research began in the early 1950's. In 1952, the remains of a mammoth and associated Clovis projectile points were excavated under the direction of Haury (1953) northwest of Naco. In 1959, Haury, Sayles, and Wasley reported the results of excavations at the Lehner site, southwest of Hereford, Arizona. Hearths, Clovis points, and other tools were found in association with the remains of nine mammoths and other extinct mammals. The site was dated by radiocarbon method and geological evidence to approximately 11,500 BP (9550 B.C.). These, as well as other Paleo-Indian sites (Murray Springs and Escapule), cluster on tributary arroyos of the San Pedro River near the international border (Bronitsky and Merritt 1986:54). Mammoth required a climate moister than presently exists in the area and became extinct in the Southwest during the Datil Drought which occurred approximately between 12,500 and 10,800 years ago (10,550-8850 B.C.) (Sayles 1983:35).

Investigations into Archaic period sites began relatively late along the San Pedro River (Agenbroad 1966, 1970, 1978). The temporal sequence and characterization of each stage was fostered by work initiated by Gila Pueblo (Sayles 1983:1). Archaic period settlement patterns along the upper San Pedro River took great strides when Whalen (1971, 1979) conducted surveys of large areas on either side of the river. Between 1966 and 1969 he surveyed a 100 square mile area on the west side of the valley between the Whetstone Mountains and the river. Ninety sites were located, only four of which postdated the Archaic period. Later, a systematic sample survey was conducted on the east side of the valley between the river and the Dragoon Mountains (Whalen 1979) that covered 16½ square miles, or 9% of a 180-square-mile area. The survey documented 293 prehistoric sites dating from 3000 B.C. to A.D. 1450.

Overviews of San Pedro River culture history and discussions regarding prehistoric site distributions derived from these earlier studies. The characterization of Salado manifestations in the lower San Pedro River Valley was presented by Franklin and Masse (1976), with strong arguments for the migration of Salado populations from the north, rather than indigenous development from earlier Hohokam occupants. Masse (1980) presented an overview of the lower San Pedro River and compared cultural developments in that area to developments in the northern Papagueria to the west of the river. Masse also used the opportunity to present new data from field school investigations of the Big Ditch Site, near the confluence of the Aravaipa Creek and the San Pedro River. A more in-depth overview was produced by Bronitsky and Merritt (1986) for the Bureau of Land Management (also see Teague 1974). It was in the form of a Class I type cultural resource inventory that included a literature and records search to compile information of known cultural resources of southeast Arizona, including both government and private lands. The study unit embraced a much larger area than the San Pedro Valley and was conducted to assist in the management of cultural resources in that area.

Much of the recent work along the San Pedro River has occurred due to land development and planning. In the late 1980's a portion of the San Pedro Riparian National Area was surveyed. Although the focus of this survey was to locate protohistoric Sobaipuri sites (A.D. 1450-1695), other sites were identified. Altogether more than 50 sites were recorded (Seymour 1988, 1989). An intensive survey was conducted at Kartchner Caverns State Park (Madsen and Baymen 1989) near the town of Benson due to plans for park development. Approximately 3000 acres were covered and 13 sites were found, 11 of which were prehistoric. Treatment of one site in the park by SWCA, Inc. (Phillips, Slaughter, and Bierer 1993) documented activities at a large Archaic site, AZ EE:3:28$^+$(ASM). In 1990, a sample survey was conducted at Fort Huachuca (Altschul and Jones 1990) that contributed to understanding prehistoric settlement in that area.

Culture History

The San Pedro Valley has a long prehistory of human occupation starting with the Paleo-Indian period. Clovis cultural materials found along the San Pedro River date to the 11,500-11,000 B.P. (9,550-9,050 B.C.) time range and are associated with streams of marshy pond deposits (Bronitsky and Merritt 1986). Clovis sites along the river include Naco (Haury 1953), Lehner (Haury, Sayles, and Wasley 1959), Murray Springs (Hemmings 1970), and Escapule (Hemmings and Haynes 1969). Mammoth remains and other fauna are present at these sites and are associated with diagnostic Clovis projectile points, large bifacially flaked and fluted points, and other flaked stone tools and debris. Sites represent kill sites, as well as other activities, such as meat processing and tool production. Paleo-Indian subsistence is usually described as dependent on the hunting of late Pleistocene megafauna such as mammoth. An alternative view (Judge n.d., cited in Bronitsky and Merritt 1986:98) is that the Clovis people were bison hunters, as well as scavengers of mammoth, with a diversified subsistence strategy that included a variety of plants and smaller animals.

Archaic period populations practiced seasonal exploitation of a wide range of wild resources and were adapted to an increasingly arid environment, generally similar to the present climate of the San Pedro Valley. The earliest evidence for Archaic period occupation, represented by the Cochise Culture of southeastern Arizona, along the San Pedro River is the Chiricahua stage (9,000-1,500 B.C.), which had more of an emphasis on hunting than the San Pedro phase (1,500-200 B.C.), which had a plant gathering emphasis. Whalen (1979) describes Cochise sites as either base camps or work camps. Base camps were loci for daily household tasks and the centers for band activities. Work camps were transient stations for activities such as plant gathering, hunting, and the procurement of resources (Whalen 1979:8). Most Archaic sites are scatters of lithic materials, both flaked and ground stone, sometimes with associated hearths. During the late San Pedro phase, shallow house features, as well as large storage pits, appear, indicating a shift to sedentism. Archaic sites are found most often on the river terraces (Whalen 1971, 1979). Few sites have been found on the floodplain due to alluviation and erosion. Sites typical of this time period are the Lone Hill site (Agenbroad 1966, 1970, 1978), Benson:8:3(GP) (Sayles 1945:1), and Benson:5:10(GP), the San Pedro stage type site.

Following the Archaic period, the San Pedro Valley was occupied by a poorly understood mix of Hohokam and San Simon Mogollon cultures (Bronitsky and Merritt 1986), with a localized variant known as the "Dragoon Culture" (Fulton and Tuthill 1940). A boundary between Hohokam and Mogollon influences can be drawn near the town of Benson, with a large overlap, particularly between Benson and Redington (Franklin 1978); this boundary happens to be the interface of the Chihuahuan and Sonoran biotic zones. The "Hohokam lifestyle was largely based on an adaptation to the Sonoran Biotic province" (Bronitsky and Merritt 1986:115), and the lower San Pedro River is represented by this meshing of archaeological and environmental patterns.

Lower San Pedro River

Early ceramic occupation in the lower San Pedro Valley began around A.D. 500-600 (Masse 1980:206) and is represented by Redington Village, the Sosa Wash Ruin, both known only from surface manifestations, and the Big Ditch Site (Masse 1980), partially excavated by a field school from Central Arizona College. These early villages were located near the mouths of major tributaries that drain into the river. Not only did the location allow exploitation of resources of two different riparian systems, but they also provided easy access to the resources in the higher elevations surrounding the river valley (Masse 1980:210). Data from the Big Ditch Site indicate that although a wide variety of wild plants was utilized, corn was probably the staple food. Masse (1980:210) believes that irrigation systems were used but that they were restricted to the floodplain due to the steepness of the river terraces. A pit house excavated at the Big Ditch Site was typical of a Hohokam house-in-a-pit construction; it measured approximately 15 X 23 ft, had encircling floor grooves, and Gila Basin ceramics predominated.

The period A.D. 850-1000 was a time of expansion in the lower San Pedro River, evident by the establishment of new sites and the intensification of occupation at previously settled villages; the Big Ditch Site had 25-30 houses occupied at the same time. Ball courts appeared at the large villages, and settlements were dispersed in a rancheria pattern. Small habitation sites, such as Second Canyon and those along Peppersauce Wash, appeared between the older villages, and occupants were mostly dependent on dry farming for subsistence; features such as rock piles, check dams, contour terraces, and gridded gardens were found at these new locations. Approximately four to five houses were occupied at the same time for limited durations, possibly seasonally (Masse 1980: 217). Pit houses along Peppersauce Wash ranged in floor area from 153 to 380 ft^2 (Hammack 1971:7-9). Few new large villages were established at this time.

By A.D. 1200, there was a marked population decline along the lower San Pedro River and many sites were abandoned. By A.D. 1250, a new influence, the Salado Culture, was felt in this area and was accompanied by an increase in occupation and a change in architectural style, pottery, and other cultural traits. Hohokam traits that were retained originated from the Tucson Basin rather than from the Gila and Salt basins. The Salado Culture is defined as a late branch of the Mogollon that is centered below the Mogollon Rim to the north (Gladwin and Gladwin 1935). It was influential in the lower San Pedro Valley from approximately A.D. 1250-1400. The Salado Culture has been interpreted either as an indigenous Hohokam development (Schroeder 1953) or as an immigration of people (DePeso 1958; Franklin and Masse 1976). Villages ranged in size from 1-2 rooms to over 100 rooms, based on surface remains (Franklin and Masse 1976:50-51), and appear to have been continuous in distribution along the river, from its mouth to around the town of Benson. Sites include Reeve Ruin (DiPeso 1958), Davis Site (Gerald 1975), and Second Canyon Ruin (Franklin 1980). Second Canyon Ruin, typical of this period, contained 21 contiguous, boulder-reinforced adobe rooms that were grouped around large plazas with an encircling compound wall (Franklin 1980:13, 43). House size varied, with houses that contained the most artifacts averaging 266 ft^2 in floor area (Franklin 1980:16). At Reeve Ruin, average room size was 128 ft^2, with a range of 53-203 ft^2, the smaller rooms serving as storage areas; ramadas (n=3) were an average of 217 ft^2 in area (DiPeso 1958:41-77).

Upper San Pedro River

The upper San Pedro Valley is dominated by the grass-scrub of the Chihuahuan Desert, which is less environmentally diverse than the Sonoran Desert, the environment preferred by the Hohokam and Saladoan cultures. A local culture variant, known as the Dragoon Culture, expanded into the upper San Pedro River area from the east, where a similar environment existed. Dragoon series pottery had design elements reminiscent of Hohokam styles, although other characteristics were distinctively Mogollon. Hohokam design elements increased in frequency through time. In fact, Hohokam influence is readily seen in Dragoon material culture, such as clay figurines, stone, bone, and shell assemblages. A unique trait of the Dragoon Culture was the elaboration of pit ovens, which were used to process plant foods such as agave. Pit ovens were olla- or bell-shaped in profile and had a variety of bottom treatments, such as plain or patterned with numerous hole or trench arrangements. Sites that are part of the Dragoon complex include Gleeson, in the Sulpher Springs Valley, Tres Alamos (Tuthill 1947), Texas Canyon (Fulton 1934), and Pearce:7:1(GP) (Trischka 1933). Formative period settlement in this area consists of sites with a small number of pit houses that are located near the mouth of a canyon or on terraces and ridges above the river (Altschul 1992:5); this early period is represented by the Gleeson and Tres Alamos sites. At Tres Alamos, two types of pit houses, Hohokam and Mogollon, were noted. Mogollon pit houses were shallow and square with plastered walls and stepped or ramp entryways. The Hohokam pit houses were shallower, nearly rectangular with straight or bulbous entries, and contained post holes for two roof supports along the long axis. House area averaged 209 ft^2, with a range of 111-512 ft^2. Stone-outlined enclosures occurred around two of the pit house clusters; the function of the enclosures is unknown.

Between A.D. 1225 and 1300, there was a decrease in population, suggested by a paucity of sites in the area, and a cessation of indigenous ceramic styles, such as the Dragoon and San Simon series (Bronitsky and Merritt 1986:192-193). Sites that date after A.D. 1200 are located mostly on arable land between the mountains and the river (Altschul 1992:7) and are represented by Tres Alamos, Babocomari (DiPeso 1951), and Boquillas Ruin (DiPeso 1953), near Fairbank. Settlement occurs in adobe-walled compounds with houses clustering around a central plaza. At Tres Alamos, two compounds were composed of 12 rooms each. The average room size was 195 or 209 ft^2, with a wide range (5-340 ft^2) of room sizes (Tuthill 1947:20), due to differences in room function. Unique structural features found at this and the Texas Canyon sites have been interpreted as granaries. They were circular structures that ranged between approximately 5 and 8 feet in diameter. The walls were adobe, and the platforms were adobe-cemented rocks.

Although most sites were abandoned by A.D. 1400, the Babocomari Village contained a loose clustering of small houses, with adobe step or covered entryways that have been dated to A.D. 1450-1692 (Bronitsky and Merritt 1986:197). Only low frequencies of Gila and Tonto polychrome of the trade wares were present. There is debate that the site represents Salado occupation (DiPeso 1951; Bronitsky and Merritt 1986), although it is clear that site occupants participated in a different economic network than contemporaneous populations to the north. Due to the presence of European-introduced walnuts at the site, DiPeso (1951:6) believes that Babocomari was occupied at European contact.

Prehistoric Use of the San Pedro River

The river valley served as the primary focus of habitation during the prehistory of the area. Earliest occupation utilized the river as a water source as well as for the biotic diversity that it enhanced. Ceramic period archaeological site locations at the intersections of canyon washes and the river provide evidence that these were deemed optimal for the exploitation of a wide variety of resources. At these locations, early villagers could exploit two different riparian systems and have easy access to resources found in the upper regions flanking the valley (Masse 1980:208). Other optimal site locations were found on terraces overlooking the river valley, making use of dry farming land and floodwater farming in the valley below (DiPeso 1958:2; Sauer and Brand 1930:425; Whalen 1979:1). Dry farming features found above the river include linear borders, rock alignments, contoured terraces, gridded gardens, and rock cairns. Floodwater farming in the valley is implied due to evidence of the San Pedro River as a perennial live stream, abundant habitations along its course, and by large cleared areas on floodplains of small tributary drainages (Breternitz 1978:18).

Some evidence of prehistoric irrigation has been found along the lower San Pedro River (Hammack 1971:5; Masse 1980) and more has been implied by what appears to be agricultural intensification during Salado occupation (Franklin 1980:223). Granaries were built, evidently necessary for the storage of large harvests. At the Big Ditch Site, analysis of macrobotanical samples indicated that corn was probably the major food staple, although a wide variety of wild plants also was exploited. Masse (1980:210) believes that irrigation systems along the San Pedro River were restricted to the floodplain because the terraces were too steep, 33-164 feet above the level of the river, to extend canals onto the terraces. Evidence of prehistoric canals is scant, probably due to floodplain erosion and alluviation and to historic use of the river (Tuthill 1947:12).

Environmental Reconstruction

Environmental information for the San Pedro Valley is more prevalent for the pre-ceramic period of prehistory than for the later ceramic period occupation. Geoarchaeological investigations have been carried out at Paleo-Indian sites along the river (Haynes 1981, 1982) and at Archaic period sites east of the river valley (Eddy and Cooley 1983; Sayles 1983; Waters 1986). Pollen data from Willcox Playa to the east indicate that there was much greater effective moisture around 22,000 BP (20,050 B.C.) than at present (Hevley and Martin 1961). Between 11,500-7000 BP (9550-5050 B.C.), there was a long-term fluctuating trend toward decreased effective moisture throughout the Southwest, with a moist episode between 11,500-11,000 BP (9550-9050 B.C.) (Irwin-Williams 1979:31) that probably expanded the grasslands, allowing the development of the Clovis horizon (Bronitsky and Merritt 1986:29). The alluvial stratigraphy at the Murray Springs and Lehner sites shows numerous depositional episodes (Table 2-2) prior to 7000 BP, after which there are periods of arroyo cutting and filling until approximately 100 BP (Haynes 1981).

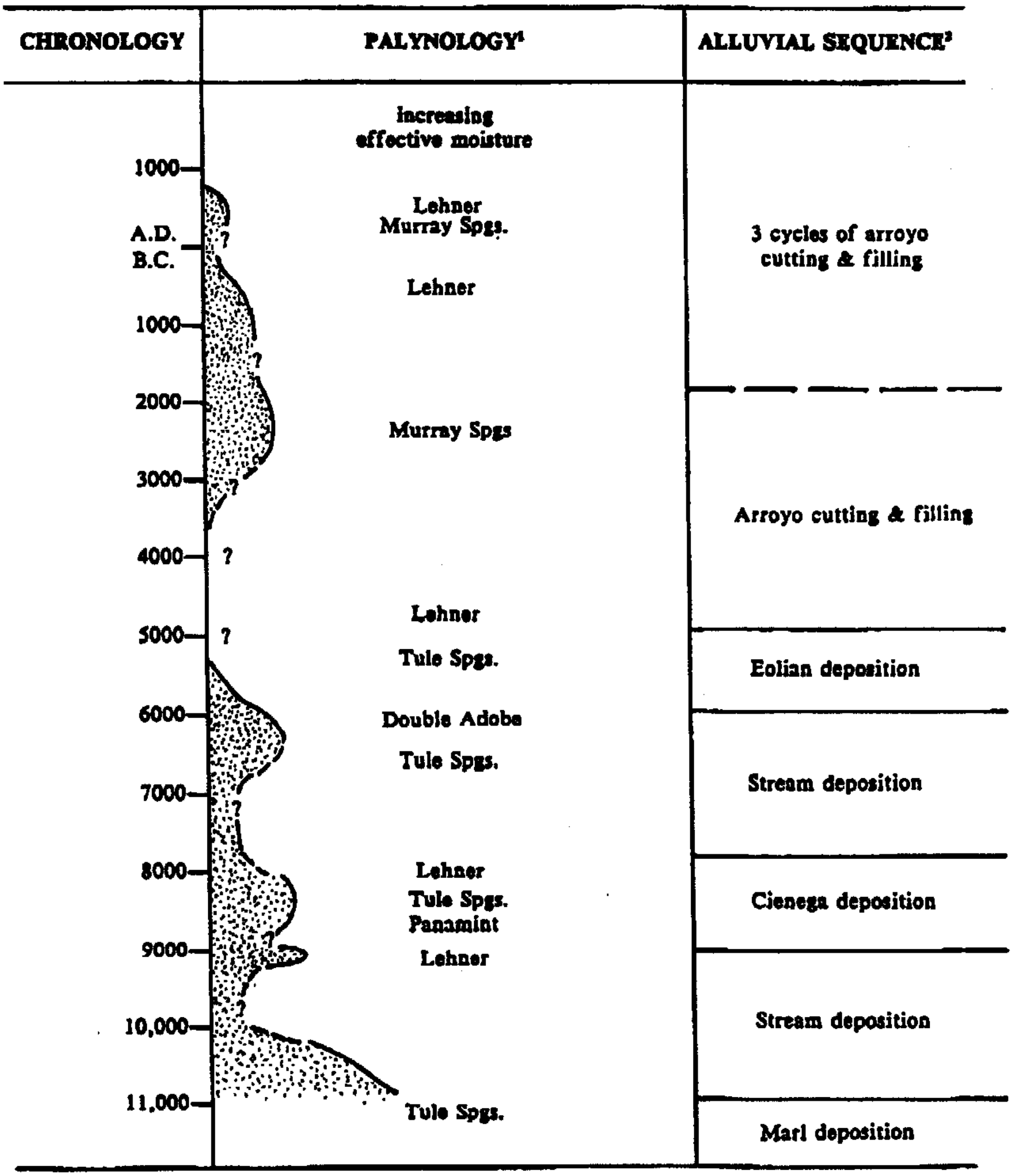
The present environment in the San Pedro Valley is thought to be similar in most respects to that of the late Archaic and ceramic periods. The river itself, however, has changed. Only until historic times was there extensive erosion, with the river channel cutting severely into the valley floor (Sauer and Brand 1930:425). Historic records indicate that in the 1870's and 1880's the river was still a perennial stream and did not have the present deep-cut channel (Tuthill 1947:12). Pollen records are scarce for the time period after 1000 BP (A.D. 950), limiting information on fluctuating climatic cycles (Mehringer 1967); however, it has been suggested that trends noted in the Anasazi cultural region in the Four Corners area also affected southeastern Arizona. According to Franklin (1978:378-379), drought in the late 1200's may have struck southeastern Arizona, resulting in the sharp decrease in population, with conditions improving by A.D. 1300, permitting resettlement.

Conclusion

The San Pedro Valley has a long, well documented prehistory of human occupation starting with the Paleo-Indian period, dating back to approximately 9550 B.C. Early occupants used the perennial river as a water source, as well as for the biotic diversity that it enhanced. Agricultural practices primarily consisted of dry farming on the floodplain terraces and floodwater farming in low lying areas. River-irrigated farming was supplemented by dry farming techniques and hunting/gathering. Dry farming features found above the river include linear borders, rock alignments, contour terraces, gridded gardens, and rock cairns. Floodwater farming in the valley is implied due to evidence of the San Pedro River as a perennial stream, abundant habitations along its course, and by large cleared areas along the floodplains of small tributary drainages. Some evidence of prehistoric irrigation has been found along the lower San Pedro in the Sonoran desert region of the river. However, evidence of prehistoric canals is scant, probably due to floodplain erosion and alluviation, and to historic use of the river valley.

No evidence of prehistoric boating on the San Pedro River, or of river conditions that would support navigation, was identified during the archaeological investigation and literature search. Archaeological evidence suggests that river flows were lower than for other Arizona rivers that supported irrigation-based agricultural societies, although the flows on portions of the San Pedro River may have been as reliable.

Table 2-2 Correlation of Environmental Palynological Data



[1]From Irwin-Williams 1979, after Mehringer 1967. [2]From Waters 1986, after Haynes 1981.

Chapter 3
History of the San Pedro River

Introduction

Historical documentation of the San Pedro Valley begins in the Spanish Period, perhaps as early as Fray Marcos de Niza's journey through the region in 1539 or the Coronado Expedition's entry into the area the following year. The valley was intensively occupied throughout much of the historic period, except when inter- and intra-tribal warfare and Apache raids depopulated it. The first historic accounts of the San Pedro River describing locations that can be definitely identified date to the late 1600's, resulted from Spanish attempts to missionize the Sobaipuri (upland Pima) Indians. Apache raids forced the Sobaipuris to abandon the valley by the 1760's. The Spanish made one unsuccessful attempt to establish a presidio in the valley. Mexican land grants were issued in the 1830's. The valley was crossed by one of the principal transcontinental routes established during the Mexican War (1846-1848) and was subsequently used by the forty-niners and then formally surveyed as a transportation corridor by the United States military after the Gadsden Purchase (1854). After the Civil War, ranchers and miners settled in the valley, and a network of roads and railroads was constructed. Table 3-1 provides a chronology of significant historical events along the San Pedro River, and Figure 3-1 illustrates the locations of significant places mentioned in the text.

Because of the long occupation in the San Pedro Valley and because the valley was an important transportation corridor, the history of the San Pedro River is as well documented as that of any stream in Arizona. Hastings and Turner's (1965) classic, *The Changing Mile*, compiled historic and scientific data on the San Pedro River and other southern Arizona streams to reconstruct the changes that occurred historically in the vegetation and hydrology of southern Arizona. More recently, Hereford and Betancourt (1993) have taken the same general approach as Hastings and Turner, but have dealt in more detail with the San Pedro River. These studies indicate that prior to about 1890, the San Pedro River was an irregularly flowing stream, marshy in places, free-flowing in other places, entrenched or subsurface in still other places. Moreover, the flow of the stream varied throughout the year. Published and archival accounts of the history of the San Pedro River suggest that the river was used for irrigation agriculture and milling of ore. The San Pedro River valley was a significant transportation route because the river was a reliable water source, but travel was along the river rather than in it. The current search of archival and historical documentation on the San Pedro River found no published accounts of boating on the San Pedro River. At least two early travelers (Cooke in 1846 and Powell in 1849) who made no attempt to boat the San Pedro River successfully boated the Gila River later during the same expedition. The only evidence for boating on the San Pedro River found during this study was the oral account of how Dora Ohnesorgen's grandfather had a toll ferry on the San Pedro River below Pomerene (Ohnesorgen, 1993).

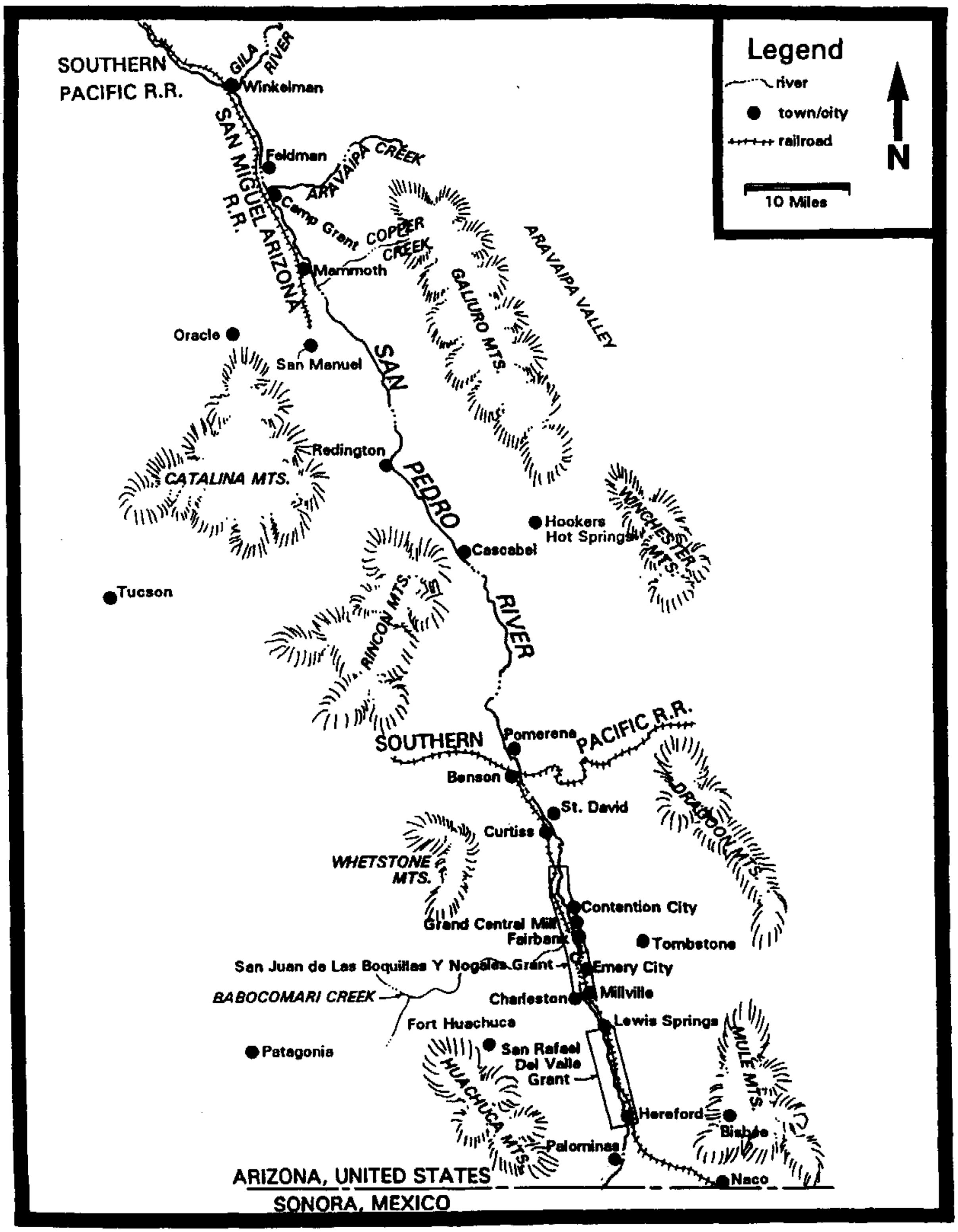


Figure 3-1 San Pedro River: Sites of Historical Significance

Table 3-1. San Pedro River Chronology	
1500-1600's	Known as the "oldest river trail"--used by the early Spanish (Powell 1980:5).
1540	Called the Rio Nexpa by the 1540 Coronado Expedition (Granger 1984:471). Francisco Vazquez de Coronado marched his army up the San Pedro Valley as his avenue of exploration into the U.S. Southwest (Walker and Bufkin 1986:13; Hoffman 1982:40).
1542	Coronado returned to Mexico by the same route (Walker and Bufkin 1986:13).
1691-1702	Father Eusebio Kino, Jesuit missionary, traveled in the area bounded by the San Pedro and Gila Rivers (Walker and Bufkin 1986:13).
1692	Lieutenant Alférez Juan Mateo Ramírez traveled down the San Pedro to Benson in search of horses stolen from a Sonoran Mission (Walker and Bufkin 1986:13). Fr. Eusebio Kino in September clearly records the name as Rio de San Joseph de Terrenate (Granger 1984:471).
1696	Kino "extended his ministry into the San Pedro Valley" Sobaipuris (upland Pimas) living there (Officer 1987:32).
1697	Fr. Kino traveled along the river (Adams 1930:71; Walker and Bufkin 1986:13; Hastings & Turner 1965:26). He found Indians living there who practiced irrigation (Hastings & Turner 1965:26).
1732	Father Ignacio Keller with Captain Juan Bautista de Anza "visited six mission visitas (missions without resident priests) which serviced 1,800 people along the San Pedro" (Hadley et al. 1991:39).
1737	Father Keller--German Jesuit missionary--followed San Pedro to the Gila--no mention of how (Wagoner 1975:99). At this time found that the Apaches had forced out most of the Sobaipuris (Hadley et al. 1991:39).
1762	Interim Governor Joseph Tienda de Cuervo transferred Sopaipuri Indians to Santa Cruz (Officer 1987:40).
1763	Sobaipuri Indians lived along banks, the river was called Sobahipuris (*sic*) (Granger 1984:471).
1763	Sobaipuris moved to Tucson; Apaches (numbering approximately 1000) moved into San Pedro Valley (Officer 1987:39-40).
1775	Captain Juan Bautista de Anza visits Chichilticale (Yaqui for Red House), a prehistoric ruin with standing walls of adobe and masonry, first visited by Coronado (Hadley et al. 1991:37-38, citing Haury 1984:14-19).
1775-1780	Santa Cruz de Terrenate, a presidio, was located on the west side of the San Pedro, north of the present town of Fairbank (Officer 1987:8; Williams 1986)
pre-1800's	"The creek seeped through a rank growth of marsh grass and can hardly be said to have a course." (Hastings & Turner 1965:36)
1800's	During the Spanish and Mexican Periods, "Tucson settlers planted and harvested crops on the San Pedro River at Tres Alamos" on the east side of the river north of present-day Benson. "Because of the Apache menace, they were escorted to and from their fields by presidial soldiers" (Officer 1987:15). In the 1800's, "peaceful Apaches, protected by fifteen or more soldiers" from the Tucson presidio, farmed the San Pedro floodplain at Tres Alamos, and supplied the Tucson presidio with farm products (Officer 1987:89).
1808	Spanish grazing stock in San Pedro Valley (Officer 1987:88).
1821	Mexican independence.
1824-5	James Ohio Pattie and company trap beaver on the river (Davis 1982; Wagoner 1975:99).
1827	San Ignacio del Babocómari land grant, from modern-day Elgin to the San Pedro, awarded (Officer 1987;109). San Rafael de Valles land grant applied for. Awarded 1828 (Officer 1987:109). Elías González family petitioned for land grant on the San Pedro. Awarded 1833 (Officer 1987:108-110).
1827-8	James Ohio Pattie and company trap beaver on the river (Davis 1982; Wagoner 1975:99).

Table 3-1. San Pedro River Chronology	
1828	San Rafael de Valles grant paid for (Officer 1987:109).
1830	Lieutenant Antonio Comaduran left Tucson presidio, traveled to Tres Alamos (north of present-day Benson) on the San Pedro, then proceeded toward the Sierra de Santa Teresa to Cajon de Agua Caliente (Hooker Hot Springs) and then to the Aravaipa Valley (Hadley et al. 1991:41, citing Dobyns 1981:16-26).
1830's	People from Tucson farming Tres Alamos, guarded by troops from Tucson presidio (Officer 1987:148).
1831	Tres Alamos land grant (Officer 1987:109-110).
1832	San Rafael del Valle--sold to Rafael Elías Gonzales for $240 as a stock farm (McClintock 1916:531).
1833	San Juan de la Boquillas y Nogales land grant awarded to Elías González family (Officer 1987:108-110).
1836	Pinaleno and Aravaipa bands of the Western Apache agree to settle at the junction of the Aravaipa and the San Pedro (Hadley et al. 1991:41).
1846	Mormon Battalion described their camp in the San Pedro River Valley "in a marshy bottom with plenty of grass and water" and the stream as a "beautiful little river." (Tyler 1881, cited in Jackson 1987:21). Lt. Col. Philip St. George Cooke called the river by the name Jose Pedro River (Granger 1984:471). "The San Pedro River...was described in 1846 as a river 'an active man could jump across.'" (Mann 1963:4).
1846?	Captain Philip St. George Cooke marched his battalion up the river to the present site of Benson (Walker and Bufkin 1986:18).
1846-48	San Pedro Valley traversed by the Army of the West under General Kearny, and the Mormon Battalion traverses it on its way from Santa Fe, New Mexico to San Diego, California (Clarke 1961 and Golder 1928 cited in Hoffman 1982:40).
1848	Treaty of Guadelupe Hidalgo.
1849	Cooke's Road went along the river (Walker and Bufkin 1986:40).
1853	Boquillas grant (17,355 acres)--title given to Ignacio Elías Gonzales and Nepomuceno Felix for sale price of $240. Was confirmed to the possession of George Hearst and Janet G. Howard (McClintock 1916:531).
1854	Gadsden Purchase (from the Gila River to the present international border).
1854-55	San Pedro Valley traversed by Major William Emory during his survey of the international U.S.-Mexico border established by the Gadsden Purchase of 1853 (Emory 1848 cited in Hoffman 1982:40).
1855-1865	Farms along the river were targets for the Apaches (McClintock 1916:182).
1857	Major W.H. Emory describes the San Pedro River not having a great amount of water, and backed by a series of large pools by beaver dams and full of fishes (Emory 1857 cited in Jackson 1987:22).
1857	James B. Leach and N.H. Hutton surveyed wagon road from El Paso to Fort Yuma. (Hutton 1859:88, as cited by Hadley et al. 1991:57).
1857	"Captain" James H. Tevis and Mose Carson hunting and trapping on Aravaipa, Gila, and San Pedro. Trapped beaver on the San Pedro near the junction of the Aravaipa (Hadley et al. 1991:57).
1857-9	Leach's Wagon Road--Followed the river north almost to the Gila River junction (Walker and Bufkin 1986:40).
1857	Benson established as a stage stop at the San Pedro River crossing of the Overland and Butterfield Trail. Later the town became a railroad center to serve the mining areas that developed in the San Pedro River Valley (Arizona Office of Economic Planning and Development [AOEPD] 1977:3). [The date is incorrect; the Butterfield Trail dates from 1858 to 1861.

Table 3-1. San Pedro River Chronology

1858-1861	Butterfield Stage Route in operation.
1859	Fort Arivaypa [sic] established at the junction of the Aravaipa and San Pedro (Hadley et al. 1991:45).
1860	Fort Arivaypa renamed Fort Breckenridge and then abandoned (Hadley et al. 1991:45).
pre-1861	San Pedro Mine discovered and located about 1/2 mile from east side of river (Adams 1930:140).
1862	Military post re-established at junction of Arivaipa and San Pedro and named Fort Stanford (Hadley et al. 1991:45).
1863	Silver-lead ore discovered in Copper Creek in Galiuro Mountains above the San Pedro River (Hadley et al. 1991:114).
1865	Fort Stanford renamed Camp Grant (Hadley et al. 1991:45, citing Granger 1985:295).
1867	William A. Bell surveyed route for Kansas Pacific Railroad (Bell 1869, as cited by Hadley et al. 1991:58).
1868	Irrigation in use on the river (Farish 1915:207).
1870	"the valley of the San Pedro 'had a shallow grassy bed and banks covered with luxuriant vegetation.'" (Mann 1963:4).
1871	Camp Grant named reservation for Aravaipa and Pinaleno bands of the Western Apache (Hadley et al. 1991:47).
1872	Reservation status for Camp Grant ended (Hadley et al. 1991:47).
1873	Location of Camp Grant moved from junction of Aravaipa and San Pedro to west side of Pinaleno Mountains near present-day Bonita, Arizona (Hadley et al. 1991:43). Indians removed to San Carlos Reservation (Hadley et al. 1991:47).
1873-4	Wet years (Hadley et al. 1991:144-145).
1874	San Rafael del Valle--claimed under mortgage by Camou Brothers of Sonora who eventually gained title (McClintock 1916:531).
1875	Reddington settled by brothers Henry and Lem Redfield (Barnes 1988:358).
1877	copper mine established at Bisbee (Barnes 1988:48).
1878	mine established at Tombstone (Barnes 1988:446).
1879	Charleston Post Office established (Barnes 1988:88).
1880	Charleston established--mill town for reduction for Tombstone Milling & Mining Company--"wild river camp" (Granger 1985:33).
1881	Mammoth Mine established (Barnes 1988:262).
1881	San Manuel Mine began production. Prior to this the Mammoth and Mohawk mines were chief producers in the area (San Manuel Copper Corporation [SMCC] 1955:1). Neptune Mining Co. of Bisbee built a smelter at Hereford (Myrick 1975:179).
1881	St. David Post Office established at Mormon settlement on spur line of EP&SW Railroad (Barnes 1988:374).
1881-2	New Mexico & Arizona Railroad built between Benson and Fairbank. The haul from Bisbee to Fairbank was accomplished by teams of 18 and 20 horses and mules (Myrick 1975:179). Atchinson, Topeka & Santa Fe Railroad built the New Mexico & Arizona Railroad from Benson to Nogales (Walker and Bufkin 1986:47).
1882	Fairbank established on EP&SW Railroad (Barnes 1988:150).

Table 3-1. San Pedro River Chronology	
ca. 1884	River description: The San Pedro rises near the lone between Arizona and Sonora, and runs in a general northerly course a distance of over one hundred miles, and enters the Gila River at the foot of Gila Cañon, in Pinal County. It has a number of small tributaries, among them Arivaypai, which enters near its mouth, after passing through Grass Valley for five miles. On the western side is a tributary called Babacomari, rising in the Huachuca Mountains (Wallace W. Elliot & Co. 1884:90).
1884	"It is a sluggish, narrow stream, but carrying sufficient water to irrigate the rich bottom-lands through which it flows." (Hamilton 1884:48). Cited river as being "capable of irrigating vast stretches of land" (Hamilton 1884:361).
1885-1903	Drought years (Hadley et al. 1991:144-145).
1886	Flooding (Hastings & Turner 1965:42).
1887	More flooding (Hastings & Turner 1965:42).
1888	More flooding (Hastings & Turner 1965:42).
1889	More flooding (Hastings & Turner 1965:42).
1889	Lewis Springs established on EP&SW Railroad (Barnes 1988:246).
1890	More flooding (Hastings & Turner 1965:42).
1890	"Where the San Pedro River of southeastern Arizona formerly wound its sluggish course northward through a marshy, largely unchanneled valley, in August, 1890, it began carving a steep-walled trench through which it thereafter emptied rapidly and torrentially into the Gila. Where it formerly ran more or less consistently throughout the year, after 1890 its flow became intermittent, leaving the new channel dry over much of its length for most of the time." (Hastings & Turner 1965:3)
1891	Stamp mill for Mammoth Mine built at Mammoth (Granger 1985:298).
1894	Arizona Southeastern Railroad Company--"Near Fairbank the track was washed for 100 feet, and 11 miles down the line a 45-foot bridge and 1-1/2 miles of track were knocked out. Mail from Bisbee was carried on horseback during the week the railroad was being repaired." (Myrick 1975:191)
9/26/1894	Arizona Southeastern Railroad track between Benson and Fairbank completed (Myrick 1975:192).
1899	Naco Post Office established on railroad to mines at Nacozori, Mexico (Barnes 1988:294).
1900	Three railroads serve the San Pedro River Valley area, and Benson is known as The Hub City (AOEPD 1977:3).
1904-5	Wet years (Hadley et al. 1991:144-145).
1905	Arizona Eastern Railroad line completed from Phoenix to junction of Gila and San Pedro at Winkelman (Hadley et al. 1991:112).
1915	Pomerene Post Office established (Barnes 1988:342).
1916	Cascabel Post Office established (Barnes 1988:80).
1917-21	Drought (Hadley et al. 1991:144-145).
1920's	The Arizona Southeastern Railroad along the river was in use at least through the 1920's (Myrick 1975).
1933-4	Drought (Hadley et al. 1991:144-145).
1945	San Manuel Copper Corporation incorporated (SMCC 1955:1).

Historical Overview/Chronology

Historic Indian Use of the San Pedro Valley

When the Spanish first explored and colonized the San Pedro Valley, it was occupied by the Sobaipuris, a band of upland Pimas. The Sobaipuris of the San Pedro Valley, whose population was estimated at between 1,800 (Keller's estimate [Hammond 1929:227, as cited by Hadley et al. 1991:39]) and 2,000 (Kino's estimate [Bolton 1948, as cited by Hastings and Turner 1965:26]), lived in villages of as many as 500 people residing in 130 houses (Kino's estimate, Bolton 1948, as cited by Hadley et al. 1991:38-39). The Sobaipuris were farmers who practiced irrigation agriculture. In the 1760's, the Sobaipuris came under increasing attack by the Apaches, and in 1763 were removed from the San Pedro River to the Santa Cruz River. Thereafter, the Apaches occupied the San Pedro River Valley. Even though the Apaches did practice horticulture and approximately 1,000 of them were estimated to be living in the San Pedro Valley (Officer 1987:39-40), the subsistence pattern of the Apaches was based more heavily on raiding and warfare while that of the Sobaipuris had been based more on agriculture. The warfare that occurred throughout the Apache occupation of the valley prevented the Apaches from establishing permanent villages.

Spanish Exploration

The first historic account of southern Arizona was that of Fray Marcos de Niza who was led to Zuni by Esteban, who had accompanied Cabeza de Vaca. Esteban was killed by the people of Zuni, and Fray Marcos never entered any of the Zuni Pueblos, but his report prompted the Coronado Expedition, which Fray Marcos accompanied (Bandelier 1890:79-103, as cited by Winship 1896:14-15. See also Bandelier 1890-92; 1892). Sauer (1937) doubts that Fray Marcos got any further north than northern Sonora. The route of the Coronado expedition through southern Arizona has been variously reconstructed (Bolton 1916, 1949, 1990; Day 1964; Di Peso 1951; Hodge 1933; Hodge and Lewis 1907; Riley 1985; Sauer 1932, 1937; Schroeder 1955, 1956; Udall 1984, 1987; Winship 1896), but a recent study by the National Park Service (NPS 1991) indicates a great deal of uncertainty about Coronado's route through the region. The location of Coronado's route through southern Arizona is largely dependent on the location of a pueblo ruin he called Chichilticale. The location of this ruin has been debated by archaeologists and historians (cf. Haury 1984; Riley 1985), and no consensus has been reached.

Spanish Colonization

Father Eusebio Kino arrived in Pimería Alta in 1687, and in 1691 was invited by the Pimas to establish missions in what is now southern Arizona. By the time of his death in 1711, Kino had founded a chain of missions throughout Pimería Alta. In conjunction with these missions, military presidios were established. Spanish missionaries introduced herds of cattle to the Pimas and by 1694, "100,000 cattle ranged the grasslands around the headwaters of the San Pedro River and Bavispe Rivers" (Bolton 1948: map, as cited by Hastings and Turner 1965:31). The missionary

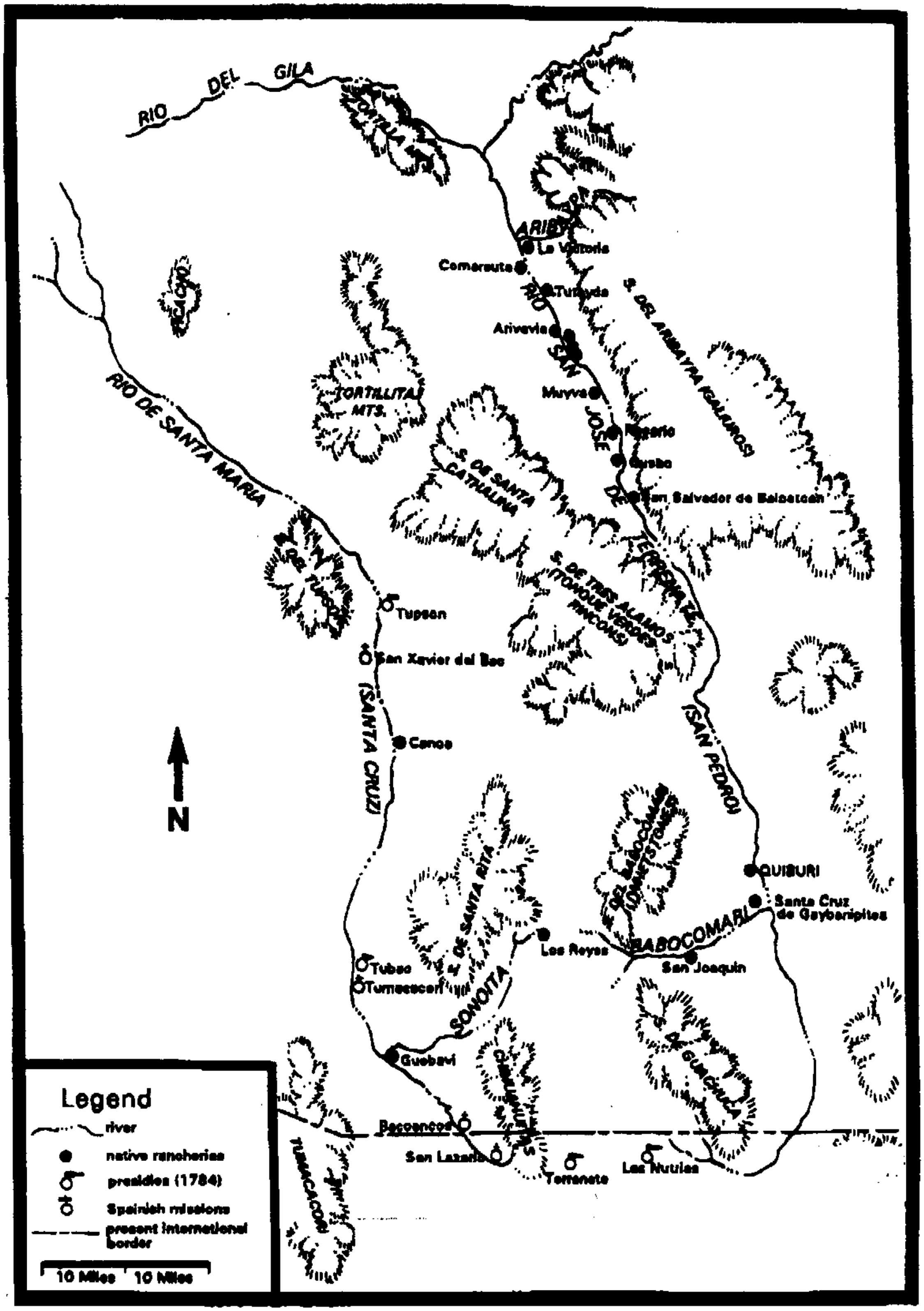


Figure 3-2: San Pedro River During the Spanish Period

of Father Eusebio Kino are discussed in many books and articles (Bolton 1936, 1960; Burrus 1965, 1971; Kessell 1966a; Smith, Kessell, and Fox 1966) that contain information on the San Pedro Valley in the Spanish Period. Figure 3-2 shows the locations of Spanish-Period sites mentioned in the text.

In 1691, Captain Ramirez and ten soldiers went to the Sobaipuri village of San Salvador de Baicatcan on the middle San Pedro River, near present-day Redington, to punish the Sobaipuris for stealing a horse (Di Peso 1953:25). In 1692, Kino went to Baicactan (Di Peso 1953:25-26). Di Peso (1953:25-26, 273) believes that Baicactan was abandoned shortly after Kino's 1692 visit and that the Sobaipuris moved to Quiburi, which became the largest of their rancherías for the next several years.

In 1694, Lieutenant Antonio Soliz led an expedition to the San Pedro River to retaliate against the Sobabpuris for stealing horses (Di Peso 1953:26). In 1696, Kino visited San Pablo de Quiburi, which was then the primary ranchería of the Sobaipuris. The following year, 1697, Kino visited San Pablo de Quiburi twice. Baicatcu was at this time abandoned. On Kino's second visit to Quiburi in 1697, he was accompanied by Captain Juan Mateo Manje, who wrote one of the most complete descriptions of the Sobaipuris' settlements along the San Pedro River (Di Peso 1953:27). Manje described the settlements along the San Pedro River as follows (Bolton 1948, as summarized by Hastings and Turner 1965:26):

Manje's party found about 2,000 Indians living in twelve villages scattered along the valley between Babocomari and Aravaipa Creeks. The approximate site of the fields of the southernmost of the rancherías, Santa Cruz de Gaybanipitea, appears in Figure 3-2. In 1697 the village contained about one hundred people, who practiced irrigation and tended a herd of cattle that Kino had given them earlier (Bolton 1948: I, 165). Below Santa Cruz about three miles lay Quiburi, the largest of the rancherías, populated by about five hundred Indians. For some fifty miles thereafter the valley contained villages recently abandoned because of an internal war among the Sopaípuris. Below these, within a stretch of thirty-five miles, Kino found ten occupied rancherías. All of them practiced irrigation and raised corn, beans, cotton, and squash (Hastings and Turner 1965:26).

In 1698, both Santa Cruz de Gaybanipitea and San Pablo de Quiburi were attacked by the Apaches and were abandoned (Di Peso 1953:30-32). The Sobaipuris rebuilt Quiburi in 1704 or 1705, renaming it Santa Ana del Quiburi (Di Peso 1953). In 1732, Captain Juan Bautista de Anza and a German Jesuit missionary, Father Ignacio Xavier Keller, followed the San Pedro River to the Gila River, inspecting the six mission visitas (including Quiburi) that served an estimated 1,800 Sobaipuris in the valley (Di Peso 1953:38; Hammond 1929:227, as cited by Hadley et al. 1991:39). When Keller visited the area five years later, though, the Sobaipuris had largely abandoned it because of Apache attacks. When Keller tried to inspect the region again in 1743, the Apachean threat forced him to turn back (Officer 1987:35). By 1763, the Sobaipuris had completely abandoned the San Pedro River Valley, moving to Santa Maria de Suamca and San Xavier del Bac (Di Peso 1953).

In 1772, the Spanish attempted to move the Presidio of Santa Cruz de Terrenate to the old site of San Pablo and Santa Ana del Quiburi (Di Peso 1953:42, 276). This event was significant because it represented an attempt by the Spanish to colonize the San Pedro Valley rather than merely to missionize the Indians living there. The attempt was unsuccessful, and the presidio was never completed. From the winter of 1775-6 to 1780, the Spanish maintained a presidio at Santa Cruz de Terrenate on the west side of the San Pedro River north of what is now the town of Fairbank. In 1789, Santa Cruz de Terranate was moved to its present location in Sonora, Mexico (Di Peso 1953:276).

Mexican Colonization

According to Officer, throughout the Spanish and Mexican periods, "Tucson settlers planted and harvested crops on the San Pedro River at Tres Alamos" on the east side of the river north of present-day Benson. "Because of the Apache menace, they were escorted to and from their fields by presidial soldiers" (Officer 1987:15). In the 1800's, "peaceful Apaches, protected by fifteen or more soldiers" from the Tucson presidio, farmed the San Pedro River floodplain at Tres Alamos, and supplied the Tucson presidio with farm products (Officer 1987:89).

During the Mexican period, land grants were established in the San Pedro Valley. In 1827, the San Ignacio del Babocómari land grant, from modern-day Elgin to the San Pedro River, was awarded (Officer 1987;109). That same year, application was made for the San Rafael de Valles land grant, and the Elías González family petitioned for a land grant on the San Pedro River. The San Rafael de Valles grant was actually awarded in 1828 (Officer 1987:109). In 1831, the Tres Alamos land grant was awarded (Officer 1987:109-110). In 1832, the San Rafael del Valle grant was sold to Rafael Elías Gonzales for $240 as a stock farm (McClintock 1916:531). In 1833, the San Juan de la Boquillas y Nogales land grant was awarded to the Elías González family (Officer 1987:108-110).

Throughout the Mexican period, Apache raids remained the greatest obstacle to colonization of the San Pedro Valley. In 1830, Lieutenant Antonio Comaduran left Tucson presidio, traveled to Tres Alamos (north of present-day Benson) on the San Pedro River, then proceeded toward the Sierra de Santa Teresa to Cajon de Agua Caliente (Hooker Hot Springs) and then to the Aravaipa Valley (Hadley et al. 1991:41, citing Dobyns 1981:16-26). In 1836, Pinaleno and Aravaipa bands of the Western Apache agreed to settle at the junction of the Aravaipa and the San Pedro River (Hadley et al. 1991:41). From 1846 through 1859, however, United States military expeditions and parties of forty-niners reported that the valley was filled with the ruins of abandoned ranches and large herds of wild cattle.

Exploration by United States Citizens

The first reports on the San Pedro Valley by citizens of the United States were made by trapper James Ohio Pattie, who made three expeditions along the Gila River from 1824 to 1828. The first of Pattie's expeditions into what is now Arizona occurred between December of 1824 and April of 1825 and followed the Gila River down to the San Pedro River, which Pattie called the Beaver River, then a short ways up the Beaver River, trapping all the way. Between January and April of 1826, Pattie traveled down the Gila River and up the Salt River (which he called the Black River). Between October of 1827 and February of 1828, Pattie again traveled down the Gila River to the Beaver (San Pedro) River (Davis 1982).

During the Mexican War, three expeditions traveled through southern Arizona. The first was Stephen Watts Kearny's, which (upon the advice of Kit Carson) left its wagons behind and followed the Rio Grande to below present-day Elephant Butte Reservoir, then went west over the mountains to the headwaters of the Gila River, and followed the Gila River to its mouth. Kearny was accompanied by William Hensley Emory of the Corps of Topographical Engineers who prepared a map and description of the route (Emory 1848). In late 1846, Philip St. George Cooke brought Kearny's wagons over a more southerly route along the present international border and followed the San Pedro River for about 50 miles before turning west to Tucson (Cooke 1848, 1938, 1964). From September of 1848 to January of 1849, after the signing of the Treaty of Guadalupe Hidalgo, Major Lawrence P. Graham led the Second Dragoons from Chihuahua to California staying south of the present international boundary until he reached the Altar Valley and leaving a trail of dead livestock, abandoned wagons, and other debris that would be followed by later travelers.

The San Pedro Valley lay on one of the principal routes for the forty-niners on their way to the gold fields of California, and numerous accounts of the forty-niners have been published (Aldrich 1950; Chamberlain 1945; Cox 1925; Durivage 1937; Eccleston 1950; Evans 1945; Harris 1960; Hunter n.d.; Pancoast 1930; Powell 1931).

From 1850 to 1853, John R. Bartlett of the United States Army Corps of Topographical Engineers attempted to survey the boundary between the United States and Mexico, as this boundary was described in the Treaty of Guadalupe Hidalgo. The description in the Treaty of Guadalupe Hidalgo was based on inaccurate maps and misunderstandings about the regional geography. Therefore, the Gadsden Purchase was negotiated and was based primarily on latitude and longitude and not on topographic or geographical features. The new boundary was surveyed in 1854 and 1855 by William Hemsley Emory. Bartlett prepared a two-volume report that was essentially a travel book (Bartlett 1854); Emory produced a two-volume report (Emory 1857) that was as much a geographical treatise as a description of the survey.

The Butterfield Stage Route, which crossed the San Pedro River at the present location of Benson, was in operation from 1858 to 1861. The station "was located on the east bank of the San Pedro River, one half mile down the river or north from the present highway bridge, almost directly opposite the present town of Benson" (Conkling and Conkling 1947:149). "By 1859 two stage lines were running along the southern route, the Overland Mail operated by John Butterfield under government contract, and the San Antonio and San Diego Mail Line" (Eaton 1933:176).

United States Colonization

During the Civil War, military posts in Arizona were abandoned until the arrival of the California Column. The San Pedro River was largely left to the Apaches. In 1867, homesteaders began to resettle the San Pedro Valley (Hastings and Turner 1965:40). The brothers Henry and Lem Redfield settled the San Pedro River east of the Santa Catalina Mountains about 1875. The Redington Post Office, named after them, was established in 1879 (Barnes 1988:358). St. David and Pomerene were Mormon settlements (Walker and Bufkin 1986: map 28). Most other towns in the San Pedro River Valley were established as a result of mining (Bisbee [1877], Tombstone [1878], Charleston [1879], Millville [1880], Mammoth [1881], and Hereford [1881]) and railroad construction (St. David [1881], Fairbank [1882], Lewis Springs [1889], Naco [1899]).

Mining in the lower San Pedro River began in 1863, when silver-lead ore was discovered in Copper Creek in the Galiuro Mountains above the San Pedro River. Mining continued in the 1870's and 1880's (Hadley et al. 1991). The mines at Bisbee were established in 1877 (Barnes 1988:48), those at Tombstone in 1878 (Barnes 1988:446). Mining began at the Mammoth Mine and San Manuel in 1881 (Barnes 1988:262; San Manuel Copper Corporation 1955:1). Six mining and milling towns were established along the San Pedro River: Contention, Grand Central, Fairbank, Emory City, Charleston, and Millville (Fulton 1966:9).

Charleston was established on the west bank of the San Pedro River in 1879 to mill the ore from the mines of Tombstone. A bridge was constructed across the San Pedro River so that shipments of ore would not be delayed by flood (Barnes 1988:88). The town flourished for eight years, until the Tombstone mines began to hit underground water, eliminating the need to haul ore to Charleston to mill it with San Pedro River water. The town was badly damaged by the earthquake of 1887 and was never rebuilt. An 1883 photograph of Charleston shows the San Pedro River as an arroyo with entrenched banks (Hastings and Turner 1965:162-163).

Millville was located on the east bank of the San Pedro River, across the river from Charleston (Fulton 1966:10; Varney 1980:108). The *Tombstone Prospector* said of Millville, "Here the great mills of the Tombstone Mining and Milling Co., and the Tombstone and Corbin Quartz Mill were located in 1880" (Barnes 1988:278). The *Arizona Gazetteer* in 1881 described Millville as "a milling town on the San Pedro River about 10 miles from Tombstone" (Barnes 1988:278).

In 1881, the Neptune Mining Co. of Bisbee built a smelter at the present-day location of Hereford and named it for Ben Hereford (Barnes 1988:204; Myrick 1975:179). It operated for only a few years and after closing was burned. About 1892, "Col." Cananea "Bill" Greene established his cattle ranch at the abandoned smelter location and retained the name (Barnes 1988:204).

The transcontinental railroad arrived in Tucson in 1880, and over the next 25 years, the San Pedro River Valley became laced with a network of railroads. In 1881, a railroad route linking Benson, Arizona, with Guaymas, Sonora, was completed (Greever 1957, as cited by Hastings and Turner 1965:40). According to Walker and Bufkin (1986: map 28), St. David (a Mormon settlement) was established in 1877. The St. David Post Office was established in 1881 when a spur line of the EP&SW Railroad reached the town (Barnes 1988:374). Fairbank was established in 1882 on the

EP&SW Railroad (Barnes 1988:150). Lewis Springs was established in 1889 on the EP&SW Railroad (Barnes 1988:246). The Naco Post Office was established in 1899 on the railroad to the mines at Nacozori, Mexico (Barnes 1988:294). The Arizona Eastern Railroad was completed from Globe to Winkelman in 1905 (Myrick 1984, as cited by Hadley et al. 1991:118).

Historical Descriptions of the River[1]

Historical descriptions of the San Pedro River--first by the Spanish, then by American trappers, explorers, military men, and travelers, and finally by late nineteenth century newspapers--suggest that prior to about 1890, the San Pedro River was variable along its course as well as seasonally. After about 1890, it began to flood more severely, and arroyo cutting began.

In 1697, "Manje noted that the San Pedro Valley was broad and productive, had an abundance of grass for livestock, was crisscrossed by irrigation ditches, and had irrigated fields in which cotton, squash, watermelon, beans and corn were growing" (Hadley et al. 1991:39).

Padre Luís Velarde's 1717 description of the Pimería Alta (Wyllys 1931:116) stated that the Gila River and the Colorado were the major rivers of the region, followed by "two others, called the Salado and the Verde, the first because it is salty, and the latter perhaps because it runs among greenish slopes or rocks." "But toward the last and most easterly part of this Pimería, there are two other rivers, really arroyos without any particular names" (Wyllys 1931:116). One of these was the Santa Cruz River, the other probably the San Pedro River. Of the vegetation in the San Pedro Valley, Velarde said, "the valley of the Sobaipuris being the poorest in woods, although they do not lack in timbers, bringing them from greater distances" (Wyllys 1931:127).

James Ohio Pattie did some trapping along the San Pedro River during two of the three trips he made into Arizona between 1824 and 1828. Between December 1824 and April 1825, he went down the Gila River to the San Pedro River, then trapped up the San Pedro River (which he called the Beaver River) before returning to the Gila River. Between October 1827 and February 1828, he repeated this route (Davis 1982).

During the Mexican War, military expeditions led by Stephen Watts Kearny and Philip St. George Cooke crossed the San Pedro River. William H. Emory, who accompanied Kearny and prepared a map and description of the route, followed the lower San Pedro River for a few miles above its mouth on November 5, 1846, and described it as "an insignificant stream a few yards wide, and only a foot deep" (Emory 1951:122). In contrast, Emory believed that "The Gila, at certain stages, might be navigated up to the Pomos village, and possibly with small boats at all stages of water" (Emory 1848:94). John S. Griffin, assistant surgeon with Kearny's expedition, also described the San Pedro River:

[1] The spelling and grammar of historical quotations have not been corrected to preserve the original flavor.

"encamped about 3 PM--some 3/4 or 1 mile on the San Pedro--above its mouth this little stream is also called the Hog river by the Americans--from the number of wild Hogs found on it--the country passed over barren mountains, and utterly worthless--" (Griffen 1943:30).

Philip St. George Cooke (1848, 1938, 1964, 1974), commander of the Mormon Battalion on their journey from Fort Leavenworth, Kansas, to San Diego, California, during the Mexican War, provided relevant observations about the conditions of the San Pedro River Valley in the mid-nineteenth century. On December 9, 1846, Cooke first saw the San Pedro Valley from the mountains to the east, but saw "no other appearance of a stream than a few ash trees in the midst.... On we pushed, and finally, when twenty paces off, saw a fine bold stream! There was the San Pedro we had so long and anxiously pursued." Cooke followed the San Pedro River for the next five days, traveling approximately 55 miles through the San Pedro Valley as far north as present-day Benson. On December 9, Cooke stated that "The San Pedro was frozen over in places this morning" (Cooke 1974:141). On December 10, he reported, "Fish are abundant in this pretty stream. Salmon trout are caught by the men in great numbers; I have seen them eighteen inches long" (Cooke 1974:142). On December 11, he said "An abundance of fine fish are caught, some that are three feet long; they are said to be salmon trout (Cooke 1974:144)."[2] On December 12, he wrote that the valley floors were, on average, more than a mile wide and covered with grass so tall that it was sometimes difficult to pass through it (Cooke 1974:145). On December 13, he described the valley as being one to two miles wide, with a plain and mesquite bosques on each side, "the mesquite in places taking the exact resemblance of orchards" (Cooke 1974:146). They passed a ruined ranch, which Cooke thought was probably "the true San Pedro." On December 13, they camped again on the San Pedro River, and on the 14th left the valley to travel west to Tucson. From Tucson, Cooke traveled down the Santa Cruz River to the Gila River, which he described as "a rapid stream of clear water, in places three or four feet deep, and here about one hundred and fifty yards wide." Cooke felt that the Gila River might be substantial enough to be boated.

At least two men in Cooke's company (Henry W. Bigler and Robert S. Bliss) wrote journals that were subsequently published. Both men wrote of catching fish in the San Pedro River. Bigler (1932:48) described catching "fine fish, plenty of them" from the San Pedro River, "and we had good eating. Some of the boys said they were salmon trout." Bliss (1931:80) described the San Pedro River as "a small clear stream which runs into the Gulf of California" and said that "one of our mess brought 6 fine Trout that he caught today to camp."

One of the principal routes for the forty-niners on their way to the gold fields of California ran along the present border between Arizona and Mexico, although at the time, the route lay in Mexican territory (Aldrich 1950; Chamberlain 1945; Cox 1925; Durivage 1937; Eccleston 1950; Evans 1945; Harris 1960; Hunter n.d.; Pancoast 1930; Powell 1931). The Evans (1945) and Harris (1960) accounts do not mention the San Pedro River, although they were favorably impressed by the Santa Cruz River. Cox (1925:141) stated only that on August 22 "arrived at our present camp ground

[2] In fact, they were probably squawfish.

which we suppose to be on the River San Pedro." From September 26 through 28, H.M.T. Powell traveled through the upper San Pedro Valley, probably southeast of the Huachuca Mountains, but could not find Cooke's trail and was never able to identify the San Pedro River for certain. Instead he crossed a number of small streams. On September 27, he (Powell 1931:130) wrote:

> *"About 5 Miles from Camp we passed a muddy stream in one of the flats. As we thought this the San Pedro we were very much disappointed. We continued on, for there was no wood to cook breakfast. At length we passed a clear stream, running over a rocky bed, and soon after, a still larger one, running North East. After passing the last one, we kept up it a short distance on to a small elevation of land and encamped near the stream. ... We are not on Cooke's route now, as we have passed the river, I am satisfied, above the forks. ... The left fork of the river on which we are encamped is the main branch. Cooke has it different."* (Powell 1931:130).

The next day, Powell (1931:131) "passed a little clear stream, running East, a tributary of the San Pedro, I suppose. ... A short distance from where we crossed the stream we saw the ruins of a number of adobe houses. The ground became swampy and heavy. In about a Mile we recrossed the same creek, which now ran southerly." On October 30, Powell's group converted their wagons into boats and also built rafts and flatboats, all of which they floated down the Gila River (Powell 1931:162). Of the Gila River, Powell (1931:174) stated, "The navigation is laborious, but perfectly practicable for flat boats properly built, Colonel Cooke to the contrary notwithstanding."

Eccleston (1950:192-193) crossed the San Pedro River on October 30, 1849, at the crossing near Tres Alamos later used by the Leach Wagon Road.

> *"This river, the San Pedro, is extremely boggy & has to be crossed by making a brush bridge.... We were the fourth that crossed, & the bridge sank pretty well with us, the water coming nearly up to the box. I was obliged, in order to manage my team, to jump in beside them, & got wet above the waist.... We all crossed safely, the bridge being fixed several times. ... I cannot agree with Colonel Cook, who calls this a beautiful little river, although where he crossed it, some 10 or 15 miles above, it may have presented more amiable qualities. Here it is lined with a poor growth of swamp willow & other brush, so that it cannot be seen till you come within a few feet of it; & then the bank is perpendicular, not affording an easy access to its waters, which, though not very clear, is good. The banks & bed are extremely boggy, & it is the worst place for cattle & horses we have yet been, being obliged to watch them very close"* (Eccleston 1950:192-193).

In the 1850's, after the Gadsden Purchase, the international boundary was formally surveyed, and the San Pedro River was described again (Bartlett 1854). Still later, surveys for a railroad (Parke 1857) and a wagon road (Hutton 1859) resulted in descriptions of the area.

Bartlett, who surveyed the international boundary with Mexico in the 1850's, described his approach to the San Pedro River from the east as follows:

"We looked in vain for a line of trees, or of luxuriant vegetation to mark the course of the San Pedro--when all of a sudden we found ourselves upon the banks. The stream ... was here about two feet deep, and quite rapid. The water, though muddy, was pleasant to the taste." (Bartlett 1854, I:377, as cited by Davis 1982:64).

Bartlett crossed the river (heading west) on September 9, 1851. He described the San Pedro River (near the mouth of Dragoon Wash) as follows:

"The valley of the San Pedro River near our camp was any thing but luxuriant. It consists of loam, which if irrigated might be productive; but as the banks are not less than eight or ten feet high, irrigation is impracticable, except by digging a canal a very long distance. The grass of the vicinity is miserably thin and poor, growing merely in tufts beneath the mezquit bushes which constitute the only shrubbery, and in some places attain a height of ten or twelve feet .... In order to cross the river, it was necessary to level the banks on both sides, and let the wagon down by hand (Bartlett 1854 [I]:379-81).

Lt. Col. Graham of the international boundary survey party also described the stream (Graham 1852:35-36, as cited by Davis 1982:64, and Hastings and Turner 1965:293).

"The San Pedro was pretty high when we arrived here. It is very muddy, with a quick current, resembling very much the Pecos, or Rio Puerco, for this is its proper name--which means dirty or muddy river. The San Pedro runs here through a soft, alluvial soil, and its rapid current has worn a deep bed for it, leaving steep banks on either side. My assistant, Mr. Clark, took from this stream several new species of fishes not known before in zoology" (Graham 1852:35, as cited by Davis 1982:64).

On his return trip, in July of 1852, Bartlett passed though the upper end of the San Pedro Valley southeast of the Huachuca Mountains, where the San Pedro Valley was "a boggy plain" crossed by numerous small streams, none of which could be identified as the San Pedro River. On July 29, he crossed "a small stream; the western tributary or source of the San Pedro" (Bartlett 1854 [II]:323-324).

Emory completed the boundary survey begun by Bartlett and also described the San Pedro River:

"At this point [on the International Boundary], approaching from the east, the traveler comes within a mile of the river before any indications of a stream are apparent. Its bed is marked by trees and bushes, but it is some sixty or one hundred feet below the prairie, and the descent is made by a succession of terraces. Though affording no great quantity of water, this river is backed up into a series of large pools by beaver-dams, and is full of fishes. West of the river there are no steep banks or terraces, the prairie presenting a gentle ascent" (Emory 1857, Pt. 1:99-100).

In 1854, John G. Parke, surveying a railroad route, crossed the San Pedro River heading east. He stated:

> *"The stream is about eighteen inches deep and twelve feet wide, and flows with a rapid current, at about twelve feet below the surface of its banks, which are nearly vertical, and of a treacherous miry soil, rendering it extremely difficult to approach the water, now muddy and forbidding. The banks are devoid of timber, or any sign indicating the course or even the existence of a stream, to an observer but a short distance removed..."* (Parke 1857:9).

Parke reached the stream on February 25, and on February 26, "started down the stream about two miles to the ford, Lieutenant Stoneman having dispatched a fatigue party to improve it; but in spite of this and the great exertion of Lieutenant S., we had no little trouble in effecting a crossing" (Parke 1857:9). Parke (1857:18) listed "the Rio San Pedro, a turbid stream, winding its way to the Gila River," as one of just nine places on the route with permanent water.

> *"At the Tres Alamos [crossing] the stream is about fifteen inches deep and twelve feet wide, and flows with a rapid current over a light, sandy bed about fifteen feet below its banks, which are nearly vertical. The water here is turbid, and not a stick of timber is seen to mark the meandering of its bed"* (Parke 1857:25, as cited by Hastings and Turner 1965:36).

> *In the gorge below [Tres Alamos] and in some of the meadows, the stream approaches more nearly the surface, and often spreads itself on a wide area, producing a dense growth of cotton-wood, willows, and underbrush, which forced us to ascend and cross the out-jutting terraces. The flow of water, however, is not continuous. One or two localities were observed where it entirely disappeared, but to rise again a few miles distant, clear and limpid (Parker 1857:25, as cited by Davis 1982:108).*

Also in 1854, Andrew B. Gray surveyed a railroad route for a private company, and crossed the middle reach of the San Pedro River.

> *"The San Pedro River, where we struck it, in latitude 31° 34' is a small stream at this stage, about eight feet wide, and shallow; between steep banks 10 feet high and 25 to 50 feet apart. ... At three points that I have crossed it, it is a living stream with large fish. ... Occasional bunches of mezquite and cotton-wood are seen upon its borders."* (Gray 1856:76-77, as cited by Davis 1982:107).

James G. Bell followed the Texas-California Cattle Trail in 1854, taking the Graham route from Janos through San Bernardino to Santa Cruz, remaining south of the present international border the whole time. Upon reaching the San Pedro, he had little to say about the nature of the stream, writing "Found plenty of water, known as the head waters of San Pedro." The next day he crossed the San Pedro several times and said "The valley through which the San Pedro passes is a desirable location for ranches. ... Upon the whole this is the most habitable place seen since I left San Antonio." He also noted that the vast herds of cattle reported a few years before had disappeared (Bell 1932:306).

In his first letter home after arriving in Arizona late in 1857, James H. Tevis described his impressions of the San Pedro River as follows:

> *"The Sanpedro river as they Call it--is a stream one foot deep six feet wide & runs a mile & half an hour & in ten minutes fishing we Could Catch as many fish as we Could use & about Every 5 miles is a beaver dam this is a great Country for them--& we have went to the river & watterd & it was running fine & a half mile below the bed of the river would be as dry as the road--it sinks & rises again & we went down as far as the aravipa & 8 miles below that the pedro Emties into the hela river"* (Tevis 1954:55).

In 1858, engineers surveying the Leach Wagon Road from El Paso to Yuma crossed the San Pedro River two miles below where Parke had crossed it and left two accounts, one from the westward trip and another from the return.

> *"The San Pedro, at the first point reached in the present road, has a width of about twelve (12) feet, and depth of twelve (12) inches, flowing between clay banks ten or twelve feet deep, but below it widens out, and from beaver dams and other obstructions overflows a large extent of bottom land, forming marshes, densely timbered with cottonwood and ash, thus forcing the road over and around the sides of the impinging spurs. This steam is not continuous all the year, but in the months of August and September disappears in several places, rising again, however, clear and limpid"* (Hutton 1859b:87).

On September 12, 1858, Leach stated:

> *"Exceedingly to the surprise of every member of the expedition who had passed over this route in the months of March and April it was discovered after a march of a few miles that the waters of the San Pedro had entirely disappeared from the channel of the stream.... Where the present reporter took quantities of fine trout in March and April 1858 not a drop of water was to be seen"* (Leach 1858:33, as cited by Hastings and Turner 1965:35).

On September 13, though, Leach arrived at the mouth of the Aravaipa, and reported, "The waters [of the San Pedro] were found full of fish, large numbers being taken daily, during our stay on the stream" (Leach 1858, as cited by Davis [1982]).

In 1858, Waterman Ormsby (the only through passenger on the first westbound trip of the Butterfield Stage) said of the San Pedro River, "The stream itself is insignificant, but the valley has the appearance of having been once a vast stream of itself" bordered by bluffs on the west "and sloping hills on the east." The stage went north several miles through the San Pedro River Valley, "and finally crossed the stream (if by that name it might be dignified)" (Ormsby 1962:85). Early in 1859, the Butterfield Stage Company constructed "a strong bridge across it [the San Pedro] at the old fording place near the station.... This bridge is mentioned in the report of Colonel Edward B. Eyre who crossed the river here on June 23, 1862, in command of the First California Volunteers on their march to Fort Thorn in New Mexico" (Conkling and Conkling 1947:149-150). "In the middle seventies, a toll bridge was established at the same location, and the station which had fallen to ruin was rehabilitated. Large shipments of mining and smelting equipment transported in twenty-mule team freight wagons to the early developed mining regions of southern Arizona, crossed over this bridge" (Conkling and Conkling 1947:150).

In 1870, the Surgeon General prepared a report on conditions at military posts, including Camp Grant located on the lower San Pedro River at the junction of the Aravaipa (U.S. War Department, Surgeon General's Office 1870). The post "was originally built immediately on the bank of the San Pedro River, but in 1866 twenty out of twenty-six adobe buildings, composing the post, were swept away by the flooding of the stream." The post was then moved to the top of a flat knoll between the junction of the two streams. "The valley of the San Pedro varies in width from one-half to four miles. Many parts of the valley can be cultivated by irrigation. Several attempts have been made to reclaim the ground in the immediate neighborhood of the camp, but without success" (Surgeon General 1870:465). "...the main supply [of vegetables] is from the company gardens in the river bottom" (Surgeon General 1870:466). Water for cooking and drinking came from a well. "The water of the San Pedro is used only by the quartermaster animals and for washing. It is pleasant enough to the taste, and turbid only during heavy rains, but coming as it does, through swampy country above the post, may be impregnated with malaria" (Surgeon General 1870:466). "The prevailing winds are from the southeast down the course of the San Pedro, carrying with them the malaria from the marshes along its banks, and exposing the troops stationed on the knoll to its deleterious influence" (Surgeon General 1870:465). Mail was dispatched to the post weekly from Tucson. "But well-escorted trains and travelers may proceed from Maricopa Wells direct, without circling southward by Tucson, as there is a good road along the Gila River between the two places" (Surgeon General 1870:465).

John G. Bourke's (1891) accounts of life at Camp Grant (at the junction of the San Pedro and the Aravaipa) include descriptions of the San Pedro River, which Bourke (1971:2) called an "insignificant sand-bed." Bourke served at Camp Grant from 1870 to 1873. He (Bourke 1971:4) described Camp Grant as being located at "the junction of the sand-bed of the Aravaypa [sic] with the sand-bed of the San Pedro, which complacently figured on the topographical charts of the time as creek and river respectively, but generally were dry as a lime-burner's lot excepting during the 'rainy season.'" Three miles above Camp Grant, Joe Felmer, the post blacksmith "lived in a little ranch in the fertile bottom of the San Pedro, where he raised a patch of barley and garden-truck for sale to the garrison" (Bourke 1971:15).

Hastings and Turner (1965:35, 293) cite four manuscripts in the archives of the Arizona Pioneers Historical Society that mention beaver in the San Pedro River during the nineteenth century, one account as late as 1882. They also report that descriptions of fish in the San Pedro River were common from Cooke's report through articles in newspapers into the 1880's (Hastings and Turner 1965:293).

An 1883 photograph of Charleston (Hastings and Turner 1965:36, 162, plate 51a) shows the San Pedro River with a well defined channel trench. In 1883-1884, a flood destroyed the old Butterfield stage station and bridge at Benson (Conkling and Conkling 1947:150). Bandelier (1892: pt.2, 478), who traveled through the area just before the flooding and arroyo cutting of the 1890's described the San Pedro River a few miles north of the mouth of Dragoon Wash as an entrenched stream within "a cut with abrupt sides... 10 to 15 feet deep, and about 25 wide."

Hadley et al. (1991:144-145) indicate that the San Pedro Valley suffered a drought from about 1885 to 1903. This drought was apparently accompanied by periodic flash flooding. According to Hastings and Turner (1965:42):

> *"In 1886 "the water in the San Pedro River was...higher than it was ever known to be. Between Contention and Benson there was four feet of water on the side of the [railroad] tracks" (Arizona Daily Star, August 30, 1886). At its junction with the Gila River, "an avalanche of water swept down...like a wave, 6' high"* (*Arizona Weekly Enterprise*, August 14, 1886).
>
> *"During the following year, 1887, the San Pedro River again had "higher water than ... ever ... known before" (Arizona Weekly Enterprise, Sept. 17, 1887). "For nearly the entire length of the river from Benson down to the Gila the crops with the exception of hay ... [were] destroyed" (Arizona Weekly Enterprise, Sept. 3, 1887). At Charleston the flood carried away the dam (Arizona Weekly Enterprise, July 16, 1887; Arizona Daily Star, July 17, 1887)."* (Hastings and Turner 1965:42)

Hastings and Turner (1965:42-43) indicate that arroyo cutting accompanied the floods of August 1890, and left the San Pedro River in an entrenched streambed (See Chapter 5).

> *"Of the country down the San Pedro, from Tres Alamos to the Gila [Captain Van Alstine] ... says, "all of it is gone, destroyed, torn up, 'vamosed' down with high water. He never saw such a destruction in all his life. ... The San Pedro never was as high as it was this time, and will probably not be for the next ten years. The losses sustained by the people will reach into the thousands (Arizona Daily Star, August 14, 1890)."* (Hastings and Turner 1965:42, their ellipsis and inserts)
>
> *"At Dudleyville, near the mouth of the San Pedro the river "caved within 15' of Cook's [store]" (Arizona Weekly Enterprise, Sept. 6, 1890), and upstream at Mammoth flood washed the soil out in places thirty feet deep, exposing archaeological relics"* (*Arizona Daily Star*, Oct. 2, 1890). (Hastings and Turner 1965:42-43, their ellipsis and inserts)

Hastings and Turner (1965:3) state that as a result of the floods of 1890:

> *"Where the San Pedro River of southeastern Arizona formerly wound its sluggish course northward through a marshy, largely unchanneled valley, in August, 1890, it began carving a*

steep-walled trench through which it thereafter emptied rapidly and torrentially into the Gila River. Where it formerly ran more or less consistently throughout the year, after 1890 its flow became intermittent, leaving the new channel dry over much of its length for most of the time" (Hastings 1959).

Even after arroyo cutting entrenched the San Pedro River, cienegas remained in the uplands. "From the court records of an early suit over water rights there can be established the existence of a large cienega extending along the San Pedro River from about modern Benson to old Tres Alamos (Cochise County District Court 1889). The boggy, but treeless and trenched location already discussed lay at the foot of it" (Hastings and Turner 1965:37).

Historical Uses of the River

Historically, the primary uses of the San Pedro River were for irrigation agriculture and milling of ore. These uses required a reliable source of large amounts of water.

Farming

Irrigation agriculture along the San Pedro River dates back to prehistoric times. The earliest Spanish explorers reported that the Sobaipuris (upland Pimas) were practicing irrigation agriculture along the entire reach of the river. In 1697, Kino and Manje found that some farms and villages in ruins because of intra tribal warfare among the Sobaipuris. In the 1760's, Apaches began moving into the area and forced the Sobaipuris out. Euroamericans and peaceful Indians from Tucson continued to farm the San Pedro River, though, with protection from the troops of the presidio.

During the Civil War, the United States Army established a number of military posts in southern Arizona, which made the area safer for homesteaders. Some of the farms were in the San Pedro River Valley were established near Camp Grant. Joe Felmer's, Israel's, and Kennedy's farms on the San Pedro River supplied the fort (Hadley et. al., 1991:217-218).

Hodge (1877:47) wrote that the San Pedro Valley contained 50,000 acres "of good farming land, most of which can be successfully cultivated. At Tres Alimos, in this valley, are some well cultivated farms and one choice dairy farm, that of H.C. Hooker, Esq." GLO maps dated to 1873, 1878, 1880, 1882, 1901, 1902, and 1903 show acequias and fields along the river in virtually every township. A map from the 1900 census shows irrigation farming all along the San Pedro River (Figure 3-3).

Fishing

Fish species found in the San Pedro River historically included some 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. Historical accounts of fishing are centered on early explorer routes and settlements, as cited earlier in this chapter. There are numerous accounts of "salmon" runs (actually squawfish) on the San Pedro River, fish clogging canals on the San Pedro River, and catching fish with pitchforks for use as fertilizer on irrigated fields. A commercial operation reportedly harvested razorback suckers from the San Pedro River between 1870 and 1910 near Tombstone.

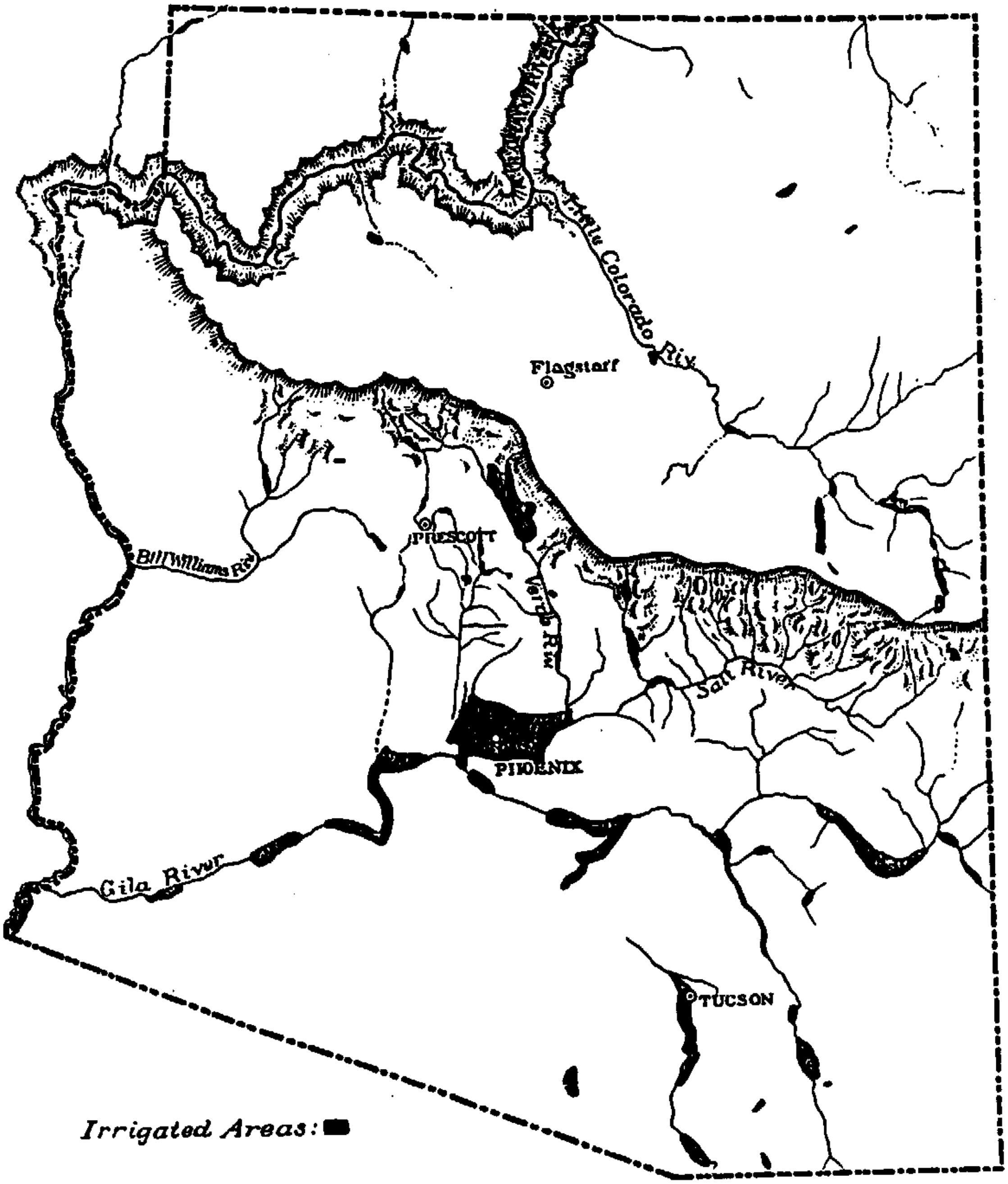
Mining

Charleston and Millville were among six mining and milling towns established to use the water from the San Pedro River to mill the ore from Tombstone mines. According to Fulton (1966:10), "The San Pedro River not only separated the two town sites, but also supplied water for the works at Millville and furnished water necessary for domestic and irrigation purposes." The Tombstone Mill and Mining Company built a 200 foot-long dam across the San Pedro River approximately one mile above its mill at Millville (Fulton 1966:13). "The San Pedro River yielded a daily supply of thirteen million gallons of water in February, 1879. Normally it could be forded, but during the rainy months of July and August, when it flooded, it became impassable" (Fulton 1966:11). In 1881, a 160-foot bridge was built over the San Pedro River so that ore shipments would not be delayed by floods (Barnes 1988:88; Fulton 1966:11). When the Tombstone mines struck ground water, there was no longer a need to haul ore to Charleston, and the town began to decline. It was not rebuilt after the 1887 earthquake (Hastings and Turner 1965).

Mining at the Mammoth Mine and San Manuel began in 1881. San Manuel mine used well water for milling (Barnes 1988:262; San Manuel Copper Corporation 1955:1).

Regional Transportation

The primary means of transportation along the San Pedro River has always been overland. Spanish missionaries and military expeditions, as well as the trappers of the 1820's, traveled on horseback. Kearny traveled by horseback in 1846, not even attempting to haul wagons. Later U.S. military expeditions did use wagons, as did the forty-niners. All of these groups followed expedient trails (Figure 3-4). The Butterfield Stage Route, which crossed the San Pedro River at the present location of Benson, was in operation from 1858 to 1861, and in 1859, a bridge was constructed across the San Pedro River (Conkling and Conkling 1947:149; Eaton 1933:176). The military was responsible for surveying and constructing a number of formal roads in the region. In 1858, the Leach Wagon Road, which ran down the San Pedro River, was surveyed but never became popular because it bypassed Tucson. By 1870, a road ran up the Gila River to Camp Grant.



[1] From Census Bulletin No. [illegible], July 29, [illegible]

Figure 3-3: Map of Irrigation in Arizona, 1900

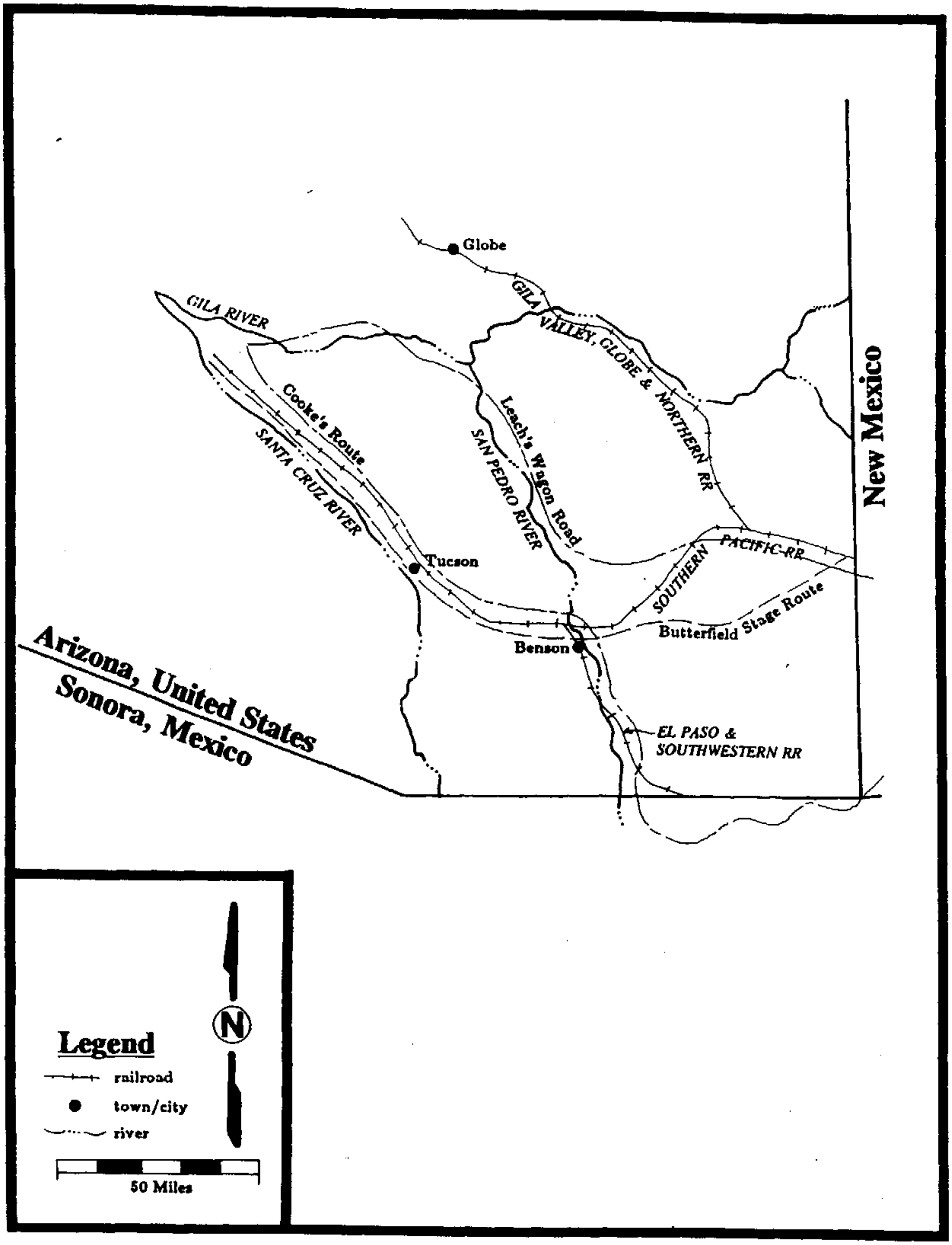


Figure 3-4: Transportation Routes in the San Pedro Valley

GLO maps were prepared for most of the San Pedro River between 1872 and 1925, although most maps were prepared before 1900. These maps indicate nine different roads crossing the San Pedro River. An 1873 GLO map shows a stage road and Schaublin's Station in T.17S R.20E (near Benson). An 1888 map shows a stage station and a road crossing the San Pedro River in Section 9, T.7S R.16E (near Ft. Grant and Aravaipa Creek). According to Hadley et al. (1991:118), "Farmers hauled fruit into Winkelman, Mammoth, and Oracle in wagons."

Transportation companies operating in Charleston in 1880 suggest the extent of stage transportation along the San Pedro River. According to Fulton (1966:17), four stage coaches arrived and departed daily from Charleston in 1880, "two from Tombstone, one from the Huachucas, and one from the Mule Mountains." The Ohnesorgen and Walker stage line, established in 1880, extended from Tombstone to Charleston. The same year, the Stillwell and Dremen Company began stage service between Charleston and Patagonia. The Ingram and Company stage line ran from McGreary's Ranch on Babocomari Creek to Charleston and Tombstone. The Arizona Transportation Company, run by C. "Ham" Light, hauled ore from the mines to the mills in 16-mule teams. In 1881, a 160-foot bridge was built over the San Pedro River between Charleston and Millville.

As described earlier, the period from 1880 (when the transcontinental railroad arrived in Tucson) to 1905 (when the Eastern Arizona Railroad was completed from Globe to Winkelman), was a time of extensive construction of railroads in the San Pedro Valley. Most of the railroads were constructed to serve the mines in the valley, but their construction led to the founding of a number of towns. Examples include Fairbank in 1882 (Barnes 1988:150), Lewis Springs in 1889 (Barnes 1988:246), and Naco in 1899 (Barnes 1988:294).

Hadley et al. (1991:118) summarize the development of railroads in the San Pedro River Valley as follows:

> *"Mining operations in the Aravaipa area shipped ore on three railroads which came within a reasonable distance of their operations. The Southern Pacific was completed across southern Arizona in 1881 with the nearest stations in Benson and Willcox. On the east end of Aravaipa, the nearest connection was the Gila Valley, Globe and Northern Railroad which reached the Solomonville area in 1885; and on the west end, the Arizona Eastern was completed in 1905 connecting Winkelman with Globe."*

A number of the early histories and boosters' descriptions of Arizona and the San Pedro River Valley (Adams 1930; Bancroft 1888; Farish 1915; Hamilton 1884; Hodge 1877; McClintock 1916; Wallace W. Elliot & Co. 1884) do not publicize river navigation; similar contemporary publications for other areas typically mentioned boating if it was at all feasible. Similarly, Hamilton (1884) has 14 pages of advertisements in the back, including advertisements for stagecoaches, but none for railroads or river transportation.

Dora Ohnesorgen and Nedra Sunderland both recalled that Dora Ohnesorgen's grandfather had operated a ferry across the San Pedro River near Pomerene, but provided no documentation of when the ferry may have been used, or for what seasons, or what was transported in the ferry. This was the only account of boating on the San Pedro River found during this study.

Summary

The history of the San Pedro River exemplifies the types of changes that occurred on some river systems in southern Arizona during the historic period. Prior to the 1880's, more of the San Pedro River flowed year round, in some areas a few feet wide and perhaps a foot deep, in other areas meandering through marshes such that it could "hardly be said to have [had] a course" (Hastings and Turner 1965:36), and several feet deep in other reaches. During this period, the stream supported fish and beaver. In protohistoric and early historic times, the Sobaipuris (upland Pimas) farmed along the river and lived in villages of perhaps as many as 500 people. During the Spanish and Mexican periods, Hispanics and peaceful Indians from the presidio of Tucson had irrigated farms along the river, supplying food to the presidio (Officer 1987). Descriptions of the river during the Mexican War, the 1849 gold rush, and the 1850's survey of the international boundary indicate that the river maintained this pattern.

Historic accounts suggest that early explorers, travelers, and settlers did not consider the stream to be boatable. Emory, for example, called the San Pedro River "an insignificant stream," but felt that the nearby Gila River could be boated. Cooke, who traveled along the San Pedro River for some 50 miles, left the river to travel to the Gila River via Tucson, and never mentions considering the San Pedro River boatable, but did in fact boat the Gila River in spite of delays and loss of supplies on that river. He then judged the "experiment" a failure. Powell, a forty-niner, was in a group that built rafts and flatboats, and converted wagons into boats, all of which they floated down the Gila River, although they never did identify the San Pedro River with certainty.

By 1890, the San Pedro River was a highly variable stream, both seasonally and along its length. In some areas, it was primarily a marsh with no discernible bed. In other areas it was a flowing stream several feet wide and as much as one foot deep, but a few miles away, surface water might not be present at all. In a few places, the stream flowed through arroyo cuts as much as 10 feet deep. Historical accounts of the river also indicate that some reaches changed from wet to dry over the course of the season.

Some time around 1890, arroyo cutting significantly changed the character of the San Pedro River. A drought beginning in 1885 and lasting until 1903 (Hadley et al. 1991:144-145), occurred during the same period as flash flooding, arroyo cutting, and increased development of the river valley. These channel changes are discussed in more detail in Chapters 5 and 7 of this report. Regardless of how or why arroyo cutting occurred, the historical channel changes suggest that many historical descriptions may not apply to the channel as it existed as of the time of statehood. River uses possible during the earliest period of exploration and settlement may have been precluded by the time of statehood.

Even if pre-arroyo channel conditions are considered, there is no documentation of boating of any kind on the San Pedro River. The river was used for irrigation agriculture, fishing, and milling. The only account of it having been boated or otherwise used for transportation is the undocumented recollection of an avocational historian and a long-term Benson resident who recalled the Ohnesorgen ferry which may have been operated below Pomerene (Chapter 6). The primary means of transportation along the San Pedro River has always been overland by horse, wagon, railroad, or foot.

Chapter 4
Oral History

Oral history for the San Pedro River was obtained primarily by writing and calling historical societies, federal and state agencies, and private organizations with interests in the various rivers. From these sources, information about the history of the river, and names of individuals who might be knowledgeable about the rivers were obtained. 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 (for example, Fischer and Fischer 1993), and the personal knowledge and contacts of the study participants. A list of contacts was compiled, and letters describing the project was sent to each person and agency on the list. 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, each individual was questioned about who might be able to provide additional information on the history of the 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, individuals who were questioned during the initial and subsequent contacts might be 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. For the San Pedro River, three professional land managers, nine professional historians, eight avocational historians, and five local residents provided information or were interviewed.

Professional land managers interviewed included Geoff Parker (Soil Conservation Service) and Terry O'Sullivan (Bureau of Land Management), who were interviewed, and Hollis N. Cook (Tombstone Courthouse State Historic Park), who sent a letter. Professional historians, archaeologists, and museum curators who were interviewed included Julio Betancourt (United States Geological Survey), Dan Brown (McFarland State Historic Park), Don Bufkin (Arizona Historical Society), Suzanne Dewberry (National Archives, Federal Records Center, Laguna Niguel, California), Mary Lou Heuett (Cultural and Environmental Systems, Inc.), Ken Kimsey (Prescott National Forest), Mary Lu Moore (Arizona State Attorney General's Office), Bob Trennert (Arizona State University), and Angie Vandereedt (National Archives of the Old Coast Guard). Avocational historians who were interviewed included Brother Tom of the Holy Trinity Monastery at St. David, Cindy Hayostek (Cochise County Historical and Archaeological Society), Helen Hume (San Pedro Valley Arts and Historical Society Museum), Rose Land (San Pedro Valley Arts and Historical Society Museum), Della Meadows (Pinal County Historical Society), Bob Rosen (Gila County Historical Museum), Nedra Sunderland (San Pedro Valley Arts and Historical Society Museum), and the secretary of the Bisbee Mining and Historical Museum. Local residents who were interviewed included Jay Bateman (Florence), Carl Black (St. David), Louise Larson (Benson), Dora Ohnesorgen (Benson), and Jerry Pratt (Sierra Vista). 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.).

A number of individuals contacted (for example, Dan Brown of McFarland State Historic Park), Suzanne Dewberry of the National Archives Federal Record Center, Laguna Niguel, California, Helen Hume and Rose Land of the San Pedro Valley Arts and Historical Society Museum, Geoff Parker of the Soil Conservation Service, and Angie Vandereedt of the National Archives of the Old Coast Guard) could not provide any information on whether the San Pedro River was boated or was susceptible to being boated as of the time of statehood.

Julio Betancourt (United States Geological Survey) has studied and written extensively about biological processes and historical changes along southern Arizona rivers (including the San Pedro River) and said that he did not think the San Pedro River was ever used for navigation.[1] Hollis N. Cook, manager of Tombstone Courthouse State Historic Park, sent a letter describing the archival holdings of the Tombstone Courthouse State Historic Park. He mentioned irrigation, dams, and smelters along the San Pedro River. He also stated, "We find the notion of the San Pedro being navigable preposterous, however perhaps `navigable' isn't defined in the obvious way." Mary Lou Heuett has done archaeological research on the Santa Cruz and San Pedro Rivers, and has not uncovered any references on navigation. Della Meadows (Pinal County Historical Society) provided a photograph of a ferry across the Gila River at Florence, but knew of no accounts of boating on the San Pedro River. Bob Rosen (Gila County Historical Museum) said that the San Pedro River was bone dry most of the time. Earl Zarbin sent two letters providing references to boating, ferries, and fish, although these references pertained essentially to the Salt and Verde rivers. Mr. Zarbin did not know of any accounts of boating on the San Pedro River. Two local residents (Jay Bateman and Louise Larson) mentioned fanciful storytelling about boating the San Pedro River.

Irrigation, mining, swimming, and picnicking were activities that were reported to have occurred along the San Pedro River. Numerous people (Carl Black with the St. David Irrigation District, Hollis N. Cook of the Tombstone Courthouse State Historic Park, Louise Larson, Della Meadows of the Pinal County Historical Society, and Nedra Sunderland) mentioned irrigation agriculture, and several museums (the Pinal County Historical Society and the Tombstone Courthouse State Historic Park), institutions (the St. David Irrigation District and the LDS Church in St. David), and individuals have records that relate to irrigation. Carl Black of the St. David Irrigation District stated that the district takes water from the San Pedro River seven months of the year and pumps groundwater the rest of the time. Mining and smelting along the San Pedro River were mentioned by Hollis Cook (Tombstone Courthouse State Historic Park), Louise Larson, and Bob Rosen (Gila County Historical Museum). The Bisbee Mining and Historical Museum has photographs of picnics held along the river. Jay Bateman recalled swimming in the San Pedro River.

[1] The H.B. 2589 or 2594 definitions of navigation/navigability was not provided to interviewees.

A number of people mentioned the changes that had occurred along the San Pedro River in historic times. Hollis Cook (Tombstone Courthouse State Historic Park) and Dora Ohnesorgen cited the presence of beavers in the San Pedro River. Louise Larson recalled that even when she was a child (in the 1920's), there was only a small amount of water in the river; now it rarely flows. Jerry Pratt, a retired wildlife biologist in Sierra Vista, thought that early fur trappers might have used boats on the San Pedro River and that the river might have been navigable before the 1887 earthquake. The secretary of the Bisbee Mining and Historical Museum also suggested that the earthquake, grazing, and drought might have affected the stream.[2] Dora Ohnesorgen and Nedra Sunderland both recalled that Dora Ohnesorgen's grandfather had operated a ferry across the San Pedro River near Pomerene. Possible operation of this ferry represented the only historical account of boating on the San Pedro River found during this study.

In summary, use of boats on the San Pedro River apparently was not common enough, if it occurred at all, to have attracted the attention of local residents and historians.

[2] Pattie's accounts and later histories of the fur trade indicate that the fur trappers of the nineteenth century traveled by horseback.

Chapter 5
San Pedro River Geology

Introduction

The San Pedro River is not a major watercourse, but it is one of the most studied rivers in the Southwest. The upper San Pedro River has been the topic of study by geologists, geographers, hydrologists, and ecologists interested in environmental change (cf Bahr, 1991; Cooke and Reeves, 1976). Since 1870, inhabitants of the San Pedro River Valley have witnessed substantial vegetation change (Bahr, 1991; Henderson and Minkley, 1986; Hastings, 1959; Hastings and Turner, 1965; Leopold, 1951) as well as changes in the geometry and hydrologic regime of the river (Cooke and Reeves, 1976; Hereford, 1993; Hereford and Betancourt, 1993). After decades of multi-disciplinary research, the chronology of historic channel changes on the upper San Pedro River is well defined, although the reasons why the channel has changed are not resolved.

This chapter describes the physical characteristics of the San Pedro River as of statehood in 1912, and provides baseline information on how the physical characteristics of the San Pedro River channel have changed through time. The San Pedro River experienced changes in channel geometry prior to and during 1912, but there are few descriptions of the channel during the year of 1912. Therefore, the physical characteristics of the river must be interpolated from descriptions made before and after 1912. The geologic and geomorphic history of the river helps to refine this interpolation.

This chapter is divided into several sections[1]. First, the physical setting and Cenozoic history of the San Pedro River Valley are reviewed in order to set the geologic context the San Pedro River. Second, an overview of the modern channel morphology is presented. Third, previous archival investigations of historical channel changes on the San Pedro River are reviewed. Fourth, channel conditions in 1912 are extrapolated from descriptions before and after statehood. The changes described herein are viewed from a geomorphic perspective emphasizing natural channel dynamics. However, as is apparent from the historical record, many of the geomorphic changes on the San Pedro River are linked to land-use changes within the river valley. This chapter avoids the human vs. natural channel change debate, and instead focuses on the river's historical geomorphology.

[1] More detailed consideration of historic channel change on the lower San Pedro is provided in Appendix K.

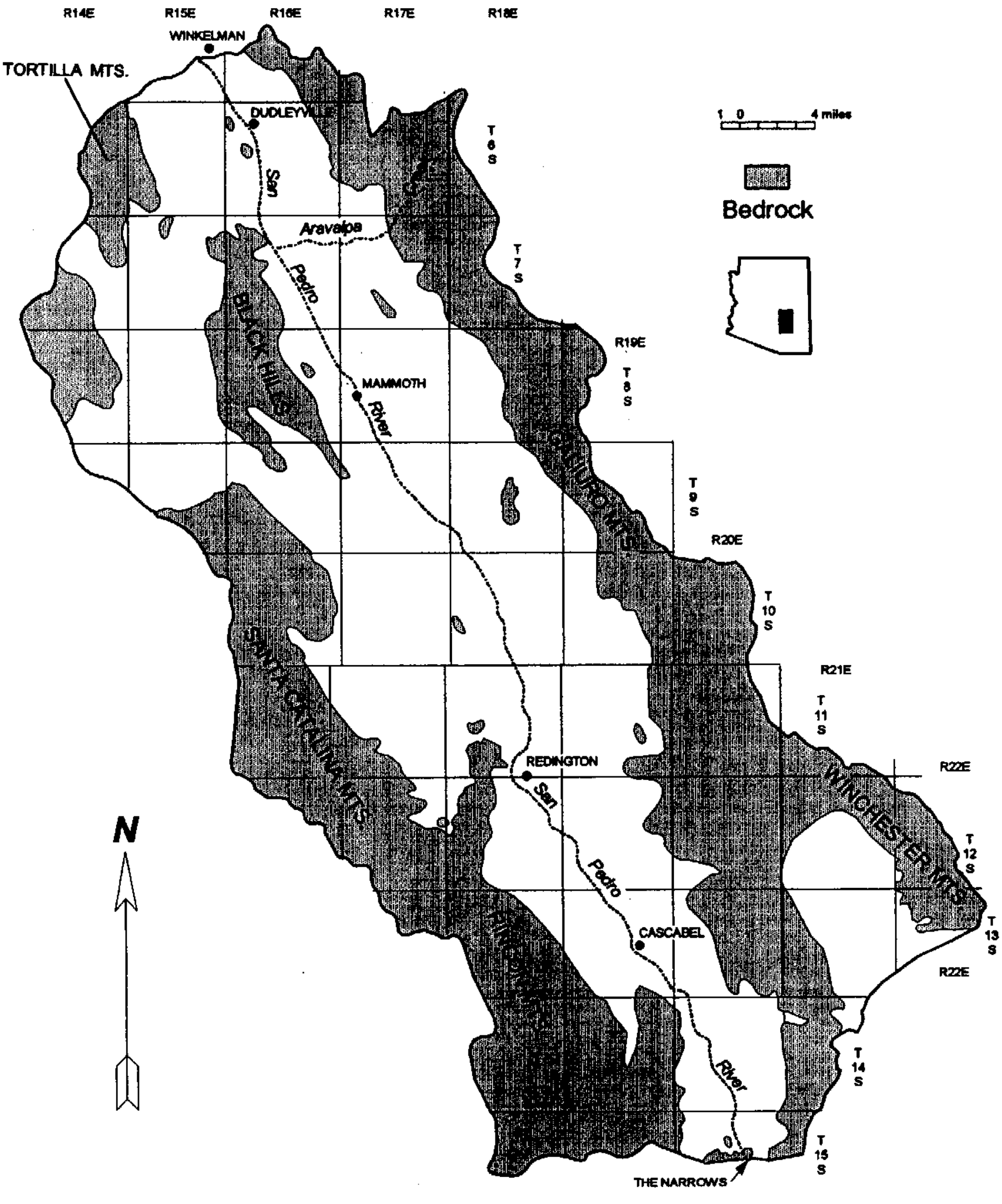


Figure 5-1
Geologic Site Map of Lower San Pedro River

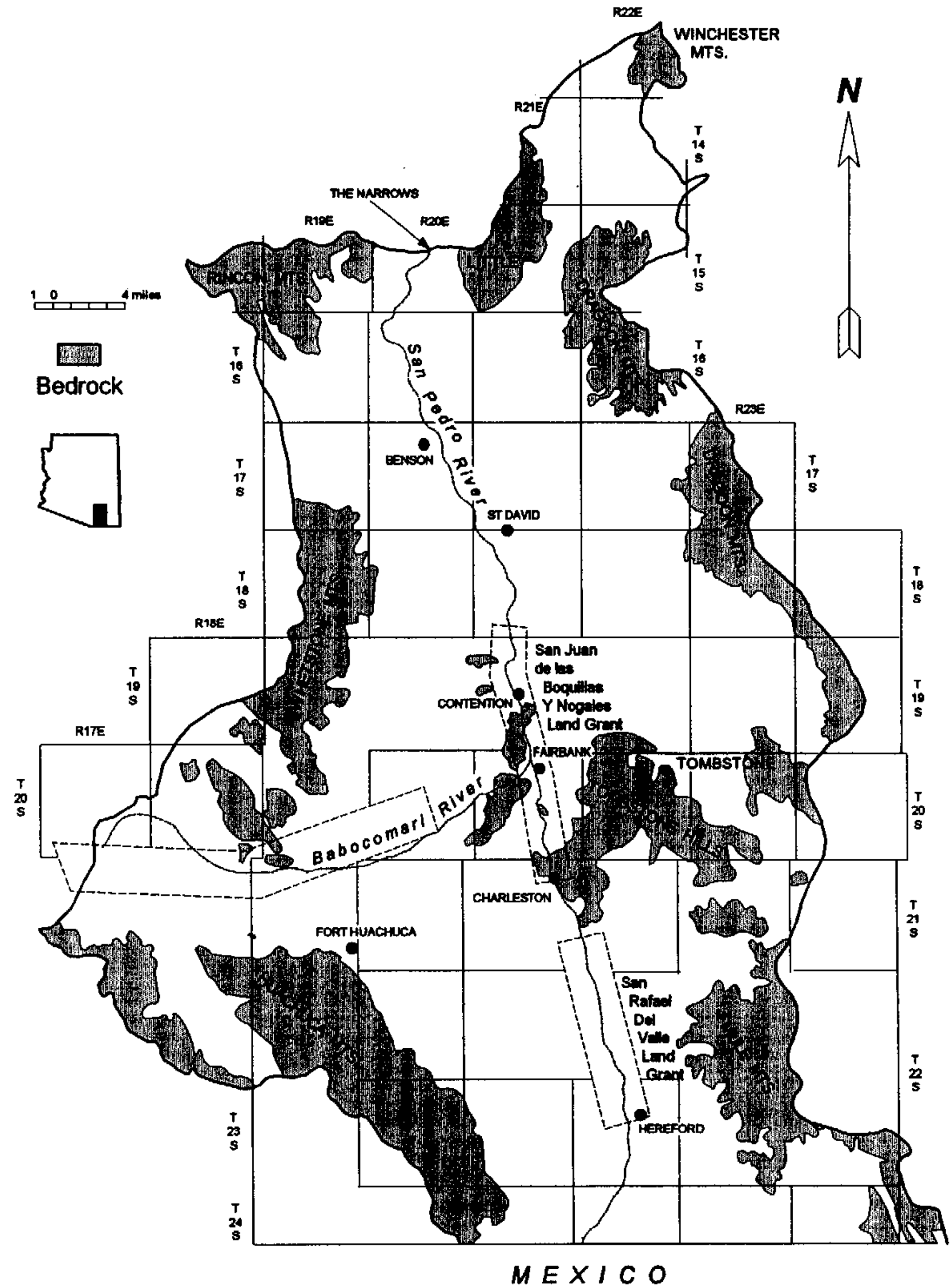


Figure 5-2: Geologic Site Map of Upper San Pedro River

Stream Reaches

Environmental and geomorphic contrasts between the upper and lower reaches of the San Pedro River (Tuan, 1962) allow the River to be divided into two reaches. The reaches may be separated at a bedrock constriction called "The Narrows" (Figures 5-1 and 5-2) following the format of Heindl (1952a,b). Geologically, this division is arbitrary since environmental and geomorphic variables are transitional between the two reaches.

Physical Setting

The San Pedro River is located in southeastern Arizona, with a small portion of the upper watershed (14%) extending into Sonora, Mexico. The total drainage area of the basin is approximately 4,720 mi^2. Aligned principally north-northeast, the elevation of the river ranges from 4,260 ft at the Mexican border to 1,920 ft at its confluence with the Gila River over a distance of 123 miles. The San Pedro River is generally bounded by linear, north-trending fault-block mountains of diverse lithologies (Table 5-1), including the Mule, Dragoon, Winchester, and Galiuro mountains to the east, and the Huachuca, Whetstone, and Tortilla mountains to the west. The Rincon and Santa Catalina Mountains on the west side of the valley have a broader and more triangular form. The river flows over alluvial basin fill, except in a few places where bedrock rises to the surface, e.g., Tombstone Hills, The Narrows, Redington, the mouth of Aravaipa Creek, and Dudleyville (Heindl, 1952a,b). The Holocene flood plain of the San Pedro River lies in an axial trench near the center of the valley and is 0.5-1.5 miles in width.

Climate in the San Pedro River valley varies with elevation. Overall, the valley is semi-arid. The lower San Pedro River valley receives less than 15 inches annually (Bahr, 1991). Some of the higher mountains bounding the valley average greater than 25 inches annually. Mean July maximum temperatures range from 103 °F at Winkelman (2,075 feet above sea level) to 89 °F at Fort Huachuca (4,664 feet above sea level; Sellers and Hill, 1974). Despite its lower elevation, Winkelman has an average January minimum temperature of 29 °F compared to 34 °F for Fort Huachuca. The lower winter minimum temperatures at Winkelman probably reflect micro environmental effects such as cold-air drainage within the middle Gila River Canyon. Throughout the entire San Pedro Valley, the bulk of precipitation comes primarily during the summer when moisture entering Arizona from the south triggers convective thunderstorms. There is also a lesser rainy season in the winter characterized by regionally extensive, frontal storm systems from the north Pacific. Occasionally during September and October, the San Pedro Valley experiences heavy rains associated with dissipating eastern Pacific tropical storms that commonly result in heavy rain and flooding (Hirschboek, 1985; Webb and Betancourt, 1992; Chapter 7).

Table 5-1 Major Mountain Ranges Bordering the San Pedro Valley, Arizona		
Mountain Range	**Highest Elevation (ft)**	
Dragoon Mountains	7,519	Jurassic and Tertiary granite
Galiuro Mountains	7,540	Tertiary volcanics
Huachuca Mountains	9,466	Precambrian granite; Jurassic volcanics
Mule Mountains	6,597	Paleozoic limestone
Rincon Mountains	8,666	Tertiary-Cretaceous granite and gneiss
Santa Catalina Mountains	9,157	Tertiary-Cretaceous granite and gneiss
Tortilla Mountains	4,547	Tertiary-Cretaceous granite
Whetstone Mountains	6,628	Paleozoic limestone; Precambrian granite
Winchester Mountains	7,631	Cretaceous-Jurassic sedimentary and volcanic rocks; Precambrian granite

Source: Reynolds (1988)

Vegetation is predominantly Sonoran desert scrub in the lower San Pedro River Valley and Chihuahuan desert scrub in the upper San Pedro River Valley (Bahr, 1991; Brown, 1982). Historically, the upper San Pedro Valley was Chihuahuan desert grassland but has since been invaded by woody shrubs (Bahr, 1991; Hastings and Turner, 1965). Riparian vegetation including cottonwood (*Populus*), willow (*Salix*), mesquite (*Prosopsis*), and tamarisk (*Tamarix*), occurs along the river. Oak woodlands dominate the higher elevations of the surrounding mountains with small areas of mixed conifer woodlands above 7,000 ft.

Late Cenozoic Geologic History

Most elements of the modern topography in the San Pedro Valley can be traced back to the Basin and Range Disturbance (8-15 Ma[2]) (Damon and others, 1984; Menges and Pearthree, 1989; Shafiqullah and others, 1980). Tensional stresses associated with the change from convergent to transform motion on the west coast tectonic plate boundary resulted in a largely north-northwest trending series of alternating basins and mountain blocks separated by steeply dipping normal

[2] 1 My = 1,000,000 years; 1 Ma = 1 My before present; 1 ky = 1,000 years; 1 ka = 1 ky before present (North American Commission on Stratigraphic Nomenclature, 1983).

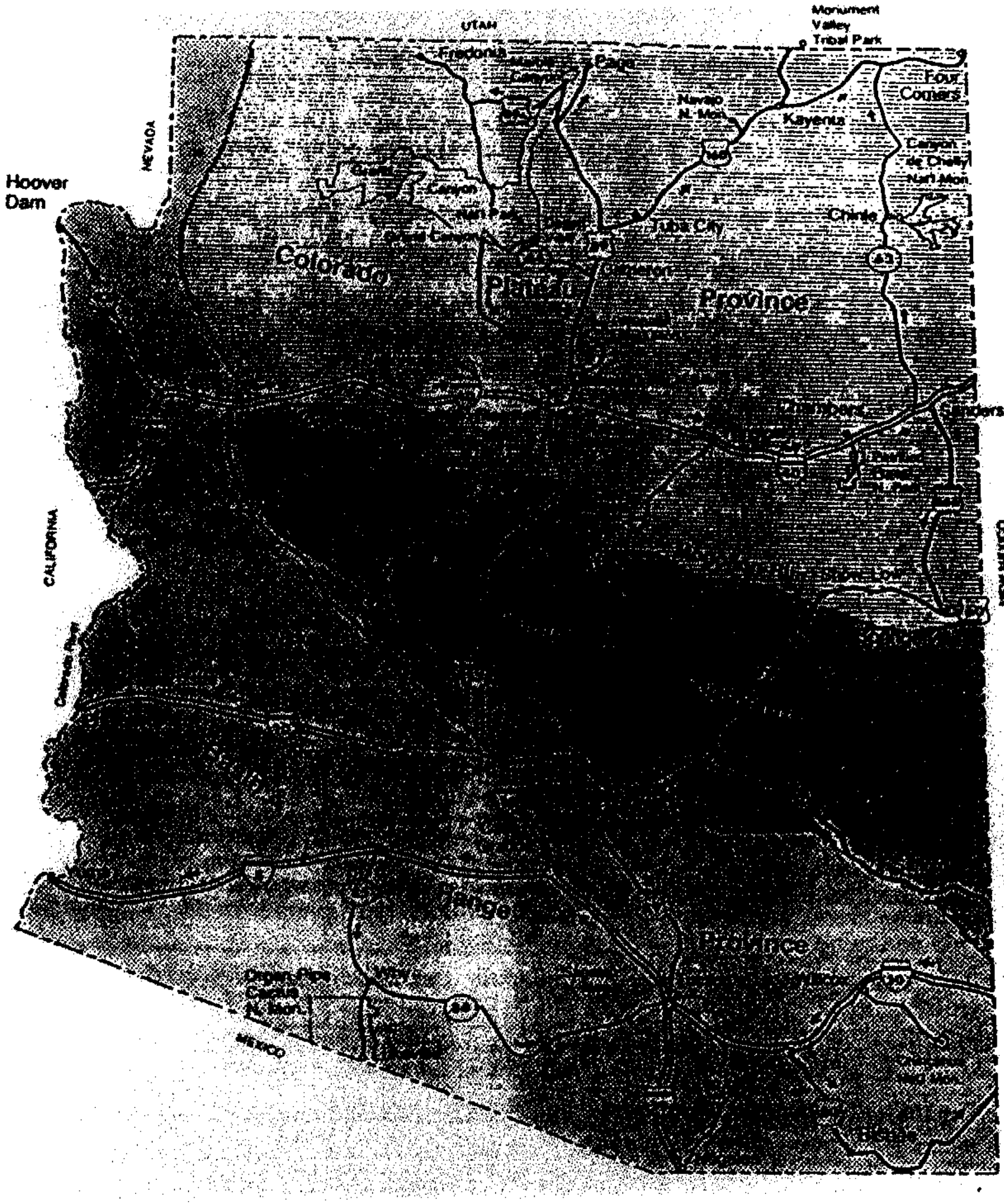


Figure 5-3
Physiographic Provinces of Arizona

faults. As the basins dropped, they simultaneously began filling with debris shed from adjacent mountain blocks. Many of the mountain fronts, especially those composed of granite, retreated from the axis of the valley forming broad pediments (Melton, 1965; Morrison, 1985; Tuan, 1962). The upper San Pedro Valley is broader and less dissected with a more gently sloping piedmont than the lower San Pedro Valley (Tuan, 1962). The basin sediments grade from coarse clastics (e.g., boulders, cobbles, and gravels) near the valley margins to finer sediment (sand, silt, and clay) and evaporites in the center (Agenbroad, 1967; Heindl, 1957a,b; Smith, 1963). The upper basin fill stratigraphy is characterized by relatively fine-textured alluvial and lacustrine sediments overlain by coarse-textured fan deposits (Johnson and others, 1975; Melton, 1965; Smith, 1964). The thickness of the basin deposits vary. Geophysical data indicate maximum depths of 4,800 to 6,400 feet in the upper San Pedro River Valley between the Huachuca and Mule Mountains and 3,200 to 4,800 feet in the lower San Pedro River Valley between the Santa Catalina and Galiuro Mountains (Oppenheimer and Sumner, 1980).

Initially, drainage in the San Pedro Valley was internal within a series of separate topographic and structural basins, but eventually the basins filled and streams became integrated sometime during the middle Pleistocene (Johnson and others, 1975). Since then, the San Pedro River and its tributaries have episodically downcut into the basin fill forming at least three major erosional surfaces, or strath terraces (Bryan, 1926; Bryan and others, 1934; Chronic, 1983; Haynes, 1987; Smith, 1963). Valley degradation within the last 1 My has been due to a combination of slow, regional uplift of the Central Highland Physiographic Province (Figure 5-3) in Arizona (Shafiqullah and others, 1980; Menges and Pearthree, 1989) and the San Pedro River's attempt to maintain a graded level or longitudinal profile of equilibrium (Mackin, 1948) as it became connected to the Gila River. During periods of temporary equilibrium the San Pedro River and its tributaries formed erosional strath terraces (Bull, 1991). Since latest Pleistocene and Holocene time, the river has deposited sediments within the axial trench of the basin (Haynes, 1987; Hereford, 1993; Morrison, 1985). Stratigraphic investigations in the upper San Pedro River Valley by Haynes (1987) indicate that the San Pedro River has repeatedly incised and backfilled its flood plain during the Holocene (approximately 10 ka to present).

Modern Channel Characteristics

Upper San Pedro River

Today the upper San Pedro River has a variably entrenched channel that meanders through a relatively mature gallery of riparian trees (Bahr, 1991). Upstream from Lewis Spring, vegetation within the entrenched channel is predominantly cottonwood and willow, whereas downstream tamarisk and mesquite are more common (Hereford, 1993). The depth of entrenchment generally increases downstream along the reach from the Mexican border to Fairbank (Lomeli, 1993). Within the entrenched channel are coarse-grained point bars that deflect streamflow and play an important role in meandering and channel-widening (Meyer, 1989). The plan view form of the channel (see Brice, 1984; Leopold and Wolman, 1957) is both braided and meandering: the low flow channel is braided with several branching channels, but the high flow channel is sinuous. Most of the sediment in the channel is coarser than that exposed in the arroyo walls, especially near the mouths of tributaries. Pre-entrenchment alluvium is composed predominantly of clay, silt, and fine sand with localized deposits of coarse sand, pebbles, and cobbles; commonly intercollated within these sediments are clayey, carbonaceous (cienega) soils (Haynes, 1987; Hereford 1993:5). Based on channel and bank alluvial particle sizes, the upper San Pedro River probably classifies as a mixed-load system (Schumm, 1977) transporting comparable amounts of suspended load and bedload.

Streamflow on the upper San Pedro River is variable spatially and temporally (Brown and others, 1981; Hirschboek, 1985; Chapter 7: This Report). Like many streams in arid and semiarid regions, the ratio of peak annual flood to mean annual discharge is high. Based on the state surface flow map by Brown and others (1981), the reach between Hereford and 3 miles above Fairbank contains a perennial baseflow less than 10 cfs. From Fairbank to The Narrows, streamflow is intermittent.

Lower San Pedro River

Below The Narrows, the lower San Pedro River has an entrenched channel that tends to be wider and less sinuous than the upper San Pedro River. Unlike the upper reach, the longitudinal profile of the lower San Pedro River is convex (Heindl, 1952b; Tuan, 1962). The average gradient between the Narrows and Redington is approximately 0.3 percent (18 ft/mi) whereas between Redington and Winkelman it is 0.4 percent (22 ft/mi). Like the upper San Pedro River, the baseflow channel is braided and contains coarse-grained (pebbles and cobbles) point bars with the coarsest deposits located near the mouths of tributaries. Because the tributaries entering the lower San Pedro River are steeper and shorter in length than upstream tributaries, overall alluvial particle-sizes in the bank and channel increase downstream, a pattern that contrasts with most humid-region streams (Knighton, 1984). The lower San Pedro River probably classifies as a bedload system (Schumm, 1977). Vegetation is mostly mesquite and tamarisk along the floodplain and except for short perennial segments where bedrock is at or near the surface, streamflow is intermittent (Agenbroad, 1967; Brown and others, 1981).

Historical Channel Changes

With the exception of a few short segments confined by bedrock, the San Pedro River is an alluvial river and thus has the capability to adjust its channel shape, plan form, and position with changing environmental conditions (Richards, 1982; Ritter, 1986:248). Specifically, alluvial rivers will adjust their depth, width, gradient, and hydraulic roughness to accommodate changing discharge and sediment load (Mackin, 1948; Leopold and Bull, 1979). Changes in channel shape and plan form can occur at a variety of time scales ranging from 1 to 10,000 years. Arid and semiarid streams tend to be more susceptible to rapid changes in channel geometry (Graf, 1988) and require a greater amount of time to re-establish their original geometry following a disturbance (Wolman and Gerson, 1979). Rapid (1-10 years) changes in channel geometry and plan form have been documented for the Gila River (Burkham, 1972; Huckleberry, 1993) and several of its tributaries (Betancourt, 1990; Cooke and Reeves, 1976; Pearthree and Baker, 1987) including the San Pedro River (Hereford, 1993).

The channel adjustment that has received the most attention in the Southwest is entrenchment or arroyo-cutting (Betancourt, 1990; Cooke and Reeves, 1976; Webb, 1985). Many alluvial streams in the region including the San Pedro River experienced extensive entrenchment in the late 19th and early 20th centuries (Bahr, 1991; Bryan, 1926; Cooke and Reeves, 1976; Hastings, 1959; Hendrickson and Minckley, 1985; Hereford and Betancourt, 1993). Stratigraphic exposures of buried arroyos (Haynes, 1987; Waters, 1988) indicate that these rivers incised prehistorically as well.

Because of academic interest in the arroyo phenomenon, historical channel changes on the San Pedro River are well documented (e.g., Cooke and Reeves, 1976; Hereford and Betancourt, 1993). Most of the historical descriptions of the San Pedro River are from the upper reach; most geological investigations of channel change have been focused on the reach south of The Narrows. Therefore, historical channel changes on the lower San Pedro River are less well defined. Channel changes on the upper reach need not necessarily be in tandem with those of the lower reach since bedrock constrictions present local base level controls and basin morphometry varies between the two reaches. Because of geomorphic contrasts between the upper and lower reaches, historical channel changes are reviewed for both reaches separately.

The chronology is divided into three parts. The first period (1697-1870) includes the earliest descriptions of the river during the Spanish, Mexican, and early part of the American periods. The second period (1871-1933) marks the beginning of permanent Anglo settlement and the first cadastral surveys. The third period (1934-present) represents the period for which systematic aerial photography exists thus allowing for more objective analysis of channel changes.

Upper San Pedro River

1697-1845. Historical descriptions of the San Pedro River begin in 1697 when Padre Eusibio Kino accompanied by Juan Manje made his 4th expedition into the Pimeria Alta (Burrus, 1971). They traveled down the entire length of the San Pedro River to its junction with the Gila River and described in their journals numerous Sobaipuri irrigation ditches and meadows. These descriptions may imply the San Pedro River Valley had shallow water tables and was not entrenched. Subsequent descriptions of the upper San Pedro River Valley during the Spanish and Mexican Periods are scant despite construction of the Presidio of Terrenate in Quiburi (Fairbank) in 1776 (Hereford and Betancourt, 1993; Kessel, 1966) and the presence of ranches on two land grants, the San Juan de las Boquillas y Nogales and the San Rafael de Valle, in 1823 (Bahr, 1991). Trapper James Ohio Pattie (1833) visited the San Pedro River during the 1820's which he called "Beaver River" after trapping "200 skins". Although tainted by hyperbole, his accounts imply perennial streamflow throughout most of the San Pedro River.

More direct descriptions of upper San Pedro River begin with the Mexican-American War in 1846. Major Cooke (1938) and his Mormon Battalion marched along the upper San Pedro River from approximately Hereford to Benson and described it as "a fine, bold, stream" where he and his men caught "fine trout" up to 16 inches long (also in Hastings, 1959:62; Rodgers, 1965:16). During the U.S.-Mexico boundary survey if 1851, J.R. Bartlett (1854) also noted continuous streamflow in the upper San Pedro River, but he also noted that the river below St. David contained steep banks approximately 9 feet high (Bartlett, 1854; also in Hastings, 1951, and Hereford and Betancourt, 1993). Bartlett further noted that incision limited the ability to irrigate adjacent terraces. A few years later, Parke (1857:24) noted that the upper San Pedro River was variably incised from a few cm to as much as 15 feet. Immediately upstream from The Narrows, Hutton (1859) described the upper San Pedro River as having a width of approximately 12 feet and a depth of 12 inches. Although Hereford (1993) cautions that some of these historical descriptions may be of steep banks on older terraces above the active channel, the cumulative archival evidence suggests that the upper San Pedro River was indeed discontinuously entrenched as early as 1850 (Henderson and Minckley, 1984:147), at least thirty years before the estimate of arroyo initiation made by Kirk Bryan (1926).

1871-1933. The first cadastral survey by the U.S. General Land Office (now the BLM) was performed within the upper San Pedro River Valley in 1873 (survey notes on file at the BLM in Phoenix). All of the section lines within townships crossed by the upper San Pedro River had been surveyed by 1901 with the exception of the original Mexican Land Grants (see Cooke and Reeves, 1976: Figure II.6). The survey notes and plat maps provide systematic descriptions of channel dimensions, particularly width and location. However, the survey notes are often cryptic and can be easily misinterpreted (see Bahr, 1991; Betancourt, 1990). For example, measurements of channel width are recorded, but these measurements were made normal to cadastral lines and thus usually do not represent true channel width. Also, whereas the G.L.O. plats are the first scaled maps showing channel location, the position of the channel is only surveyed where it crosses cadastral lines; channel locations between cadastral lines are interpolated. Nonetheless, the G.L.O. survey notes are the first systematic measurements of the San Pedro River and provide a base for analyzing historical channel change.

The first townships in the upper San Pedro River Valley to be surveyed were Townships T. 15, 16, and 17 S., R. 20 E., by Theodore White in 1873. He later surveyed Township T18S., R21E. in 1881. Very few channel measurements are provided for Townships 19, 20, and 21 S., R. 21 E. and Townships 21 and 22 S., R. 22 E. due to the private land grants, and Townships 23 and 24 S., R. 22 E. were not surveyed until 1901 by Phillip Contzen. Following the procedure of Burkham (1972), measurements of channel width (normal to cadastral lines) were compiled (Appendix E) and averaged for each Township (Table 5-2). Between St. David and The Narrows, the channel width in 1873 averaged less than 36 feet. Between the San Juan de las Boquillas y Nogales land grant and St. David, the channel width in 1881 averaged approximately

60 feet. This agrees with historical descriptions of a relatively narrow channel (Hastings, 1959; Hereford and Betancourt, 1993).

Descriptions of the San Pedro River during the 1870's and 1880's increase in step with Anglo settlement (Rodgers, 1965). Streamflow diversions for irrigation and processing ore from the Tombstone Mining District increased during this period. This may have led to reaches on the upper San Pedro River becoming intermittent during periods of heaviest water use (Hereford and Betancourt, 1993). However, overall the area was characterized by shallow water tables. In fact, settlers in St. David destroyed beaver dams and drained local swamps in order to lower water tables and prevent malaria outbreaks (Rodgers, 1965). Descriptions of the river during this period are generally consistent with earlier descriptions, i.e., alternating entrenched and unentrenched reaches and overall perennial flow.

Beginning in the 1880's and continuing into the 1890's were a series of large floods that impacted the geometry of the upper San Pedro River (Hereford and Betancourt, 1993). Large floods occurred in 1886, 1887, 1890, and 1896. The impacts of these floods were variable, but overall they resulted in expanding the entrenched reaches upstream via knick-point retreat (Hastings, 1959; Hereford and Betancourt, 1993) and expanding channel width via bank cutting and collapse (Meyer, 1989). Cadastral survey notes confirm channel widening after 1890 (Cooke and Reeves, 1976; Appendix E). Average channel widths in Township T. 23 S., R. 22 E. and Township T. 24 S., R. 22 E. were 85 and 138 feet, respectively (Table 5-2). The archival record also indicates that more segments of the upper San Pedro River were intermittent after 1890 (Hastings, 1959). This change in streamflow may be related to the large Pitaycachi earthquake that shook the region in 1887 and modified spring activity in the valley (DuBois and Smith, 1980). Drought may also have affected the baseflow. Bahr (1991) notes that one of the worst droughts on record occurred 1891-1893. This drought coincided with a record number of cattle in the San Pedro Valley, and overgrazing undoubtedly increased the severity of the floods by increasing runoff and gullying (Carpenter and Bransford, 1921; Cooke and Reeves, 1976; Dobyns, 1981).

Almost the entire reach of the upper San Pedro River was entrenched by 1920 (Bryan, 1926; Hereford, 1993). Most of the channel changes in the early 20th century consisted of channel widening, although near Benson the channel may still have been incising (Carpenter and Bransford, 1921). In some reaches, the radii of meanders increased (compare channel positions in 1881 and 1988 in Sec. 21, T. 18 S., R. 21 E., Plate 1). At Contention, the river meandered over part of the old townsite (Bahr, 1991:69). Most of the widening and increased sinuosity occurred during large floods. The largest gaged flood on the upper San Pedro River occurred in September, 1924 and was estimated to have had a peak discharge of 100,000 ft^3/s. Although this estimate may be exaggerated, this flood nonetheless resulted in tremendous bank erosion and channel widening throughout the San Pedro River system (Hereford and Betancourt, 1993).

Table 5-2 Mean Channel Widths for the Upper San Pedro River (ft)		
Township	**Year**	**Mean**
T15S R20E	1873[1] 1935[9]	35 266
T16S R20E	1873[2] 1935[9]	27 238
T17S R20E	1873[3] 1935[9]	28 285
T18S R21E	1881[4] 1935[9]	58 367
T19S R21E	-	-
T20S R21E	-	-
T21S R21E	1901[5] 1935[9]	73 492
T21S R22E	1909[6] 1935[9]	261 246
T22S R22E	-	-
T23S R22E	1901[7] 1935[9]	85 303
T24S R22E	1901[8] 1935[9]	137 321

[1] White; Book 811 [2] White; Book 804 [3] White; Book 845 [4] White; Book 889
[5] Contzen; Book 935 [6] Wright; Book 2167 [7] Contzen; Book 983 [8] Contzen; Book 989
[9] Measured from 1:62,500 scale aerial photography

1934-1993. The first systematic aerial photographs were flown in 1935 and show a largely continuous streamflow within a sandy, braided channel. Channel widths measured normal to section lines on the 1935 photography are considerably greater than those recorded by the GLO surveyors (Table 5-2). As mentioned above, some meandering reaches show significant changes in channel location during the last 60 years whereas other reaches show very little spatial changes (Plate 1). The frequency of large floods decreased during the 1940's, and 50's, as did the rate of channel widening (Hereford, 1993). Hereford's (1993) photographic analysis of the reach from Hereford to Contention indicates that the entrenched channel reached its maximum width in the 1950's. Since then, alluvium has been accumulating within the entrenched channel. Removal of cattle from this reach in 1986 has resulted in increased vegetation within the channel which in turn has facilitated aggradation (Lomeli, 1993).

Lower San Pedro River

1697-1870. Descriptions of the lower San Pedro River during the Spanish, Mexican, and early American periods are less abundant than those for the upper reach since most of the ranching and agricultural activity took place upstream from The Narrows. In general, descriptions of the lower reach during this period are consistent: a small unentrenched stream with low but generally consistent streamflow. The numerous Sobaipuri irrigation ditches described by Kino and Manje (Burrus, 1971) imply that the river in 1697 was unentrenched, at least at the Sobaipuri villages. They also described marshy conditions indicating shallow water tables (Henderson and Minckley, 1985). The river also contained numerous beaver ponds and edible fish (Patty, 1833).

Like the upper reach, descriptions of the lower San Pedro River begin in earnest with the Mexican-American War in 1846. The archival record suggests that water tables were generally shallow, but there may have been some reaches below Mammoth that were seasonally dry. In November, 1846, Steven Watts Kearny expedition passed down the Gila River and camped on the lower San Pedro River approximately 1 mile from its mouth. Several men kept journals describing the terrain including William Emory and Abraham Johnston. Emory (1848:75) noted that the San Pedro River was a "few yards wide and one foot deep", and Johnston (1848:592) commented that an active man could jump across the water. Six years later, Parke (1857:24-26) noted that at this reach (within a few miles of the Gila River) "water sinks below the surface and rarely runs above it". This is the earliest reference to intermittent streamflow on the San Pedro River. Leach (1858; referenced in Brown and others, 1981) also noted no flow in reaches of the lower San Pedro River. Other indications are that water tables were still relatively high in the lower San Pedro Valley. Conditions were certainly marshy at Camp Grant located at the mouth of Aravaipa Canyon. Constructed in 1859, it was plagued by malaria and soon abandoned and moved to the base of the Pinaleno Mountains (Bahr, 1991; Henderson and Minckley, 1985).

1870-1933. Channel conditions changed little between 1870 and 1890 (Hastings, 1959). The first cadastral surveys were performed in the lower San Pedro Valley in 1877 and 1879 by John L. Harris. His survey notes indicate that the channel was generally less than 40 feet wide (Table 5-3). Moreover, survey plat maps show several "acequias" or irrigation ditches implying non-entrenchment.

Beginning in 1890, the lower San Pedro River started to change. A series of large floods in 1890, 1893, 1894, and 1896 resulted in channel cutting and widening along some portions of the lower San Pedro River (Hereford and Betancourt, 1993). Newspaper accounts indicate considerable farm property was lost along the river during this decade, especially near Dudleyville. Bahr (1991:111) quotes rancher C.H. Bayless comments made in 1900[3] regarding channel change:

> *"About 12 years ago the [lower] San Pedro Valley consisted of a narrow strip of*

[3] Descendants of C.H. Bayless dispute the accuracy of this quotation (See Appendix K).

subirrigated and very fertile lands. Beaver dams checked the flow of water and prevented the cutting of a channel. Trappers exterminated the beavers, and less grass on the hillsides permitted greater erosion, so that within four or five years a channel varying in depth from 3 to 20 feet was cut almost the whole length of the river. Every year freshets are carrying away new portions of the bottom lands."

Table 5-3
Mean Channel Widths for the Lower San Pedro River (ft)

Township	Year	Mean
T5S R15E	1877[1] 1934[14]	35 1,600
T6S R16E	1877[2] 1934[14]	36 1,280
T7S R16E	1877[3] 1934[14]	38 930
T8S R16E	1877[4] 1934[14]	35 1,120
T8S R17E	1877[5] 1934[14]	40 925
T9S R17E	1877[6] 1934[14]	33 1,312
T9S R18E	1879[7] 1934[14]	32 1,210
T10S R18E	1879[8] 1934[14]	34 1,310
T11S R18E	1879[9] 1934[14]	35 837
T12S R18E	1879[10] 1934[14]	26 236
T12S R19E	1879[11] 1934[14]	28 338
T13S R19E	1879[12] 1934[14]	29 512
T14S R20E	1902[13] 1934[14]	99 223

[1] Harris; Books 633, 1477
[2] Harris; Books 672, 1477
[3] Harris; Books 686, 1477
[4] Harris; Books 698, 1477
[5] Harris; Book 699
[6] Harris; Books 733, 1477
[7] Harris; Books 734, 1474
[8] Harris; Book 752
[9] Harris; Book 721
[10] Harris; Books 762, 1474
[11] Harris; Books 763, 1474
[12] Harris; Books 780, 1474
[13] Jacobs; Book 879
[14] Measured from 1:62,500 scale aerial photography

By 1926, well defined channels existed along the lower San Pedro River and the dominant channel process was channel widening. The first cadastral survey of Township T. 14 S., R. 20 E. was in 1902 (Table 5-3) and records wider channel dimensions than those in adjacent townships that were surveyed 25 years earlier. The main channel of the San Pedro River did not become incised into the floodplain in the Redington area, however, until the flood of September 1926 (J. Smallhouse, oral communication, 1996).

1934-1993. The first systematic aerial photography of the lower San Pedro Valley was performed by the Soil Conservation Service in 1934. The photography reveals a shallow, braided channel within an incised flood plain. The channel is dramatically wider than in the 19th century (Appendix E; Table 5-3), especially downstream from Redington. The magnitude of widening during this period is greater on the lower reach, perhaps because the bank materials are coarser and more susceptible to erosion (Knighton, 1984:63; Schumm, 1977). Because of the wider, entrenched reach below Redington, changes in channel position through time are greater along this segment than any other part of the river. Channel widening has probably slowed if not stopped, and reaches below Mammoth are presently aggrading (Hereford and Betancourt, 1993).

Channel Conditions in 1912

As of the time of statehood, Arizona was experiencing one of the wettest periods in several centuries (Stockton, 1975). The period 1905-1917 was a time of above average winter and spring precipitation throughout the region. Some of the largest historical peak discharges within the Gila River system occurred during this period (Burkham, 1970; Ely, 1992, Huckleberry, 1993; Olmstead, 1919). The frequency of large floods on the San Pedro River increased as early as 1890, although Hereford (1993) notes that on the upper San Pedro River it was greatest between 1915 and 1940. This period of increased large flood frequency during the early part of the 20th century undoubtedly affected channel geometry and position. There is, however, no evidence that the baseflow of the river changed during this period.

Channel entrenchment had begun on the San Pedro River several decades before statehood, and most of the San Pedro River was already entrenched by 1912 (Bahr, 1991; Cooke and Reeves, 1976; Haynes, 1987; Hereford, 1993; Hereford and Betancourt, 1993). Exceptions were along short bedrock reaches (e.g., The Narrows) and a reach near Hereford that was only 1 to 3 feet deep between 1910 and 1914 (Haury and others, 1959). In 1912, streamflow in the upper San Pedro River was largely perennial and shallow with less than 10 cfs baseflow, and the braided channel meandered within the confines of the arroyo banks. On the lower San Pedro River, streamflow was largely intermittent with short reaches of perennial flow (less than 10 cfs).

Because much of the river was already entrenched, flood flows during the wet period of the early part of this century were largely confined within the walls of the channel. This undoubtedly increased the velocity and magnitude of floods along the river since less water was retained as storage on the vegetated flood plain (Burkham, 1976). The incised channel also effectively concentrated flow and accentuated the erosive capacity of the river. Gravel bars within the channel deflected flow into the arroyo walls resulting in bank collapse and channel widening (Meyer, 1989). Thus the dominant channel process in 1912 was channel widening.

Although not as wide as shown in 1934 and 1935 photography, the entrenched channel of the San Pedro River in 1912 was considerably wider than what was recorded in the original cadastral survey notes of the 1870's and 1880's (Tables 5-2 and 5-3). On the upper San Pedro River, the width of the entrenched channel probably averaged between 130 and 260 feet. On the lower San Pedro River channel widths were greater and more variable. Between The Narrows and Redington, the width of the entrenched channel probably averaged 130 to 260 feet; downstream from Redington, channel width probably averaged 330 to 650 feet. The depth of the modern entrenched channel varies 5 to 20 ft throughout the San Pedro River (Kottlowski and others, 1965: Figure 1) and probably does not differ substantially from channel depths in 1912.

Summary

The San Pedro River is a representative example of alluvial streams in the Southwest that have experienced significant geomorphic and hydrological changes in response to climatic and/or human perturbations. Both the upper and lower reaches experienced channel entrenchment and widening during the last half of the 19th century and the first half of the 20th century (Bahr, 1991; Henderson and Minckley, 1985; Hereford, 1993; Hereford and Betancourt, 1993). By 1912, most of the San Pedro River had already experienced entrenchment. In the upper San Pedro Valley, the river generally consisted of a small braided stream with a baseflow of less than 10 cfs that flowed between vertical banks 130 to 260 feet wide. In the lower San Pedro Valley, the river also had a small braided channel that flowed between vertical banks, but intermittent reaches were common below Redington, and the channel banks were commonly wider than 330 feet.

Based on Holocene stratigraphy (e.g., Haynes, 1987; Hereford, 1993), entrenchment and widening have occurred in the past and appear to be a natural cycle within the fluvial system. This may simply be a fluvial adjustment to changes in the discharge:sediment load ratio. Human disturbances probably have also affected the magnitude and rate of channel change on the San Pedro River (Bahr, 1991; Dobyns, 1981), but the driving force in these changes are probably not anthropogenic. That some reaches are presently aggrading (Hereford, 1993) suggests that these fluvial adjustments are cyclical, and one can expect the entrenched channel to fill in the future.

In general, the geomorphology of the existing channel is broadly representative of the channel conditions as of the time of statehood. The geologic investigation indicates that impediments to boating include seasonal low flow, intermittent flow conditions (no flow), shifting channels, and erosive conditions during periods of high flow and floods.

Chapter 6
San Pedro River Land Use

Introduction

This chapter summarizes land uses along the San Pedro 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
- Existing Improvements
- Wildlife and Recreation Classifications

No updates or changes in the land use or land ownership data base were made as part of 1997 or 2004 revisions of the original CH2M HILL report.

Data Sources

The primary data sources for San Pedro River land ownership, land use, and improvements was information obtained from county assessors' offices, and other public agencies as described below. 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 Game and Fish Department and the U.S. Fish and Wildlife Service.

Methodology

The primary work product for the land use assessment is a GIS for the San Pedro 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. The San Pedro GIS was constructed from assessor records from Pima County, Pinal County, and Cochise County, and other information from a GIS being constructed by ALRIS, an inter-agency group funded by the State of Arizona, and information from the BLM. However, parcel datasets for portions of the San Pedro received from Pima FCD, Cochise FCD, and BLM, but were found to be incompatible with ALRIS coordinates, and the parcels were digitized from the assessor maps.

GIS tiles from ALRIS's LAND library were received from ALRIS as Arc/Info export files and reconverted into PC Arc/Info coverages. Periods (.) within PAT attribute names were converted by PC Arc/Info into underlines (_), and STATUS.DATE was truncated to STATUS_DAT due to the length of the name. Four new items -- BOOK, MAP, PARCEL, and OWN_CODE -- were added (See Appendix H). To facilitate digitizing of parcel polygons, tic marks were generated for each tile using NODEPOINT. The point cover was converted into a text file using UNGENERATE, and appended to the TIC file using TABLES. Arcs for parcel polygons were digitized from assessor maps. In most cases, parcels were digitized on and/or adjacent to the river bed as delineated on the assessor maps, though USGS maps and ALRIS's HYDRO layer were consulted as well. Where "meander lines" were delineated on assessor maps, all parcels within that area were digitized.

Where possible, tic marks at section corners were used for reference. For half- or quarter- section maps, tics were generated using a midpoint algorithm. For detail maps lacking sufficient reference points, tics were placed at strategic points corresponding to the outline of the mapped area. USGS quad maps provided additional coordinates for certain boundaries. In most cases, assessor maps were considered the final authority in matters of boundary and ownership, though USGS and Forest Service maps were consulted in cases of conflicting data regarding boundaries of agency administered lands. Where conflicts were irreconcilable, ALRIS-digitized boundaries were left as is.

Once all arcs for a particular tile were digitized, topology was rebuilt using CLEAN (fuzzy tolerance 1.5, dangle length 20), the results were checked for dangles and slivers, and polygons were rechecked against the original maps. Polygon labels were then created and attributes assigned and checked for consistency.

The OWN_CODE attribute was assigned using a dBASE macro. Once the owner relate files were completed, parcel polygons were checked to make sure that every one could relate to the owner file. Ownership relate files were entered in Quattro Pro from "field notes" taken at assessor offices. The files were then converted to dBASE III and reformatted. Assessor land use codes (State of Arizona Property Use Codes) were recorded and entered at the same time as name and address of owners. Metroscan files also included the land use code. A dBASE program was written to convert those values to the standard table given in Appendix H -- the standard table was developed in collaboration with the Arizona State Land Department.

A MOSS file was received from BLM representing riparian vegetation for part of the San Pedro River and was shifted to match the ALRIS coordinate system. Attribute items TYPE, ACRES, MAP_LABEL, and DESCRIP were added (See Appendix H). Ordinary high watermarks for the San Pedro River were digitized from lines drafted onto USGS 7.5' topographic maps. Gaging stations were also digitized where encountered on the base maps. Since these maps were not made available until after the completion of the land ownership/use GIS, they were not used as a guide in digitizing parcels.

Plots of GIS information for the San Pedro River are included in Appendix H. The San Pedro River GIS plots included in appendix H include:

- Land Ownership
- Ordinary High Watermark
- Land Use

FCDMC GIS. Technical details regarding creation of the GIS are summarized in Appendix H. The remainder of this chapter summarizes information represented graphically in the GIS.

Land Use and Ownership

Land ownership, or current title, and land use information obtained from assessors' records and other sources are shown in Tables 6-1 and 6-2. The largest percentage of land in the reach is privately held. The BLM and the State are the next largest land holders. Land uses in the river valley include grazing, agricultural (orchards/crops/miscellaneous), residential, and undeveloped. The San Pedro River reach includes three land grant parcels, the San Pedro Riparian Preserve, and several Nature Conservancy holdings. The San Carlos Indian Community also claims a portion of the reach.

Table 6-1
San Pedro River Land Ownership.

Owner	Acres
Private	10,185
Bureau of Land Management	3,566
State	1,010
Highway (R-O-W)	26
San Carlos Indian Community	45

Table 6-2 San Pedro River Land Use.	
Land Use	**Acres**
Grazing	5,936
Crops/Orchards	1,458
Misc. Undeveloped	1,210
Residential	895
Mineral/Mining	226
Unclassified	178
Misc. Developed	91
Municipal/County	20
Misc. Agricultural	14
Misc. Commercial	11

Riparian Information

BLM provided riparian data for a portion of the San Pedro. The BLM's MOSS data file was converted to an Arc/Info coverage and was slightly reformatted. Riparian vegetation data are summarized in Table 6-3.

Table 6-3 San Pedro River Riparian Data	
Land Use	**Acres**
Int.SW riparian deciduous forest	2486
Semidesert grassland	642
Private agricultural	199
Chihuahuan desert scrub	144
Agricultural	39
Int.SW swamp and riparian scrub	28
Chihuahuan interior marshland	3
Californian maritime marshland	26

Chapter 7
Hydrology of the San Pedro River

Introduction

The San Pedro River is one of the most intensely studied rivers in the southwest. A plethora of studies have been conducted which have attempted to determine the cause of channel changes which occurred in the late 1800's and early 1900's. While the cause of pre-statehood channel change has not yet been definitively established, these studies provide a useful database from which to obtain information on the hydrology of the San Pedro River at the time of statehood. This chapter describes the hydrology of the San Pedro River as it relates to title navigability. Several types of information are presented:

- Historical Flow Records
- Modern Flow Records
- Hydraulic Rating Curves
- Flood Frequency Data

In addition, information on flood frequency, boating, and irrigation is presented.

Stream Reaches

The San Pedro River can be broken into two reaches with somewhat distinct hydrologic conditions (Figure 7-1). The two reaches meet at "The Narrows" a bedrock constriction located between the foothills of the Rincon Mountains to the west and the Little Dragoon Mountains[1] to the east. The upper San Pedro River extends upstream from The Narrows through the City of Benson, and the communities of St. David, Fairbank, Charleston, Hereford, and Palominas. The upper San Pedro River is perennial from about Hereford to Fairbank, and intermittent downstream of Fairbank. The lower San Pedro River extends downstream from The Narrows to the confluence with the Gila River, passing through the communities of Cascabel, Redington, Mammoth, and Dudleyville. The lower San Pedro River is characterized by an entrenched, broad, braided channel with only isolated reaches of perennial flow near areas of shallow bedrock.

[1] Technically, a portion of the Little Dragoon Mtns called "Johnny Lyon Hills."

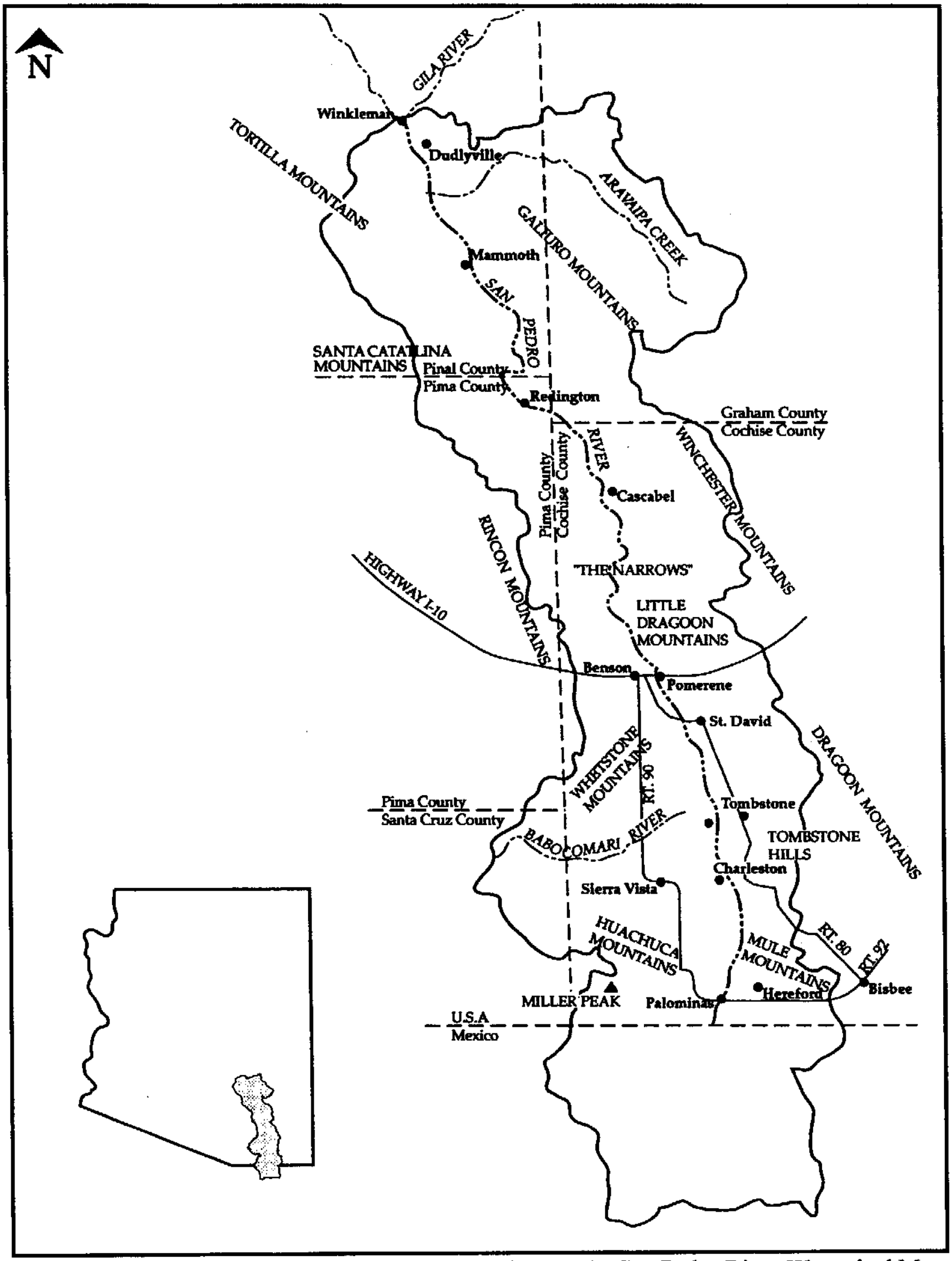


Figure 7-1: San Pedro River Watershed Map

Data Sources

Hydrologic data were derived primarily from published stream gage records of the U.S. Geological Survey (cf. USGS, 1954; 1991), historical accounts of the San Pedro River (cf. Dobyns, 1981; Davis, 1981), and other reports on the hydrology of the San Pedro River (cf. ADWR, 1991). More detailed descriptions of archeological and historical records, stream geology and geomorphology, and boating and navigability criteria for the San Pedro River basin are summarized elsewhere.

Hydrologic Setting

The San Pedro River is located in Cochise, Pima, and Pinal Counties in southeastern Arizona with a portion of the watershed extending into northern Sonora, Mexico. The river drains north from Mexico to Winkelman where it joins the Gila River. The total drainage area is 4,453 mi^2 at Winkelman. Elevations within the watershed range from 9,466 ft. at Miller Peak in the Huachuca Mountains to 1,920 ft at the Gila River confluence. The maximum elevation of the river itself within the study area is 4,260 ft. at the Mexican border near Palominas. The rivers flows entirely within the Basin and Range Physiographic Province of Arizona (Figure 5-3). The watershed is bounded by the Mule, Dragoon, Winchester, and Galiuro Mountains to the east, and the Huachuca, Whetstone, Rincon, Santa Catalina, and Tortilla Mountains to the west. The river flows in alluvium except in short reaches where bedrock is exposed in the channel, such as at Tombstone Hills and The Narrows, near Redington and the Aravaipa Creek confluence, and at Dudleyville.

Climate conditions in the San Pedro River watershed vary with elevation, though most of the basin may be classified as semi-arid. Annual precipitation is bimodally distributed with about 55 percent of the total precipitation occurring between July and August, and 20 percent occurring between December and February. Lower elevations receive about 15 inches of precipitation annually, but precipitation at higher elevations can reach 25 or more inches. Peak precipitation occurs from about July to September, during summer "monsoon" rainstorms caused by orographic release of tropical moisture entering the watershed from the Gulf of Mexico. A slight increase in average monthly rainfall occurs during winter months due to cyclonic storms originating over the Pacific Ocean. Tables 7-1 and 7-2 illustrate the temporal and areal variation of recorded precipitation and temperature within the watershed.

Vegetation along the San Pedro River is predominantly Sonoran desert scrub in the lower reaches, with Chihuahuan desert scrub in the upper reaches. Historically, the upper San Pedro Valley was Chihuahuan desert grassland but has since been invaded by woody shrubs and other species (Huckleberry, 1993). Since the late 1800's, riparian vegetation such as cottonwood, willow, tamarisk, and mesquite have populated the river corridor (Hastings and

Turner, 1965). At higher elevations oak woodland and mixed conifer species are found.

Table 7-1
Climatic Data for San Pedro River Watershed Stations

Average Annual Statistic	Winkelman 1942-1980 elev.= ft.	Benson 1900-1975 elev.= ft.	Bisbee 1900-1982 elev.= ft.
Precipitation (in)	14.1	11.4	18.4
Max. Temperature	84	80	74
Min. Temperature	46	45	49

Table 7-2
Seasonal Climatic Variation in the San Pedro River Watershed.
Precipitation (Inches) and Temperature (°F)

Month	Winkelman 1942-1980 elev.=1,325 ft.	Benson 1900-1975 elev.=3,314 ft	Bisbee 1900-1982 elev.=5,410 ft.
January	1.3	0.7	1.1
February	1.1	0.8	1.3
March	1.1	0.5	1.0
April	0.4	0.2	0.5
May	0.3	0.1	0.2
June	0.3	0.3	0.7
July	2.0	2.7	4.0
August	2.6	2.8	4.7
September	1.5	1.3	1.8
October	1.3	0.6	0.9
November	0.9	0.6	0.8
December	1.4	0.7	1.4
Annual	14.1	11.4	18.4

SOURCE: Sellers et al, 1989

The hydrology of the San Pedro River is also impacted by irrigation diversions, ground water pumping, evapotranspiration (cf. ADWR, 1991), ground water-surface water interactions (cf

Stetson, 1987), and watershed impacts including grazing, timber, and fire (Dobyns, 1978).

Statehood/Pre-Statehood Hydrology

Hydrologic data for the San Pedro River for the period preceding statehood is derived primarily from historical accounts of early explorers and settlers. Although the San Pedro River is one of the most thoroughly studied rivers in the southwest, systematic collection of hydrologic data generally did not begin until after 1912.

Historical Descriptions of River Flow. Historical documentation of pre-statehood river conditions dates to the mid 1500's and early exploration by Spanish missionaries. Accounts of these explorations as they relate to hydrology and stream channel conditions are described in more detail elsewhere (cf Hastings and Turner, 1965; Davis, 1982; Dobyns, 1978; Chapters 3 and 5, this report) and will not be repeated here. Interest in the impact of climate change and anthropogenic forces on southwestern rivers have prompted historical analyses of the San Pedro River which document the transformation of the San Pedro River from what may have been a mostly unentrenched stream with perennial flow and beaver and fish populations, to a entrenched arroyo with limited perennial reaches, and almost no aquatic animal and fish species.

However, for the purposes of analysis of the hydrology of the San Pedro River as of the time of statehood, it is important only to note that the entrenchment was substantially completed by 1912 (cf Cooke and Reeves, 1976; Hereford and Betancourt, 1993; Haury et al, 1959). By 1912, few beaver were found on the river, large fish were all but eliminated, and a deep arroyo had formed over most of the study area (Dobyns, 1978), leaving the San Pedro river channel as a braided stream winding back and forth on a sandy bed located within an entrenched floodplain (USGS, 1901). Furthermore, most investigators believe these channel changes to be, at least in part, caused by natural forces (cf. Cooke and Reeves, 1976; Hastings and Turner, 1965). Therefore, natural stream conditions as of statehood were probably not dissimilar to existing stream conditions.

Streamflow measurements. Four USGS gaging stations (Figure 7-2) were operated prior to or during 1912: (1) San Pedro at Charleston; (2) San Pedro near Fairbank; (3) San Pedro at Fairbank; and (4) San Pedro at Winkelman. None of these stations were in operation during the month of February 1912.

- The San Pedro at Charleston station was established in 1904, but was operated only as a crest stage gage between August 1906 and 1913. No streamflow measurements of any kind were reported at the Charleston gage for 1912 (USGS, 1914). Long-term streamflow records for the Charleston gage indicate that the average flow rate for the month of February is 28 cfs, with an average annual flow rate of 13 cfs (USGS, 1991).

- The San Pedro near Fairbank station was operated downstream of a diversion dam for irrigation on the Boquillas Ranch. Streamflow measurements are reported for three dates. The total[2] estimated flow in the river was 14 cfs, 22 cfs, and 18 cfs on January 19, March 18, and April 20, 1912, respectively. Flow in the river downstream of the dam was 14 cfs, 1 cfs, and 3 cfs, respectively. Gage notes state that "nearly the entire low-water flow is diverted at the dam [upstream] for irrigation on Boquillas ranch" (USGS, 1914).

- The San Pedro at Fairbank[3] station was operated in late 1912 and recorded only four discharge measurements ranging from 11 cfs to 18 cfs. Unfortunately the dates of measurement do not correspond to dates of measurements at other stations on the San Pedro River (USGS, 1914). The average monthly discharge for February between 1913 and 1920 was 47 cfs, with an average annual discharge of 96 cfs in the same time period.

- The USGS (1901) reported in 1899 that the lower San Pedro River was dry, due in part to the large number of small canals.

- The San Pedro at Winkelman station operated from April through August 1890 with average monthly flows ranging from 0 cfs to 295 cfs. The station notes that 2,700 acres were irrigated on the San Pedro River in 1890 (USGS, 1954).

Systematic analyses of long-term stream gage records (ADWR, 1991), precipitation (Cooke and Reeves, 1976), ground water levels (ADWR, 1991), and climatic indices (Sellers, 1960) have identified trends that would tend to slightly decrease average annual runoff rates on the San Pedro River between 1900 and the present.

Summary. The San Pedro River was dramatically altered from the channel conditions described by the first non-native explorers in the period prior to statehood. However, most of the literature supports the conclusion that these channel changes were substantially completed by 1912. Since 1912, the hydrology of the river has not radically changed, although average annual streamflow rates have progressively declined since the 1920's. Thus, long-term modern gage records are probably broadly representative of streamflow rates as of the time of statehood.

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[2] Includes flow in sluiceways and canals at diversion dam.

[3] Station name changed to San Pedro near Fairbank in 1913 Surface Water Summary and subsequent USGS report. The original San Pedro near Fairbank station at the Boquillas diversion dam was not used after 1912.

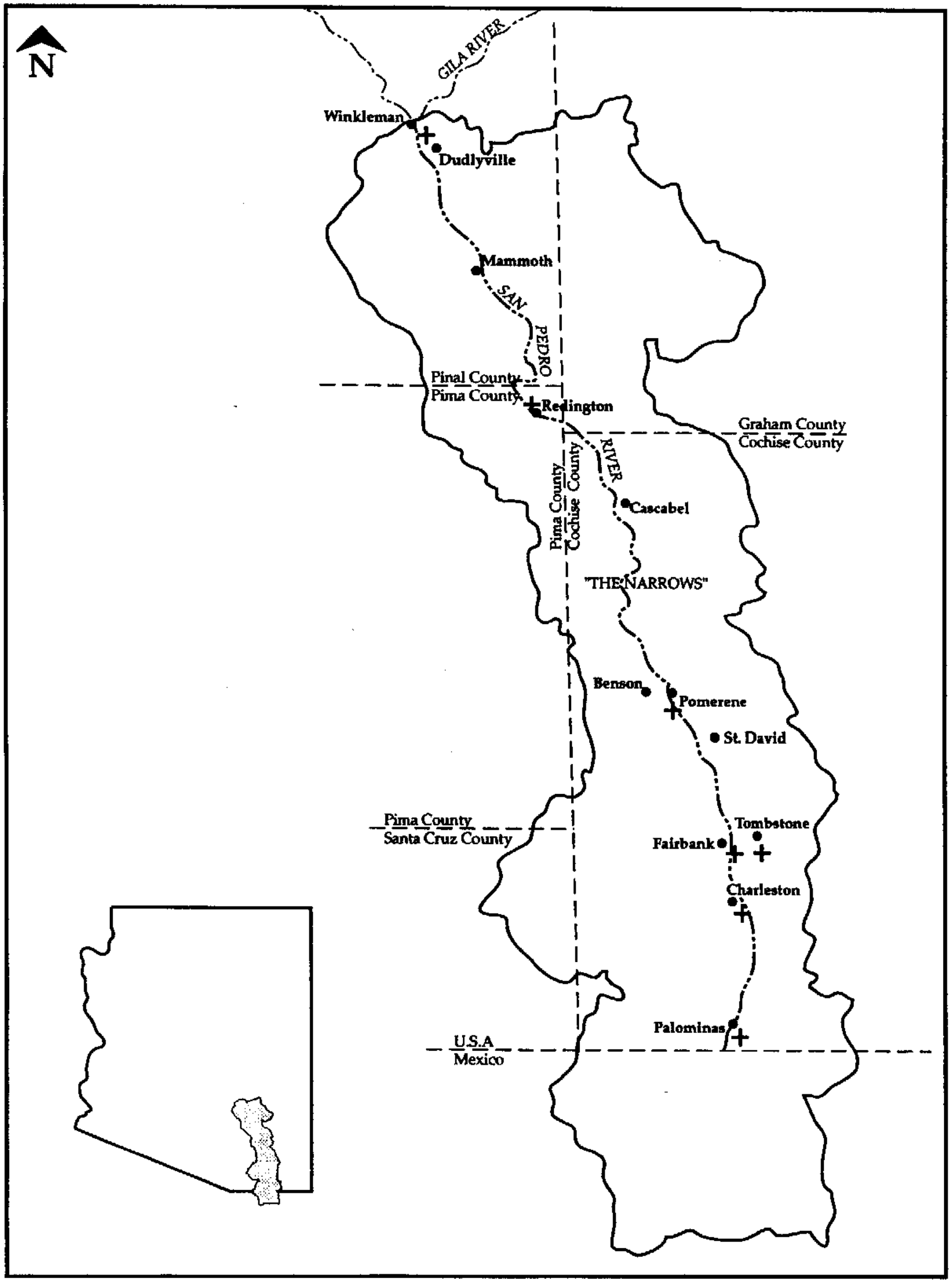

Figure 7-2: Location of San Pedro River Stream Gage Sites and Rating Curve Reaches

Post-Statehood Hydrology

The hydrology of the San Pedro River has been investigated for water rights settlements, ground water-surface water interaction studies, climate change studies, in-stream flow permit applications, and other related studies. The long-term stream gage records of the USGS form the basis of the majority of these analyses.

Gage Records. Streamflow records for nine gaging stations are available for the San Pedro River, not including tributaries (Table 7-3). Sufficient data to develop statistical streamflow summaries are available for six of these stations (Tables 7-4 and 7-5).

Table 7-3
San Pedro River USGS Streamflow Gaging Stations

Station Name	Period of Record	Location
at Palominas	10/30 - 6/41; 10/50 - 9/89	4.5 mi. d/s Mexico
at Charleston	4/04 - 8/06; 10/13 - 9/89	0.3 mi. S Charleston
near Fairbank	9/12 - 9/26	2.5 mi. u/s Fairbank
at Fairbank	10/26 - 9/28	Rt. 82 Bridge
near Tombstone	6/67 - 9/86	2.6 mi. N Fairbank
near Benson	10/66 - 9/76	11 mi. N Benson
near Redington	6/43 - 6/47; 7/50 - 9/89	4.5 mi. u/s Redington
near Mammoth	5/31 - 6/41	Rt. 77 Bridge
at Winkelman	5-8/1890; 6/66 - 9/78	1.0 mi. u/s Gila River

Sources: USGS, 1914; 1954; 1991

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). The station at Palominas and the stations from Benson downstream have steeply sloping flow duration curves. These stations correspond to the intermittent reaches of the river. The Charleston and Tombstone station have less steeply sloped flow duration curves, though they are steep compared to other perennial rivers in Arizona such as the Verde River. Flow frequency estimates for all of the San Pedro River stations converge for low frequency events (less than 20%), indicating a similar flood hydrology for the entire river.

Average Flow Rates. Monthly and average annual flow rates at San Pedro River gage stations are shown in Table 7-5. Floods with high peaks tend to skew the average as indicated by median flow rates and flow duration statistics shown in Table 7-4. Therefore, median (50%) flow rates are probably best representative of "typical" flow conditions. However, average flow rates are useful for showing spatial and temporal variation of streamflow during the year at various locations in the study area. The skew of average rates is best illustrated at the Benson, Redington, and Winkelman stations where the median flow rates (50% duration) in this intermittent reach are close to zero, but average flow rates are about 40 cfs.

Table 7-4
San Pedro River Streamflow Statistics (cfs)

Gage	Average Annual[a]	90% Flow Rate	50% Flow Rate	10% Flow Rate
Palominas	32	35	2.7	0
Charleston	59	77	14	4
Tombstone	56	82	13	0
Benson	32	41	0	0
Redington	45	55	1	0
Winkelman	44	52	3	0

General Information. ADWR (1991) provides the most detailed description of the existing hydrology of the San Pedro River. Key information reported by ADWR includes:

- Most of the San Pedro River between Hereford and the St. David Irrigation ditch is perennial. Only about four miles of the river downstream of St. David is perennial.
- The few springs in the study area discharge at rates of only a few gallons per minute (0.002 cfs).
- Ground water in the San Pedro River basin flows toward or into the San Pedro

River.

- Surface water flows are highly variable, with the major component of flow (including base flow) resulting from direct response to precipitation.

- The average annual discharge rate from the river at Winkelman would increase by about 42 cfs if existing diversions and other water withdrawals were (includes ground water pumping and other depletive uses in the watershed) removed.

- Average streamflow rates have declined since the 1920's at some stations on the San Pedro River.

Stetson, Inc (1987) reports the general decline in streamflow is due in part to ground water withdrawals in excess of natural recharge.

Table 7-5
Average Flow Rates, San Pedro River (cfs).

Month	Palominas 1931-1981	Charleston 1905-1989	Tombstone 1968-1986	Benson 1967-1976	Redington 1944-1989	Winkelman 1967-1978
January	22	38	56	3	33	15
February	11	28	45	8	22	43
March	8	24	37	8	16	74
April	3	13	15	0	4	8
May	1	9	8	0	1	2
June	4	13	4	5	2	.2
July	89	148	104	124	103	66
August	154	233	160	165	215	134
September	36	91	58	34	50	39
October	26	40	95	9	51	80
November	5	18	16	2	4	7
December	22	50	63	20	36	55
Annual	32	59	56	32	45	44

Sources: USGS (1954; 1991)
NOTE: Compare average and median flow rates, as in Table 7-4.

Comparison of Modern and Historical Record. No systematic data exist by which to compare post-statehood flow rates with flow rates at the time of statehood. Secondary sources such as tree-ring data (Smith and Stockton, 1981) and precipitation analyses (Cooke and Reeves, 1976) indicate that the period around statehood was wetter and more flood prone that the most recent period of record. However, since no statistically significant climatic change has occurred since statehood (Sellers, 1960), streamflow records unaffected by development-related changes should adequately predict statehood streamflow rates. Some stations in the San Pedro watershed have shown declining flow rates, possibly due to increased ground water withdrawals. Therefore, use of long-term gage records may tend to under predict flow rates which occurred at statehood, but are broadly representative of that time period.

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 San Pedro 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. A typical rating curve for the San Pedro River is shown in Figure 7-3; locations of San Pedro stream gages are shown in Figure 7-2; documentation on rating curves is attached in Appendix F.

Historical streamflow data were available from the Charleston (1904-1906), and (near) Fairbank (1915-1924), stations. To reconstruct rating curves, published stage, velocity, and discharge readings from the period of record closest to statehood were 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, as illustrated below.

Recent stream gage measurements were available for the Redington (10/81 to 10/92) and Tombstone (9/81 to 10/86) gages. Field measurements of stream width, velocity, topwidth, and velocity were entered into a data base and a rating curve was fit to the data. Hydraulic characteristics for monthly and average annual flow rates were then obtained from the rating curve.

[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.

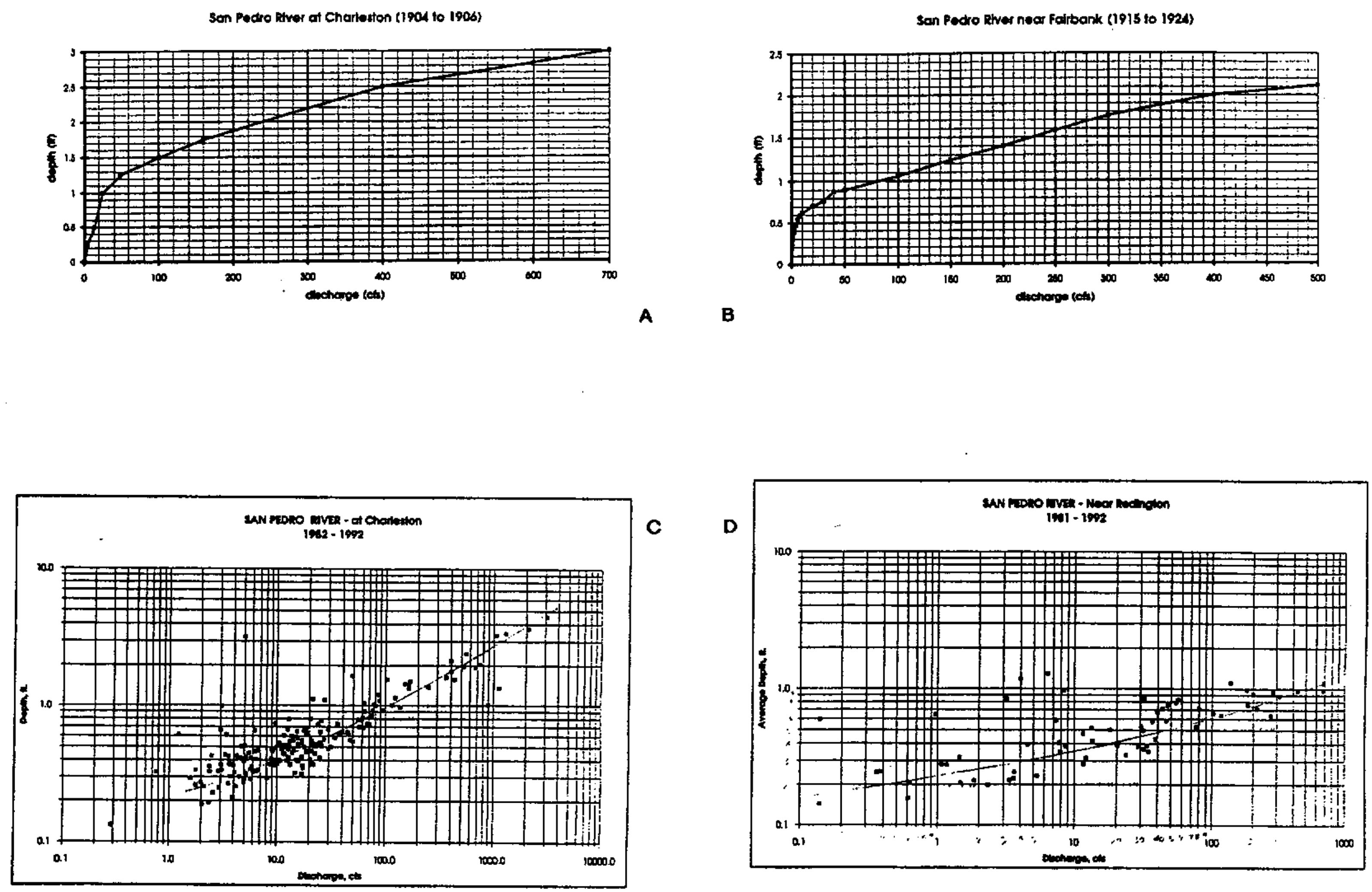

Figure 7-3: Typical Hydraulic Rating Curve for Upper and Lower San Pedro River

Summaries of the data from the rating curves for each station are shown in Tables 7-6 to 7-10. These data are intended to be representative of the following reaches:

- Upper San Pedro River: Charleston (Table 7-6, Historical Data); Charleston (Table 7-7, Recent Data); Fairbank (Table 7-8, Historical Data); Tombstone (Table 7-9, Recent Data)

- Lower San Pedro River: Redington (Table 7-10, Recent Data)

The Tombstone station is located about 5 miles from the historic Near Fairbank station. These data may be compared in a general way to illustrate potential changes in river characteristics from the time of statehood and the present time.

Table 7-6a
San Pedro River at Charleston, 1904 to 1906
Average Hydraulic Characteristics

Month	Flow Rate (cfs)	Average Depth (ft)	Velocity (ft/sec)	Topwidth (ft)
January	38	1.1	3.9	8
February	28	1.0	3.7	7
March	24	1.0	3.6	7
April	13	0.5	3.0	5
May	9	0.4	2.8	4
June	3	0.2	2.5	3
July	148	1.7	5.1	17
August	233	1.9	5.6	19
September	91	1.5	4.6	13
October	40	1.2	4.0	8
November	18	0.7	3.3	5
December	50	1.3	4.2	10
Annual	59	1.3	4.3	10

NOTE: Discharges from entire gage record: 1904-1991

Table 7-6b San Pedro River at Charleston, 1904 to 1906 Flow Duration Hydraulic Characteristics				
Flow Period	**Flow Rate (cfs)**	**Average Depth (ft)**	**Velocity (ft/sec)**	**Topwidth (ft)**
Average Annual Flow	59	1.3	4.3	10
90% Flow	77	1.4	4.4	12
50% Flow	14	0.5	3.0	5
10% Flow	4	0.2	2.5	3

Table 7-7a San Pedro River at Charleston Gage #09471000 Average Hydraulic Characteristics				
Month	**Flow Rate (cfs)**	**Average Depth (ft)**	**Velocity (ft/sec)**	**Topwidth (ft)**
January	38	0.7	1.7	37
February	28	0.6	1.5	33
March	24	0.5	1.4	31
April	13	0.4	1.2	23
May	9	0.4	1.1	19
June	3	0.3	0.9	10
July	148	1.2	2.3	60
August	233	1.4	2.7	69
September	91	0.9	2.1	50
October	40	0.7	1.7	38
November	18	0.5	1.3	28
December	50	0.7	1.8	41
Annual	59	0.8	1.9	43
NOTE: Discharges from entire gage record: 1904-1991				

Table 7-7b San Pedro River at Charleston, Gage #09471000 Flow Duration Hydraulic Characteristics				
Flow Period	**Flow Rate (cfs)**	**Average Depth (ft)**	**Velocity (ft/sec)**	**Topwidth (ft)**
Average Annual Flow	59	0.8	1.9	43
90% Flow	77	0.9	2.0	48
50% Flow	14	0.4	1.3	24
10% Flow	4	0.3	1.0	12

Table 7-8a San Pedro River at Fairbank, 1915 to 1924 Average Hydraulic Characteristics				
Month	**Flow Rate (cfs)**	**Average Depth (ft)**	**Velocity (ft/sec)**	**Topwidth (ft)**
January	56	0.9	3.0	20
February	45	0.9	2.9	17
March	37	0.9	2.8	15
April	15	0.7	2.4	9
May	8	0.5	2.2	6
June	4	0.5	2.0	5
July	104	1.1	3.3	29
August	160	1.3	3.7	34
September	58	0.9	3.0	20
October	95	1.0	3.2	28
November	16	0.7	2.4	9
December	63	1.0	3.0	22
Annual	56	0.9	3.0	20
NOTE: Discharges derived from San Pedro near Tombstone gage.				

Table 7-8b San Pedro River near Fairbanks, 1915 to 1924 Flow Duration Hydraulic Characteristics				
Flow Period	**Flow Rate (cfs)**	**Average Depth (ft)**	**Velocity (ft/sec)**	**Topwidth (ft)**
Average Annual Flow	56	0.9	3.0	20
90% Flow	82	1.0	3.2	25
50% Flow	13	0.7	2.4	9
10% Flow	0	0	0	0

Table 7-9a San Pedro River: Near Tombstone, Gage 09471550 Average Hydraulic Characteristics				
Month	**Flow Rate (cfs)**	**Average Depth (ft)**	**Velocity (ft/sec)**	**Topwidth (ft)**
January	56	0.5	1.9	58
February	45	0.5	1.8	53
March	37	0.5	1.7	48
April	15	0.4	1.4	28
May	8	0.3	1.3	16
June	4	0.3	1.2	9
July	104	0.6	2.1	72
August	160	0.8	2.4	84
September	58	0.5	1.9	59
October	95	0.6	2.1	70
November	16	0.4	1.5	29
December	63	0.5	1.9	61
Annual	56	0.5	1.9	58

Table 7-9b San Pedro River: Near Tombstone, Gage 09471550 Flow Duration Hydraulic Characteristics				
Flow Period	**Flow Rate (cfs)**	**Average Depth (ft)**	**Velocity (ft/sec)**	**Topwidth (ft)**
Average Annual Flow	56	0.5	1.9	58
90% Flow	82	0.6	2.0	66
50% Flow	13	0.4	1.4	24
10% Flow	0	0	0	0

Table 7-10a San Pedro River: Near Redington, Gage 09472000 Average Hydraulic Characteristics				
Month	**Flow Rate (cfs)**	**Average Depth (ft)**	**Velocity (ft/sec)**	**Topwidth (ft)**
January	33	0.5	2.2	27
February	22	0.4	1.9	21
March	16	0.4	1.7	18
April	4	0.3	1.1	8.5
May	1	0.3	0.8	5.7
June	2	0.3	0.9	6.0
July	103	0.6	3.1	50
August	215	0.8	3.6	74
September	50	0.5	2.6	33
October	51	0.5	2.6	33
November	4	0.3	1.1	8
December	36	0.5	2.3	28
Annual	45	0.5	2.5	31

Table 7-10b San Pedro River: Near Redington, Gage 09472000 Flow Duration Hydraulic Characteristics				
Flow Period	**Flow Rate (cfs)**	**Average Depth (ft)**	**Velocity (ft/sec)**	**Topwidth (ft)**
Average Annual Flow	45	0.5	2.5	31
90% Flow	55	0.5	2.6	35
50% Flow	0.6	0.2	0.6	4
10% Flow	0	0	0	0

Rating curves of depth vs. discharge for high flow conditions have been developed by the BLM (1987) for seven locations between Hereford and St. David. BLM rating curves are based application of Manning's equation to surveyed cross section information. These rating curves probably have little applicability to navigability on "ordinary and natural" conditions, since flows in excess of 1,000 cfs occur less than one percent of the time, according to flow duration statistics, and because no flow velocities are given. In general, the BLM curves agree with the low flow rating curve data summarized in Tables 7-6 to 7-10, in that low flows are about two feet deep or less. The BLM cross section data also predict flow depths of 5 to 10 feet for the 2-year flood. BLM cross section plots are attached in Appendix E.

Summary. Hydraulic rating curves are shown for five stations on the San Pedro River. These data indicate that flow depths are generally less than one foot and flow velocities are generally about two to four feet per second. Historical rating curves indicate somewhat greater flow depths and higher velocities than comparable rating curves for nearby stations developed from recent field measurements of flow conditions.

Floods

Flood frequency data are available from Flood Insurance Studies (FEMA, 1989; 1990) and from USGS gage records (1991). Large flood occurred in the year prior to statehood, as well, reported causing channel erosion and channelization of most of the San Pedro River.

Flood Recurrence Intervals. Flood discharge rates at various key concentration points are listed in Table 7-11. Flow rates obtained from Flood Insurance Studies (FIS, 1989; 1990) are based on rainfall runoff modeling and are significantly different from flow rates determined by the USGS (1991) using streamflow records.

Location	Area (mi^2)	Q2	Q5	Q10	Q50	Q100	Q500
Palominas	737	5810	9190	11800	18300	21500	-
SR 92	741	-	-	13,000	19,400	22,300	29,500
Charleston	1,234	6600	11900	16900	33800	44000	-
Tombstone	1,730	7490	12000	15400	23900	28000	-
I-10	2,167	-	-	20,000	37,500	46,600	74,500
Redington	2,927	7800	16100	23100	43000	53200	-
Mammoth	3,610	-	-	23,200	38,300	46,800	72,400
Dudleyville	4,471	-	-	20,000	38,800	49,600	72,600
Winkelman	4,453	6390	12800	19500	44300	60900	-

Table 7-11
Summary of San Pedro River Flood Frequency Discharges (cfs)

Source: FEMA, 1989; 1990; USGS, 1991

Historic Floods. The largest floods recorded at USGS gaging stations are summarized in Table 7-12. USGS (1991) gage records site the 1926 flood as the largest since 1906. However, no estimates of the magnitude of the 1906 event are available. All of the largest floods on the San Pedro River have occurred during late summer. Dobyns (1978) also records that large floods on the San Pedro River occurred in 1833[5] 1868, 1874, 1880, 1887, 1890, 1891 prior to gaging by the USGS. Dobyns claims that the flood of 1890 caused the "death of the San Pedro River", which removed or drained numerous swampland areas along its course. The 1891 flood may have actually been larger than the 1890 flood, but the newly entrenched channel of the San Pedro conveyed the flood more efficiently (Dobyns, 1978).

[5] Actually reported as a flood on Gila River which destroyed beaver dams.

Table 7-12 Dates and Discharges of Large San Pedro River Floods (cfs)		
Gage Station	**Discharge (cfs)**	**Date**
Palominas	22,000	8-14-26
	16,500	8-5-58
Charleston	98,000	9-28-26
	31,000	8-13-40
Tombstone	24,200	19-9-77
Benson	9,520	7-20-74
Redington	90,000	9-28-26
	50,000	8-14-40
	25,400	10-2-83
Winkelman	135,000	10-1-83
	85,000	9-28-26
	45,000	8-14-40

Flood Hydraulics. Limited flood hydraulics data are available from Flood Insurance Studies for the San Pedro River. Flood depths, of course, are not limiting with respect to boating. In the lower reach, velocities for the 100-year flood average about 6.5 feet per second (fps), and range from about 4 fps to 16 fps. Higher velocities typically occur in constricted reaches, such as at bridges. Lower velocities typically occur upstream of constrictions and in relatively wider, shallower reaches. In the upper reach, 100-year velocities average about 8.5 fps, and range from about 5 to 11 fps, although only limited data were available in this reach. These average velocities 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 in flood waters hazardous.

Irrigation

The first irrigation diversions on the San Pedro River date back to 500 to 1500 A.D., and were operated by Hohokam Indians who lived near the Babocomari River confluence (Wilken and Galante, 1987). In the late 1600's, Father Kino noted the presence of irrigation systems of the lush agricultural area along the San Pedro Valley. Anglo irrigation of the valley dates to the 1880's, with the first diversions located on Aravaipa Creek and at St. David (ADWR, 1991). By 1900 there were about 2,500 acres of irrigated land between Palominas and Winkelman, although much of this land was irrigated from artesian wells (ADWR, 1991). In 1899, the USGS (1901) reported that 3,160 acres were irrigated[6] from ten canals 1.5 to 2 miles in length, and that the lower San Pedro River was dry due to the large number of small canals. Today, the majority of irrigation water is pumped from the subsurface to supply water to more than 20,000 acres of farmland, although some surface water diversions remain (Table 7-13).

Table 7-13
San Pedro River Surface Water Irrigation Diversions

Name	Average Diversion (cfs)	First Use
St. David Irrigation District	5.8	1881
Pomerene Water Users Assoc.	2.1	1912
Bayless & Berkalew	0.8	1988
Nature Conservancy	0.3	1867
D.E. Geldmacher	2.7	?
W.H. Claridge	2.1	?
E. Salazar	0.3	?

NOTE: May include diversions from tributaries, pumpage of surface water from San Pedro not listed.

Other non-natural uses of water in the San Pedro Basin include water transfers to other basins for mining, municipal water supply, mining uses, industrial/commercial uses, reservoirs and stock ponds (none on the main stem of the San Pedro), and domestic uses.

Summary. Although irrigation was practiced in the San Pedro River valley, irrigation was not as extensive as for other Arizona rivers such as the Salt, Gila, and Verde Rivers. Limited streamflow and channel cutting may have prevented more extensive irrigation in the watershed. On average, about 14 cfs of surface water is currently diverted from the entire San Pedro River for use on about 3,300 acres, most of which must be supplemented by ground water (ADWR, 1991). Around the time of statehood, about 2,500 acres were irrigated (ADWR, 1991), with much of the water supply derived from wells. The increased number of canals during the pre-statehood period, particularly in the lower San Pedro River, may indicate higher flow rates in the lower reach at that time.

[6] Total diversion of 117.6 cfs in March 1899 between St. David and Riverside (near Winkelman).

Summary

Analysis of the hydrology of the San Pedro River reveals that portions of the river between Hereford and St. David are currently perennial, and probably were perennial as of statehood as well. The rest of the river is presently intermittent or ephemeral, except for a number of short reaches near areas of shallow bedrock. Some of these currently intermittent reaches may have experienced perennial, or longer duration intermittent flow at statehood, but groundwater withdrawal and slightly drier climatic conditions have reduced average surface flow rates. Average monthly flow rates derived from long term stream gage records are available for several stations, but may under predict average flow rates as of statehood by an undetermined amount. However, since average flow rates are skewed, they are probably a conservative estimate of the median flow rates at statehood. Median flow rates are usually a better indicator of "typical" flow conditions. Rating curves based on recent stream gage data and historical flow measurements indicate that flow depths are generally less one foot, and are less than one-half foot much of the year. Flow rates which would result in greater flow depths generally occur during floods.

The hydrologic record for the San Pedro River indicates the following:

- The Upper San Pedro River about St. David was perennial at of the time of statehood, with an average annual flow rate of about 50 cfs, and a median (50%) flow rate of about 10 cfs. These flow rates correspond to flow depths, widths, and velocities of about 1 feet, 30 feet, and 3 feet per second, for the average annual rate, and about 0.5 feet, 10 feet, and 2 feet per second, for the median flow rate, respectively. The natural average flow rate during the month of February was about 40 cfs.

- The remaining reaches of the San Pedro River were mostly intermittent, with a few local ephemeral or perennial reaches of limited extent. In these reaches, such as near Redington, the average annual flow rate is about 45 cfs, but the median (50%) flow rate is less than 1 cfs. Both the average annual and median flow rates are associated with flow depths of less than 0.5 feet, and velocities of less than 3 feet per second.

Chapter 8
Boating on the San Pedro River

Introduction

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

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

This chapter presents historical and modern accounts of boating for the San Pedro River. Other information on boating and stream conditions was presented in Chapters 3 and 7.

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 In-stream flow needs for certain recreational activities, including boating (US Fish and Wildlife, 1978). The US Department of the Interior independently developed its own boating standards (Cortell and Associates, 1977). These federal criteria, summarized in Tables 8-1 and 8-2, were developed primarily for recreational boating (transport of people), 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**	**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 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."

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

No documentation of application of these guidelines by the BLM in Arizona was uncovered, or specifically on the San Pedro River. No evidence of any other federal agency's decision of navigability for the San Pedro River was found during the course of this study.

Historical Accounts of Boating

Boats were in use in Arizona 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 other Arizona rivers are also documented. Review of historical records of boating gives the general impression is that there was no shortage of boats in certain parts of Arizona as of the time of statehood. 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, or simply constructed on the spot.

No documented historical accounts of boating on the San Pedro River were uncovered. SWCA ethnographers discovered anecdotal evidence of a ferry operated on the San Pedro River at Pomerene at some time in the past. It is noted that early explorers who traveled the San Pedro on foot, or by horseback and wagon, in some cases built boats after reaching the Gila River.

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 San Pedro River during pre-statehood times included very large fish such as squaw fish (a.k.a. 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.

Historical accounts of fishing are centered on early explorer routes and settlements. There are numerous accounts of "salmon" runs (actually squaw fish) on the San Pedro River, fish clogging canals on the San Pedro River, and catching fish with pitchforks for use as fertilizer on irrigated fields. A commercial operation reportedly harvested razorback suckers from the San Pedro River between 1870 and 1910 near Tombstone.

Modern Accounts of Boating

Some Arizona rivers are boated for recreation 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 time of statehood, with use of more durable inflatable rafts, inflatable and hard-shell kayaks becoming some of the preferred modes of recreational river 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 (CAPC), 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 the San Pedro from Palominas to Hereford Road has been boated in recent years (Central Arizona Paddlers Club, 1992). CH2M HILL informally polled CAPC members willing to be interviewed to determine flow conditions at the time the San Pedro River was boated. Data collected in this poll reveal that all of the San Pedro River except the reach from Mammoth to Aravaipa Creek, and from Curtis to I-10 have been boated at least once. A brief summary of the CAPC poll showing reaches and flow data is presented in Table 8-3 (Also see Appendix G).

Although the San Pedro River has been boated, Arizona State Parks Department classified the river as a hiking or general recreation area, rather than a boating stream (1989). Some boaters who have traveled 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 modern, documented boating excursions on the San Pedro River occurred in the month of August, during the monsoon season. A boating guide to the southwest does not list the San Pedro River (Anderson and Hopkinson, 1982). The San Pedro River: A Discovery Guide (Hanson, 2001) does not mention boating of any kind, but does mention hiking and biking as ways to travel the river corridor.

[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.

Table 8-3 Central Arizona Boaters Club Survey Results: Selected San Pedro Reaches Boated							
River	Reach	Date mo-yr	Flow (cfs)	Depth (ft)	Width (ft)	Craft	Portage (%)
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	Rubbr 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	1,00 0	1.5	< 120	Canoe	0

It is noted that for all of the instances of boat use on the San Pedro River, the boaters traveled downstream or across the river. No evidence of boating in the upstream direction was found. The types of boats typically used were low-draft boats, such as canoes, kayaks, or inflatable rafts. Information presented in Table 8-4 summarizes probable stream characteristic required to support use of the type of boats available at statehood. The criteria for canoes available as of the time of statehood are not substantially different from criteria for canoes available today.

Table 8-4 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	

Navigability Decisions

No evidence of any federal or other formal decisions of title navigability for the San Pedro River were discovered during the data collection phase of this study.

Summary

No documented historical accounts of boating on the San Pedro River was uncovered, although anecdotal evidence of a ferry operated on the San Pedro River at Pomerene at some time prior to statehood was discovered, but not confirmed. Historical accounts of early explorers of Arizona who traveled the San Pedro River, did so on foot or by horseback and wagon. In some cases, these travelers built boats upon reaching the Gila River after walking or riding along the San Pedro River.

In recent history, most of the San Pedro River has been canoed, kayaked, or rafted during summer high flows. Some of these boating trips are very opportunistic, where boaters drive to a launching point on likely rain days, and "put in" the water if rain conditions favor runoff (cf. Central Arizona Paddlers Club, 1992). All but one of the boating excursions on the San Pedro River occurred in the month of August, during the summer monsoon season. Arizona boaters have floated all of the San Pedro River except the reach from Mammoth to Aravaipa Creek, and from Curtis to I-10. In spite of the activities of these boaters, the Arizona State Parks Department classifies the San Pedro as a hiking or general recreation river (1989). A boating guide to the southwest does not list the San Pedro River (Anderson and Hopkinson, 1982).

Chapter 9
Conclusions

This report documented the archaeology, history, geology, and hydrology of the San Pedro River. Review of historical and physical records for the San Pedro River Valley lead to several conclusions. First, historical and archaeological records indicate that exploration, exploitation, and development of the San Pedro River Valley was focused on the river water, although other factors such as mining and transportation also played important roles. Second, historical and physical records suggest the river had reliable stream flow in the upper reach, but became less reliable near the river's mouth, especially after arroyo cutting transformed the channel around the turn of the century. Third, the historical record lacks documented accounts of boating on the river, although the history of the region is very well documented. Documentation of several other modes of transportation was found. Finally, modern boating enthusiasts have shown that most of the river can be boated in shallow-draft boats such as kayaks and canoes during portions of some years.

The archaeology, history, geology, and hydrology of the San Pedro River Valley are well documented and have been thoroughly studied by others. Beginning in about 9000 B.C., the river attracted human occupation and exploitation of river resources. However, even in modern times development and use of the river never reached the scale achieved in the Salt and Gila River valleys. Smaller scale development was probably due to climatic differences from the Salt and Gila River valleys, and differences in the character of the floodplain. However, less reliable and lower average stream flow rates probably also limited the scale of development. This report has summarized information regarding historical and potential navigation of the San Pedro River as of the period around statehood.

The archaeological record of the San Pedro River suggests that prehistoric river uses included water supply, flood irrigation, and exploitation of the diverse environment found along the river. Environmentally and archaeologically, the river may be divided into two segments: the lower San Pedro River which extends from the Gila River confluence to the town of Benson; and the upper San Pedro River which extends from Benson to the headwaters. Prehistoric settlement patterns and lifeways reflect the different micro-environments and proximity to differing cultural cores in these two reaches. Human occupation began about 9500 B.C., where early occupants used the perennial river as a water source, as well as for the biotic diversity that it enhanced. Agricultural practices primarily consisted of dry farming on the floodplain terraces and floodwater farming in the floodplain. River-irrigated farming was supplemented by dry farming techniques and hunting/gathering. Some evidence of prehistoric irrigation has been found along the lower San Pedro in the Sonoran desert region of the river, though evidence of prehistoric canals is scarce. Prehistoric settlements were small compared to the complex culture which existed concurrently on the Salt River.

The modern history of the San Pedro River is as well documented as that of any stream in Arizona. Classic studies of arroyo processes documented in studies such as Hastings and Turner's (1965) *The Changing Mile*, compiled historic data for the San Pedro River. These studies indicate that prior to about 1890, the San Pedro River was an irregularly flowing stream, marshy in places, free-flowing in other places, entrenched or subsurface in still other places. Moreover, the flow of the stream varied throughout the year. Published and archival accounts of the history of the San Pedro River suggest that the river was used for irrigation agriculture and milling of ore mined in the nearby mountain foothills.

Historically, the San Pedro River valley was a significant transportation route through southern Arizona because of the river's reliable water source. However, travel was along the river rather than in it. The current search of archival and historical documentation on the San Pedro River found no published accounts of boating on the San Pedro River. In fact, although Cooke in 1846, and Powell in 1849 made no attempt to boat the San Pedro River, were inspired to build boats later in their expeditions and float the Gila River. Other historic accounts suggest that early explorers, travelers, and settlers did not consider the stream to be boatable. An undocumented account of a ferry operated near Pomerene is the only evidence for boating on the San Pedro River found during this study.

Around 1890, the San Pedro River was a highly variable stream, both seasonally and along its length. In some areas, it was primarily a marsh with no discernible bed. In other areas it was a flowing stream several feet wide and as much as one foot deep, but a few miles away, surface water might not be present at all. In a few places, the stream flowed through arroyo cuts as much as 10 feet deep. Historical accounts of the river also indicate that some reaches changed from wet to dry over the course of the season. Some time around 1890, arroyo cutting significantly changed the character of the San Pedro River. Both the upper and lower reaches of the San Pedro River experienced channel entrenchment and widening during the last half of the 19th century and the first half of the 20th century. By 1912, most of the San Pedro River had already experienced entrenchment. In the upper San Pedro Valley, the river generally consisted of a small braided stream with a baseflow of less than 10 cfs flowed between vertical banks 130 to 260 feet wide. In the lower San Pedro Valley, the river also had a small braided channel that flowed between vertical banks, but intermittent reaches were common below Redington, and the channel banks were commonly wider than 330 feet.

Analysis of the hydrology of the San Pedro River reveals that portions of the river between Hereford and St. David are currently perennial, and probably were perennial as of statehood as well. The rest of the river is presently intermittent or ephemeral, except for a number of short reaches near areas of shallow bedrock. Some of these currently intermittent reaches may have experienced perennial or longer duration intermittent flow at statehood, but groundwater withdrawal and slightly drier climatic conditions have reduced average flow rates. Hydraulic ratings of average flow rates indicate that average and median flow depths for the entire study reach are generally less than one foot. This estimate is supported by historical and modern observations of flow conditions in the river. Flow rates which would result in greater flow depths generally occur during floods or brief periods of higher flow.

No documented historical accounts of boating on the San Pedro River were uncovered, although anecdotal evidence of a ferry operated on the San Pedro River at Pomerene at some time prior to statehood was discovered, but not confirmed. Historical accounts of early explorers that traveled the San Pedro River indicate that they did so on foot or by horseback and wagon. In some cases, these travelers built boats upon reaching the Gila River after walking or riding along the San Pedro River. In recent history, most of the San Pedro River has been canoed, kayaked, or rafted during summer high flows. Some of these boating trips are very opportunistic, where boaters drive to a launching point on likely rain days or after periods significant rainfall, and "put in" the water if rain conditions favor runoff. The San Pedro River is not generally considered a recreational or commercial boating stream.

Chapter 10
References Cited

Adams, Ward R.
1930 *History of Arizona*, Vol. 1. Record Publishing Co., Phoenix.

Agenbroad, Larry D.
1966 Preliminary Report on a Desert Culture Site: San Pedro Valley, Arizona. Ms. on file, Arizona State Museum Library, University of Arizona, Tucson.

1967 Cenozoic Stratigraphy and Paleo-Hydrology of the Redington-San Manuel Area, San Pedro Valley, Arizona: Tucson, Ph.D. Dissertation, University of Arizona, 119 p.

1970 *Cultural Implications from the Statistical Analysis of a Prehistoric Lithic Site in Arizona.* Unpublished Master's Thesis, Department of Anthropology, University of Arizona, Tucson.

1978 Cultural Implications from the Distributional Analysis of a Lithic Site, San Pedro Valley. In *Discovering Past Behavior: Experiments in the Archaeology of the American Southwest*, edited by P. Grebinger, pp. 55-71. Gordon and Breach, New York.

Aldrich, Lorenzo D.
1950 *A Journal of the Overland Route to California and the Gold Mines.* Dawson's Book Shop, Los Angeles.

Alexander, W.B.
\- Property of the Bayless and Beralew Company Situated Along the San Pedro River, Arizona.

Altschul, Jeffrey H.
1992 The Formative Period in the San Pedro River Valley. Paper presented at the 17th Simposio de Historia y Antropología de Sonora, Hermosillo.

Altschul, Jeffrey H., and Bruce A. Jones
1990 *Settlement Trends in the Middle San Pedro Valley: A Cultural Resources Sample Survey of the Fort Huachuca Military Reservation.* Statistical Research Technical Series No. 19. Tucson.

Anderson, F., and Hopkinson, A.
1982 Rivers of the Southwest: A Boaters Guide to the Rivers of Colorado, New Mexico, Utah, and Arizona. Pruett Publishing, Boulder, Colorado.

Arizona Department of Water Resources
- Application and Documentation for San Pedro River Instream Flow Permit.

1991 Hydrographic Survey Report for the San Pedro River Watershed, Vol 1. General Assessment. See also Volumes 2-9. November 20.

Arizona Office of Economic Planning and Development
1977 *Benson, Arizona Community Prospectus.* Arizona Office of Economic Planning and Development, Phoenix.

Arizona State Parks Department
1989 Arizona Rivers, Streams, and Wetlands Study: Draft: Statewide Comprehensive Outdoor Recreation Plan. Phoenix, Arizona.

Arizona State Water Commission
1972 Land Ownership and Administration, Santa Cruz-San Pedro River Basins, Arizona.

Bahr, C.J.
1991 A Legacy of Change: Tucson, University of Arizona Press, 231 p.

Bahre, Conrad J. and Charles F. Hutchinson
1985 The impact of historic fuelwood cutting on the semidesert woodlands of southeastern Arizona. *Journal of Forest History 30.* 176-186 p.

Bancroft, Hubert Howe
1888 The Works of Hubert Howe Bancroft, Volume XVII: History of Arizona and New Mexico, 1530-1888. The History Company, Publishers, San Francisco.

Bandelier, Adolf F.
1892 *Final Report of Investigations Among the Indians of the Southwestern United States, Carried on Mainly in the Years from 1880-1885.* Papers of the Archaeological Institute of America, American Series 3 and 4. John Wilson and Son, Cambridge.

Bandelier, Adolph F.A.
1890 *Hemenway Southwestern Archaeological Expedition: Contributions to the History of the Southwestern Portion of the United States.* Papers of the Archaeological Institute of America, American Series 5. Cambridge, Mass.

1890-92 *Final Report of Investigations Among the Indians of the Southwestern United States, Carried on Mainly in the Years from 1880 to 1885.* 2 Vols. Papers of the Archaeological Institute of America, American Series 3 and 4. Cambridge, Mass.

Barnes, Will C.
1988 *Arizona Place Names*. University of Arizona Press, Tucson.

Bartlett, John Russell
1854 *Personal Narrative of Exploration and Incidents in Texas, New Mexico, California, Sonora, and Chihuahua, connected with the United States and Mexico Boundary Commission, during the Years 1850, '51, '52, and '53* (2 Vols.). D. Appleton & Co., New York.

Basso, Keith H.
1983 Western Apache. In *Handbook of North American Indians, Volume 10, Southwest*, edited by Alfonso Ortiz, pp. 462-488. Smithsonian Institution, Washington, D.C.

Batman, Richard
1984 *James Pattie's West: The Dream and the Reality*. University of Oklahoma Press, Norman.

Beiber, Ralph P.
1936 Marching with the Army of the West, Journal of Johnston, Edwards, and Ferguson. Arthur H. Clark Co., Cleveland, Ohio.

Bell, James G.
1932 A Log of the Texas-California Cattle Trail, 1854, edited by J.Evetts Haley. *Southwestern Historical Quarterly* 35:290-316; 36:47-66.

Bell, William A.
1869 *New Trails in North America*. Vols. 1 and 2. Chapman and Hall, London.

Betancourt, J.L.
1990 Tucson's Santa Cruz River and the Arroyo Legacy: Tucson, University of Arizon Ph.D. Dissertation, 239 p.

Betancourt, Julio L. and Richard Hereford
None *Historic Geomorphology of the San Pedro River: Archival and Physical Evidence.*

Bigler, Henry
1932 Extracts from the Journal of Henry W. Bigler. *Utah Historical Quarterly* 5 (2, 3, 4):35-64, 87-112, 134-160.

Bliss, Robert S.
1931 The Journal of Robert S. Bliss, With the Mormon Battalion. *Utah Historical Quarterly* 4 (3, 4):67-96, 110-128.

Bolton, Herbert Eugene
1916 *Spanish Exploration in the Southwest, 1542-1706.* C. Scribner's, New York.

1936 *Rim of Christendom: A Biography of Eusebio Francisco Kino, Pacific Coast Pioneer.* McMillan, New York.

1948 *Kino's Historical Memoir of Pimeria Alta.* University of California Press, Berkeley.

1949 *Coronado, Knight of Pueblos and Plains.* University of New Mexico Press, Albuquerque.

1960 *Rim of Christendom: A Biography of Eusebio Francisco Kino, Pacific Coast Pioneer.* Russell and Russell, New York.

1990 *Coronado, Knight of Pueblos and Plains.* University of New Mexico Press, Albuquerque.

Bourke, John Gregory
1971 *On the Border with Crook.* (Reprint, 1891 edition) Rio Grande Press, Glorietta, New Mexico.

Breternitz, Cory D.
1978 *An Archaeological Survey of the Continental Copper Company 69 and 115 KV Transmission Line in the Lower San Pedro Valley, Arizona.* Arizona State Museum Archaeological Series No. 121. University of Arizona, Tucson.

Brice, J.D.
1984 Planform properties of rivers, In Elliot, C.M. (ed), River Meandering: NewYork, American Society of Civil Engineers, p. 1-15.

Bronitsky, Gordon, and James D. Merritt
1986 *The Archaeology of Southeast Arizona: A Class I Cultural Resource Inventory.* Cultural Resource Series Monograph No. 2. Bureau of Land Management, Arizona State Office, Phoenix.

Brown, D.E. (ed)
1982 Biotic Communities of the American Southwest, United States and Mexico, In Desert Plants, vol. 4: Tucson, University of Arizona Press.

Brown, David E., Neil B. Carmony, and Raymond M. Turner
1981 *Drainage map of Arizona showing perennial streams and some important wetlands.* Arizona Game and Fish Department.

1974 Erosion Classification of the Santa Cruz- San Pedro River Basins, Arizona. July.

Browning, Sinclair
1982 *Enju: The Live and Struggle of an Apache Chief from the Little Running Water.* Northland Press, Flagstaff.

Bryan, K.,
1926 San Pedro Valley, Arizona, and the geographic cycle [abstr]: Geological Society of America Bulletin, v. 37, p. 169-170.

Bryan, K., Smith, G.E.P, and Waring, G.A.
1934 Geology and water resources of the San Pedro Valley, Arizona: Tucson, U.S. Geological Survey Open-File Report, 167 p.

Bryan, Kirk
1925 Date of channel trenching (arroyo-cutting) in the arid Southwest. Science 62: 338-344.

Bryan, Kirk, G.E.P. Smith, and G.A. Waring
1934 *Ground-water supplies and irrigation in the San Pedro Valley, Arizona.* U.S.G.S. Open-File Report 67-31.

Bull, W.B.
1991 Geomorphic Responses to Climate Change: New York, Oxford University Press, 326 p.

Burkham, D.E.
1976 Effects of changes in an alluvial channel on the timing, magnitude, and transformation of flood waves, southeastern Arizona: U.S. Geological Survey Professional Paper 655-K, 25 p.

1972 Channel changes of the Gila River in Safford Valley, Arizona: U.S. Geological Survey Professional Paper 655-G, 24 p.

1970 *Precipitation, Streamflow, and Major Floods of Selected Sites in the Gila River Drainage Basin above Coolidge Dam, Arizona.* U.S. Geological Survey Professional Paper 655-B. Washington, D.C.: U.S. Government Printing Office.

Burrus, E. J.
1971 Kino and Manje: Explorers of Sonora and Arizona; Their Vision of the Future: Jesuit Historical Institute, Rome and St. Louis, 793 p.

1892 Outline of the Documentary History of the Zuñi Tribe. *Journal of American Ethnology and Archaeology* 3(1):1-115.

Burrus, Ernest J., S.J.
1965 *Kino and the Cartography of Northwestern New Spain.* Arizona Pioneers Historical Society, Tucson.

1971 *Kino and Manje, Explorers of Sonora, Their Vision of the Future, A Study of the Expeditions and Plans*. Sources and Studies for the History of the Americas, Vol. 10. St. Louis University and Jesuit Historical Institute, St. Louis, Missouri.

Carpenter, E.J., and Bransford, W.S.
1921 Soil Survey of the Benson Area, Arizona: Washington D.C., U.S. Department of Agriculture, Field Operations, Bureau of Soils, p. 247-280.

Central Arizona Paddlers Club
1992 Boating Survey of Arizona Rivers, Document distributed at ANSAC Meeting of April 13, 1993.

Chamberlain, William H.
1945 From Lewisburg to California in 1849. Edited by Lansing B. Bloom. *New Mexico Historical Review* 20 (1, 2, 3, 4):14-57, 144-180, 239-268, 336-357.

Christiansen, L.D.
1983 The Mormon batallion in Cochise County and adjacent areas. *The Cochise Quarterly 13.* 47 p.

Chronic, H.
1983 Roadside Geology of Arizona: Missoula, Montanta Press Publishing Co., 314 p.

Clarke, Asa B.
1852 *Travels in Mexico and California: Comprising a Journal of a Tour from Brazos Santiago through Central Mexico by Way of Monterrey, Chihuahua, the Country of the Apaces, and the Gila River to the Mining Districts of California.* Wright & Hasty's Steam Press, Boston. Reprint edited by Anne M. Perry published by Texas A&M Press, College Station, Texas, 1988.

Clarke, Dwight L.
1961 *Stephen Watts Kearny, Soldier of the West.* University of Oklahoma Press.

Cole, W.R.
1937 Dates of Floods in the San Pedro Valley, Arizona.

Conkling, Roscoe P., and Margaret B. Conkling
1947 *The Butterfield Overland Mail, 1857-1869.* 3 vols. Arthur H. Clark Co., Glendale.

Contzen, P.
1901 General Land Office survey notes, Books 935, 983, and 989: Microfiche on file at Bureau of Land Management, Phoenix.

Cooke, Philip St. George
1848 *Report of Lieut. Col. P. St. George Cooke of his March from Santa Fe, New Mexico to San Diego, Upper California.* In U.S. Engineer Dept. Notes of a Military Reconnaissance. U.S. 30th Cong. 1st Sess. House Exec. Doc. 41.

1938 Cooke's Journal of the March of the Mormon Battalion, 1846-1847. In *Exploring Southwest Trails, 1846-1854,* by Philip St. George Cooke, William Henry Chase Whiting, and Francois Xavier Aubry (Vol. VII of Southwest Historical Series), edited by Ralph P. Bieber in Collaboration with Averam B. Bender, pp. 65-240. Arthur H. Clark Co., Glendale.

1964 *The Conquest of New Mexico and California in 1846-1848.* Horn and Wallace, Albuquerque.

1974 Cooke's Journal of the March of the Mormon Battalion, 1846-1847. In *Exploring Southwest Trails, 1846-1854,* by Philip St. George Cooke, William Henry Chase Whiting, and Francois Xavier Aubry (Vol. VII of Southwest Historical Series), edited by Ralph P. Bieber in Collaboration with Averam B. Bender, pp. 65-240. Arthur H. Clark Co., Glendale (revised edition).

Cooke, Ronald U. and Richard W. Reeves
1976 Arroyos and environmental change in the American Southwest. Clarenden Press, Oxford. 213 p.

Cooke, Philip St. George
1938 Cooke's journal of the march of the Mormon Battalion, 1846-1847, In Bieber, R.P. (ed), Exploring Southwest Trails, 1846-1854: Glendale, California, Arthur H. Clark Company, Southwest Historical Series, v. 7, p. 65-240.

Cooke, R.U., and Reeves, R.W.
1976 Arroyos and environmental change: Oxford, Clarendon Press, Oxford Research Studies in Geography, 213 p.

Cooke, Ronald U. and Richard W. Reeves
1976 Arroyos and environmental change in the American Southwest. Clarenden Press, Oxford. 213 p.

Cox, Cornelius C.
1902 Reminiscences of C.C. Cox. *Southwestern Historical Quarterly* 6(2, 3):113-138, 204-235.

1925 *From Texas to California in 1849*, edited by Mabelle Eppart Martin. Southwestern Historical Quarterly 29 (1-3):36-50, 128-146, 201-223.

Damon, P.E., Lynch, D.J., Shafiqullah, M.
1984 Cenozoic landscape development in the Basin and Range province of Arizona, *In* Smiley, T.L., Nations, J.D., Pewe, T.L., and Shafer, J.P. (eds), Landscapes of Arizona: the Geological Story, p. 175-206: Lanham, MD, University Press of America.

Davis, Goode P.
1982 *Man and Wildlife in Arizona: The American Exploration Period, 1824-1865.* Arizona Fish and Wildlife Service in cooperation with the Arizona Cooperative Wildlife Research Unit. Somers Graphics, Scottsdale.

Day, A. Grove
1964 *Coronado's Quest: The Discovery of the Southwestern States.* University of California Press, Berkeley.

DeCook, K.J., D.K. Kreamer, S.B. Keith, S.F. Mack, and J.P. Hutton
1977 Surface Water Quality Monitoring, San Pedro River Basin, Arizona: A Report to the Arizona Department of Health Services, Bureau of Water Quality Control. Submitted by the Water Research Center, University of Arizona, Tucson, Arizona.

DiPeso, Charles C.
1951 *The Babocomari Village Site on the Babocomari River, Southeastern Arizona.* The Amerind Foundation 5. Dragoon, Arizona.

1953 *The Sobaipuri Indians of the Upper San Pedro River Valley, Southeastern Arizona.* The Amerind Foundation 6. Dragoon, Arizona.

1958 *The Reeve Ruin of Southeastern Arizona: A Study of a Prehistoric Western Pueblo Migration into the Middle San Pedro Valley.* The Amerind Foundation 8. Dragoon, Arizona.

Dobyns, Henry F.
1981 From Fire to Flood: Historic Human Destruction of Sonoran Desert Riverine Oases. Anthropological Papers No. 20. Ballena Press, Socorro, New Mexico.

DuBois, Susan M. and A.W. Smith
1980 The 1887 earthquake in San Bernardino Valley, Sonora: Historic accounts and intensity patterns in Arizona. Bureau of Geology and Mineral Technology, University of Arizona. Special Paper 3. 112 p.

Duffen, W.A.
1936 Development of Human Culture in the San Pedro River Valley, Arizona. Univ. of Arizona M.A. Thesis.

Durivage, John E.
1937 "Journal," In *Southern Trails to California in 1849*, Vol. V of Southwest Historical Series, edited by Ralph P. Bieber, pp. 159-255. Arthur H. Clark Co., Glendale.

Eaton, W. Clement
1933 Frontier Life in Southern Arizona, 1858-61. *Southwestern Historical Quarterly* 36(3):173-192.

Eberhardt, Sandra
1980 San Pedro River Basin Water Quality Status Report for Period 1973-1979.

Eccleston, Robert
1950 *Overland to California on the Southwestern Trail: 1849*. Edited by George P. Hammond and Edward H. Howes. University of California Press, Berkeley.

Eddy, Frank W., and Maurice E. Cooley
1983 *Cultural and Environmental History of Cienega Valley, Southeastern Arizona*. University of Arizona Press, Tucson.

Ely, L.L.
1992 Large Floods in the Southwestern United States in Relation to Late-Holocene Climate Variations: Tucson, University of Arizona, Ph.D. Dissertation, 326 p.

Emory, William Hensley
1848 *Notes of a Military Reconnoissance from Fort Leavenworth, in Missouri to San Diego in California, Including Parts of the Arkansas, Del Norte, and Gila Rivers*. 30th Cong., 1st Sess., Sen. Exec. Doc. 7, H.R. Ex. Doc. No. 41, Washington, D.C.

1857 *Report on the U.S. and Mexican Boundary Survey, Vols I-II*. U.S. 34th Congress, 1st Sess., Sen. Exec. Doc. 108, H.R. Exec. Doc. 135, Washington, D. C.

1857 Sketch of Territory Acquired by Treaty of December 30, 1853. In *Report on the U.S. and Mexican Boundary Survey, Vol I*, by William H. Emory, Chaper 6, Part 1:93-100.

1951 *Lieutenant Emory Reports: A Reprint on Lieutenant W.H. Emory's Notes of a Military Reconnoissance*. University of New Mexico Press, Albuquerque.

Evans, George W.B.
1945 *Mexican Gold Trail: The Journal of a Forty-Niner*. Edited by Glenn S. Dumke. Huntington Library, San Marino, California.

Evans, Henry R. and W.T. Lee
1921 *3rd Annual Report of U.S. Reclamation Services*. 157 ff p.

Ezell, Paul H.
1983 History of the Pima. In *Handbook of North American Indians, Volume 10, Southwest*, edited by Alfonso Ortiz, ppl 149-160. Smithsonian Institution, Washington, D.C.

Farish, Thomas Edwin
1915 *History of Arizona*, Vol. 1-8. The Filmer Brothers Electrotype Company, San Francisco.

Federal Committee on Ecological Reserves
1977 A Directory of Research Natural Areas on Federal Lands of the United States of America. USFS Forest Service, Washington, D.C.

Ferg, Alan
1977 *The Poor Canyon Scatter: A Cochise Site near Redington, Arizona*. Arizona State Museum Archaeological Series No. 114. University of Arizona, Tucson.

Finch, George Robert
1903 *The Life of a Pioneer*. Unpublished manuscript by early Arizona pioneer lived in San Pedro Valley and later operated ferry at Tempe.

Fischer, Al, and Mildred Fischer
1993 *Arizona Museums: Your Guide to Arizona's Treasures!* Golden West Publishers, Phoenix.

Fontana, Bernard L.
1983 Pima and Papago: Introduction. In *Handbook of North American Indians, Volume 10, Southwest*, edited by Alfonso Ortiz, pp. 125-136. Smithsonian Institution, Washington, D.C.

Forbes, R.H.
1919 *The Penningtons, Pioneers of Early Arizona*. Arizona Archaeology and Historical Society.

Franklin, Hayward Hoskins
1978 *The Second Canyon Ruin.* Unpublished Ph.D. Dissertation, Department of Anthropology, University of Arizona, Tucson.

1980 *Excavations at Second Canyon Ruin, San Pedro Valley, Arizona.* Arizona State Museum Contributions to Highway Salvage Archaeology in Arizona No. 60. University of Arizona, Tucson.

Franklin, Hayward H., and W. Bruce Masse
1976 The San Pedro Salado: A Case of Prehistoric Migration. *The Kiva* 42:47-56.

Freethey, G.W.
1982 *Hydrologic Analysis of the Upper San Pedro Basin from the Mexico-United States International Boundary to Fairbank, Arizona.* U.S. Geological Survey Open-File Report, 82-752, 64 p.

Fulton, Richard W.
1966 Milleville-Charleston, Cochise County, 1878-1889. *Journal of Arizona History* 7:9-22.

Fulton, Richard W. and Conrad J. Bahre
1967 Charleston, Arizona: A Documentary Reconstruction. *Arizona and the West* 9:41-64.

Fulton, William Shirley
1934 *Archaeological Notes on Texas Canyon, Arizona.* Contributions from the Museum of the American Indian, Heye Foundation 12(1-3). New York.

Fulton, William S., and Tuthill, Carr
1940 *An Archaeological Site near Gleeson, Arizona.* The Amerind Foundation 1. Dragoon, Arizona.

Gerald, R. E.
1975 *Drought Correlated Changes in Two Prehistoric Pueblo Communities in Southeastern Arizona.* Unpublished Master's Thesis, University of Chicago.

Gillilan, D.M.
1992 Institutional Alternatives for Managing Water Resources in the Upper San Pedro River Basin, Arizona. Univ. of Arizona M.S. Thesis, Dept. of Hydrology and Water Resources.

Gladwin, Winifred, and Harold S. Gladwin
1935 *The Eastern Range of the Red-on-Buff Culture.* Medallion Paper 16. Gila Pueblo, Globe, Arizona.

Glinski, R.L.
1977 An Introduction to the Raptors and Habitat of the San Pedro River. Arizona State University, Dept. of Zoology, Tempe, Arizona.

Goetzmann, William H.
1959 Army Exploration in the American West, 1803-1863. Yale Univeristy Press, New Haven, Conn., 509 p.

Golder, Frank Alfred, Thomas A. Bailey, and J. Lyman Smith
1928 *The March of the Mormon Battalion.* The Century Company, New York.

Graf, W.L.
1988 Fluvial Processes in Dryland Rivers: New York, Springer-Verlag, 346 p.

Graham, J.D.
1852 Report of the Secretary of War, Communicating, in Compliance with a Resolution of the Senate, the Report of Lieutenant Colonel Graham on the Subject of the Boundary Line between the United States and Mexico. U.S. 32nd Congress, 1st Sess., Sen. Exec. Doc. 121. A. Boyd Hamilton, Washington, D.C.

Granger, Byrd Howell
1985 *Will C. Barnes' Arizona Place Names.* The University of Arizona Press, Tucson.

1984 *Arizona's Names (X Marks the Place).* The Falconer Publishing Company, Tucson Arizona.

Gray, Andrew B.
1856 Survey of a Route for the Southern Pacific Railroad on the 32nd Parallel. Wrightson and Co., Printer, Cincinnati.

Greever, William S.
1957 Railway Development in the Southwest. *New Mexico Historical Review* 32(2):151-203.

Griffin, John S.
1943 *A Doctor Comes to California.* California Historical Society, San Francisco.

Griffiths, D.A.
1901 *Range Improvement in Arizona.* USDA Bureau of Plant Industry Bulletin 4. Government Printing Office, Washington, D.C.

Hackenburg, Robert A.
1983 Pima and Papago Ecological Adaptations. In *Handbook of North American Indians, Volume 10, Southwest,* edited by Alfonso Ortiz, pp. 161-177. Smithsonian Institution, Washington, D.C.

Hadley, Diana, Peter Warshall, and Don Bufkin
1991 *Environmental Change in Aravaipa, 1870-1970: An Ethoecological Survey.* Cultural Resource Series, No. 7. Arizona State Office, Bureau of Land Management, Phoenix.

Hamilton, Patrick
1884 *The Resources of Arizona.* Third edition. A. L. Bancroft and Company, Printers, San Francisco.

Hammack, Laurens C.
1970 Second Canyon Ruin. Ms. on file, Arizona State Museum, University of Arizona, Tucson.

1971 The Peppersauce Wash Project: A Preliminary Report on the Salvage Excavation of Four Archaeological Sites in the San Pedro Valley, Southeastern Arizona. Arizona State Museum, University of Arizona, Tucson. Submitted to the Arizona State Highway Department.

Hammond, George P.
1929 Pimaría Alta After Kino's Time. *New Mexico Historical Review* 4(3):220-238.

Harris, J.L.
1879 General Land Office survey notes, Books 721, 739, 752, 762, 763, 780, and 1474: Microfiche on file at Bureau of Land Management, Phoenix.

1877 General Land Office survey notes, Books 633, 672, 686, 698, 699, 733, and 1477: Microfiche on file at Bureau of Land Management, Phoenix.

Harris, Benjamin Butler
1960 *The Gila Trail: The Texas Argonauts and the California Gold Rush.* University of Oklahoma Press, Norman.

Hastings, James R.
1959a The Tragedy of Camp Grant in 1871. *Arizona and the West* 1(2):146-160.

1959b Vegetation Change and Arroyo Cutting in Southeastern Arizona. *Journal of the Arizona Academy of Science* 1:60-67.

Hastings, James Rodney, and Raymond M. Turner

1965 *The Changing Mile: An Ecological Study of Vegetation Change With Time in the Lower Mile of an Arid and Semiarid Region.* The University of Arizona Press, Tucson.

Hastings, J.R.

1959 Vegetation change and arroyo cutting in southeastern Arizona: Arizona Academy of Sciences, v. 1, p. 60-67.

Hastings, J.R., and Turner, R.M.

1965 The Changing Mile; An Ecological Study of Vegetation Change with Time in the Lower Mile of an Arid and Semiarid Region: Tucson, University of Arizona Press, 317

Haury, Emil W.

1953 Artifacts with Mammoth Remains, Naco, Arizona. *American Antiquity* 19:1-14.

1984 The Search for Chichilticale. *Arizona Highways* 60(4):14-19.

Haury, E., E.B. Sayles, and W.W. Wasley

1959 The Lehner Mammoth Site, Southeastern Arizona: American Antiquity, Vol. 25, p. 2-30.

Hayes, Benjamin

1850 Diary of Judge Benjamin Hayes. Ms. on file, Bancroft Library, University of California, Berkeley, and Arizona Historical Society, Tucson.

Haynes, C. V.

1981 Geochronology and Paleoenvironments of the Murray Springs Clovis Site, Arizona. *National Geographic Society Research Reports* 13:243-251.

1982 Archaeological Investigations at the Lehner Site, Arizona. *National Geographic Society Research Reports* 14:325-334.

Haynes, C. V., Jr.

1987 Curry Draw, Cochise County Arizona: A late Quaternary stratigraphic record of Pleistocene extinction and paleo-Indian activities: Geological Society of America Field Guide, p. 23-38.

Heindl, L.A.

1952 Upper San Pedro basin (groundwater), In Ground Water in the Gila River Basin and Adjacent Areas - A Summary: Tucson, U.S. Geological Survey Open-file Report, pp. 69-86.

1952 Lower San Pedro basin (groundwater):In Ground Water in the Gila River Basin and Adjacent Areas - A Summary: Tucson, U.S. Geological Survey Open-file Report, pp. 87-100.

Hemmings, E. T.
1970 *Early Man in the San Pedro Valley, Arizona.* Unpublished Ph.D. Dissertation, University of Arizona, Tucson.

Hemmings, E. T., and C. V. Haynes, Jr.
1969 The Escapule Mammoth and Associated Projectile Points, San Pedro Valley, Arizona. *Journal of the Arizona Academy of Science* 5(3):184-188.

Hendrickson, D.A., and Minckley, W.L
1985 Cienegas - vanishing climax communities of the American Southwest, Desert Plants, vol. 6, p. 130-175: Tucson, University of Arizona Press.

Herbert, Harold E., and Erick Campbell
1986 Time Line/Social History of the Upper San Pedro River Valley (1540 through 1986). Ms. on file, Cochise County Historical and Archaeological Society, Douglas, Arizona.

Hereford, Richard
1991 Geomorphic evolution of the San Pedro River channel since 1900 in the San Pedro River Riparian National Conservation Area, southeast Arizona. U.S. Geological Survey Open-File Report 91.

1993 Entrenchment and Widening of the Upper San Pedro River, Arizona. Geological Society of Arizona Special Paper 282. Geological Society of America, Boulder, Colorado.

Hereford, R. and J. Betancourt
1993 Historic Geomorphology of the San Pedro River: Archival and Physical Evidence, in Haynes, C.V. and B.M. Huckell, "Spunge and Clovis Hunters of the San Pedro Valley," University of Arizona Press, Tucson, Arizona.

Hereford, R., and J.L. Betancourt
1993 Historic geomorphology of the San Pedro River: archival and physical evidence, *In* Haynes, C.V. and Huckell, B. (eds), The First Arizonans: Clovis Occupation of the San Pedro Valley, Manuscript in preparation.

Hevly, R. H., and Paul S. Martin
1961 Geochronology of Pluvial Lake Cochise, Southern Arizona: Pollen Analysis of Shore Deposits. *Journal of the Arizona Academy of Science* 32:168-185.

Hine, Robert V.
1968 *Bartlett's West:Drawing the Mexican Boundary*. Yale University Press, New Haven and London.

Hinton, R.J.
1878 Handbook of Arizona.

Hirschboek, K.K.
1985 Hydroclimatology of Flow Events in the Gila River Basin, Central and Southern Arizona: Tucson, University of Arizona, Unpublished Ph.D. Dissertation, 335 p.

Hodge, Frederick Webb
1933 Introduction. In *The Journey of Francisco Vázquez de Coronado, 1540-1542*, by George P. Winship, pp. i-xxvii. Grabhorn Press, San Francisco.

Hodge, Frederick Webb, and Theodore H. Lewis, editors
1907 The Narrative of the Expedition of Coronado, by Pedro de Castaneda. In *Spanish Explorers in the Southern United States, 1528-1543.* Charles Scribner's Sons, New York.

Hodge, Hiram C.
1877 *Arizona As It Is*. Hurd & Houghton, New York.

Hoffman, Michael Howard
1982 *The Role of Intermittent Rivers and Streams in the National Wild and Scenic Rivers System.* National Park Service and University of Arizona.

Huckleberry, G.
1993 Historical Changes on the San Pedro River, Arizona. Manuscript prepared for CH2M HILL on behalf of the Arizona State Land Department. Not published.

1993 Late-Holocene Stream Dynamics on the Middle Gila River, Pinal County, Arizona: Tucson, University of Arizona, Ph.D. Dissertation, 135 p.

Hunter, William H.
n.d. Transcript of a Diary-Journal of Events, Etc. on a Journey from Missouri to California in 1849. Ms. Special Collections, University of Arizona Library, Tucson, Arizona.

Hutton, N.H.
1859 Engineers Report--El Paso and Fort Yuma Wagon Road. In Records of the Office of the Secretary of the Interior Relating to Wagon Roads, 1857-1881. Nation. Archives film microcopies, M-95, roll 3.

1859 *Report of Superintendent James B. Leach upon the El Paso and Fort Yuma Wagon Road Constructed under the Direction of the Department of the Interior, 1857-1858.* House Ex. Doc. 108-107. Government Printing Office, Washington, D.C.

Hvorek, Pamela

1981 Typewritten transcript of oral history interview with Ms. Clara Curtis Kimball, 1890- , lifetime San Pedro Valley resident, on July 23, 1981.

International Boundary and Water Commission, U.S. and Mexico

1972 Flow of the Colorado River and other Western Boundary Streams and Related Data: Colorado River, Tijuana River, Santa Cruz River, Whitewater Draw, San Pedro River. Western Water Bulletin, 98 p.

Irwin-Williams, Cynthia

1979 Post-Pleistocene Archeology, 7000-2000 B.C. In *Southwest,* edited by Alfonso Ortiz, pp. 31-42. Handbook of North American Indians, vol. 9, William G. Sturtevant, general editor. Smithsonian Institution, Washington, D.C.

Jackson, William L.

1987 *Assessment of Water Condition and Management Opportunities in Support of Riparian Values: BLM San Pedro River Properties, Arizona.* Project Completion Report. U.S. Department of the Interior, BLM, Denver.

Johnson, N.M., Opdyke, N.D., and Lindsay, E.H.

1975 Magnetic polarity stratigraphy of Pliocene-Pleistocene terrestial deposits and vertebrate faunas, San Pedro Valley, Arizona: Geological Society of America Bulletin, vol. 86, p. 5-12.

Johnston, A.R.

1848 Journal of Captain A.R. Johnston, 1st Dragoons: 30th Congress, 1st Session, House Executive Document No. 41.

Judge, W. J.

n.d. Early Man: Plains and Southwest - An Interpretive Summary of the Paleo-Indian Occupation of the Plains and Southwest. In *Environment, Origins, and Population. Environment, Origins, and Population.* Handbook of North American Indians, vol. 3, William G. Sturtevant, general editor. Smithsonian Institution, Washington, D.C.

Karns, H.J.

1954 *Unknown Arizona and Sonora 1693-1721.* (Luz de Tierra Incognita by Captain Juan Mateo Manje), Part II. Arizona Silhouettes, Tucson.

Kayser, David W.
1968 Survey of the Proposed Charleston Dam and Reservoir, Southeastern Arizona. Ms. on file, Arizona State Museum, University of Arizona, Tucson.

Keith, S.J.
1978 Ephemeral Flow and Water Quality Problems - A Case Study of the San Pedro River in Southeastern Arizona. Hydrology and Water Resources in Arizona and the Southwest. Vol. 8, No. 3, p. 42-50.

Kessell, John L.
1966a Peaceful Conquest in Southern Arizona. In *Father Kino in Arizona*, by Fay Jackson Smith, John L. Kessell, and Francis J. Fox, S.J, pp. 53-95. Phoenix Historical Foundation, Phoenix.

1966b The Puzzling Presidio: San Phelipe de Guevavi, Alias Terrenate. *New Mexico Historical Review 41*:21-46.

1976 *Friars, Soldiers, and Reformers: Hispanic Arizona and the Sonora Mission Frontier, 1767-86*. University of Arizona Press, Tucson.

Knighton, D.
1984 Fluvial Forms and Processes: London, Edward Arnold (Publishers), Ltd., 218 p.

Kottlowski, F., Cooley, M.E., and Ruhe, R.
1965 Quaternary geology of the Southwest, *In* Wright, H.E., and Frey, D.G. (eds), The Quaternary of the United States: Princeton, Princeton University Press, p. 287-298.

Leach, James B.
1858 Itinerary of the El Paso and Fort Yuma Wagon Road Expedition under the Superintendence of James B. Leach. 1858. Film Microcopies of Records in the National Archives, No. M-95, Roll 3. "Records of the Office of the Secretary of the Interior relating to Wagon Roads, 1857-1881."

Leach, J.B.
1858 Itinerary of the El Paso and Fort Yuma Wagon Road Expedition. National Archives Film Microcopies, No. M95, Roll 3.

Lee, W.T.
1905 Notes on the Underground Water of the San Pedro Valley, Arizona. U.S. 58th Congress, 3rd Session, House Document 28, 2nd Edition. Washington, D.C., p. 165-170.

Lensink, Stephen C.
1976 *An Archaeological Survey of the West Coast/Mid-Continent Pipeline Project, El Paso Natural Gas Company*. Arizona State Museum Archaeological Series No. 105. University of Arizona, Tucson.

Leopold, L.B.
1951 Vegetation of the southwestern watersheds in the nineteenth century: Geographical Review, vol. 41, p. 295-316.

Leopold, L.B., and Bull, W.B.
1979 Base level, aggradation, and grade: Proceedings of the American Philosophical Society, vol. 123, p. 168-202.

Leopold, L.B., and Wolman, M.G.
1957 River channel patterns: braided, meandering and straight: U.S. Geological Survey Professional Paper 282B, p. 39-85.

Mackin, J.H.
1948 Concept of a graded river: Geological Society of America Bulletin, vol. 59, p. 463-512.

Madsen, John H., and James M. Bayman
1989 An Archaeological Survey of Kartchner Caverns State Park. Ms. on file, Arizona State Museum, University of Arizona, Tucson.

Mann, Dean E.
1963 *The Politics of Water in Arizona*. University of Arizona Press, Tucson.

Masse, W. Bruce
1980 The Hohokam of the Lower San Pedro Valley and the Northern Papagueria: Continuity and Variability in Two Regional Populations. In *Current Issues in Hohokam Prehistory*, edited by David E. Doyel and Fred Plog, pp. 205-223. Arizona State University Anthropological Research Paper No. 23. Tempe.

Mattison, R.H.
1946 Early Spanish and Mexican settlements in Arizona. *New Mexico Historical Review 21*: 282, 286, 288-289.

McClintock, James
1916 *Arizona: Prehistoric-Aboriginal, Pioneer-Modern*, Vol. I and II. S. J. Clark Publishing Co., Chicago.

McClintock, J.H.
1921 Mormon settlement in Arizona. Manufacturing Stationers, Phoenix.

Melton, M.A.
1965 The geomorphic and paleoclimatic significance of alluvial deposits in southern Arizona: Journal of Geology, vol. 73, p. 1-38.

Menges, C.M. and Pearthree, P.A.
1989 Late Cenozoic tectonism in Arizona and its impact on regional landscape evolution. In Jenney, J.P., and Reynolds, S.J. (eds), Geologic Evolution of Arizona: Arizona Geological Society Digest 17, p. 649-680.

Meyer, D.F.
1989 The significance of sediment transport in arroyo development: U.S. Geological Survey Water-Supply Paper 2349.

Montgomery, E.L.
1963 The Geology and Ground Water Investigation of the Tres Alamos Dam Site Area of the San Pedro River, Cochise County, Arizona. Univ. of Arizona M.S. Thesis, 61 p.

Morrison, R.B.
1985 Pliocene/Quaternary geology, geomorphology, and tectonics of Arizona, *In* Weide, D. (ed), Soils and Quaternary Geology of the Southwestern United States: Geological Soceity of America Special Paper 203, p. 123-146.

Myrick, David F.
1968 Brief Survey of the Histories of Pioneer Arizona Railroads.

1975 *Railroads of Arizona, Vol. I: the Southern Roads.* Howell-North Books, Berkeley, California.

National Park Service
1991 *National Trail Study, Environmental Assessment, Coronado Expedition: Arizona/New Mexico/Texas/Oklahoma/Kansas.* United State Department of the Interior, National Park Service, Denver Service Center.

Newell, F. H.
1904 *Annual Report of Reclamation Service 1902-03.*

North American Commision on Stratigraphic Nomenclature
1983 North American stratigraphic code: American Association of Petroleum Geologists Bulletin, vol. 67, p. 841-875.

Officer, James E.
1987 *Hispanic Arizona, 1536-1856.* University of Arizona Press, Tucson.

Ogle, Ralph Hedrick
1970 *Federal Control of the Western Apaches, 1848-1886.* (Reprint, 1940 edition) University of New Mexico Press, Albuquerque.

Olmstead, F.H.
1919 Gila River flood control: a report on floods of the Gila River in Graham County, Arizona: U.S. 65th Congress, 3d Session, Document 436, 94 p.

Oppenheimer, J.M., and Sumner, J.S.
1980 Depth-to-Bedrock Map, BAsin and Range Province, Arizona: Tucson, Laboratory of Geophysics, University of Arizona, (scale 1:1,000,000).

Ormsby, Waterman L.
1962 *The Butterfield Overland Mail,* edited by Lyle H. Wright and Josephine M. Bynum. The Huntington Library, San Marino, California.

Owen-Joyce, S.J. and Bell, C.K.
1983 Appraisal of Water Resources in teh Upper Verde RIver rea, Yavapai and Coconino Counties. Arizona Department of Water Resources Bulletin No. 2. 219 p.

Page, H.G.
1963 *Water Regimen of the Inner Valley of the San Pedro River near Mammoth, Arizona (A Pilot Study).* U.S. Geological Survey Water-Supply Paper 1669-I, 22 p.

Pancoast, Charles
1930 *A Quaker Forty-Niner:The Adventures of Charles Edward Pancoast on the American Frontier*, edited by Anna Paschal Hannum. University of Pennsylvania Press, Philadelphia.

Parke, J.G.
1857 Report of explorations for railroad routes. In Explorations and surveys to ascertain the most practicable and economical route for a railroad from the Mississippi River to the Pacific Ocean. U.S. 33rd Congress, 2nd Session, Senate Executive Document 78, Vo. 7: 1-469.

Parke, John G.
1857 Report of the Explorations for That Portion of a Railroad Route, Near the Thirty-Second Parallel of North Latitude, Lying Between Dona Ana, on the Rio Grande and Pimas Villages, on the Gila, by Lt. John G. Parke. In *Reports of Explorations and Surveys, to Ascertain the Most Practicable and Economic Route for a Railroad from the Mississippi River to the Pacific Ocean.* Vol. II, 33rd Cong., 2nd Sess., Senate Exec. Doc. No. 78 (Serial No. 759). Beverly Tucker, Printer, Washington, D.C. (1855), and Vol. VII, Part I, No. 2, 33rd Cong, 2nd Sess, Senate Exec. Doc. No. 78 (Serial No. 764). Beverley Tucker, Printer, Washington, D.C. (1857).

1857 Report of Explorations for Railroad Routes from San Francisco Bay to Los Angeles, California, West of the Coast Range, and from the Pimas Villiages on the Gila to the Rio Grande, near the 32nd Parallel of North Latitude, in *Pacific Railroad Reports*, 7, Pt. I, pp. 19-42. Volume VII of Reports of Explorations and Surveys. U.S. Congress, House Exec. Doc. 91, 2nd session. A.D.P. Nicholson, Washington, D.C.

Pattie, J.O.
1905 The personal narrative of James O. Pattie. In Volume 18, Early western travels, 1748-1846. R.G. Thwaites (ed). Arthur H. Clarke Co., Cleveland, 379 p.

Pattie, James Ohio
1883 *The Personal Narrative of James O. Pattie of Kentucky*, edited by Timothy Flint. E.H. Flint, Cincinnati.

Pearthree, M.S., and Baker, V.R.
1987 Channel change along the Rillito Creek System of southeastern Arizona, 1941 through 1983; Implications for flood-plain management: Arizona Geological Survey Special Paper 6, 58 p.

Phillips, David A., Jr., Mark C. Slaughter, and Susan B. Bierer
1993 *Archaeological Studies at Kartchner Caverns State Park, Cochise County, Arizona.* SWCA Archaeological Report No. 93-26. SWCA, Inc., Tucson. Submitted to Arizona State Parks, Phoenix.

Powell, H.M.T.
1931 *The Santa Fe Trail to California, 1849-1852: The Journal and Drawings of H.M.T. Powell*, edited by Douglas S. Watson. Book Club of California, San Francisco.

Powell, Lawrence Clark
1980 *Where Water Flows: The Rivers of Arizona.* Northland Press, Flagstaff.

Putnam, F., et al.
1987 *Water Resources of the Upper San Pedro River Basin, Arizona.* Arizona Department of Water Resources.

Reichardt, K.L., B. Schladweiler, and J.L. Sterling
1978 An Inventory of Riparian Habitats Along the San Pedro River. University of Arizona Office of Arid Lands Studies, Tucson, Arizona, 23 p.

Reynolds, S.J.
1988 Geologic Map of Arizona: Arizona Geological Survey Map 26, scale 1:1,000,000.

Richards, K.
1982 Rivers, Form and Process in Alluvial Channels: London, Methuen and Co., Ltd., 358 p.

Richardson, Rupert N.
1925 Some Details of the Southern Overland Mail. *Southwestern Historical Quarterly* 24(1):1-18.

Riley, Carroll L.
1985 The Location of Chichilticale. In *Southwestern Culture History: Collected Papers in Honor of Albert H. Schroeder*, edited by Charles H. Lange, pp.153-162. Papers of the Archaeological Society of New Mexico, No. 10. Ancient City Press, Santa Fe.

Ritter, D.F.
1986 Process Geomorphology, 2nd Edition: Dubuque, IA, William C. Brown Publishers, 579 p.

Rodgers, W.M.
1965 Historical Land Occupance of the Upper San Pedro Valley Since 1870: Tucson, University of Arizona, M.A. Thesis, 167 p.

Roeske, R.H. and W.L. Werrell
1971 *Hydrologic Conditions in the San Pedro Valley, Arizona.* U.S. Geological Survey and Arizona Water Commission Bulletin 4, Phoenix, Arizona: Arizona Water Commission, 76 p.

Russell, Frank
1908 *The Pima Indians.* 26th Annual Report of the Bureau of American Ethnology. Washington, D.C.

San Manuel Copper Corporation.
1955 *San Manuel.* San Manuel Copper Corporation, Arizona. (no publisher).

San Pedro Interdisciplinary Study Team
1991 *A Study of Water Resources of San Pedro Basin and Options for Efficient-Equitable Water Management.* Water Resources Research Center.

Sauer, Carl Ortwin
1932 The Road to Cibola. *Ibero-Americana* 3. University of California Press, Berkeley.

1937 The Discovery of New Mexico Reconsidered. *New Mexico Historical Review* 12(3):270-287.

Sauer, Carl, and Donald Brand
1930 *Pueblo Sites in Southeastern Arizona.* University of California Publications in Geography Vol. 7, No. 3.

Sayles, E. B.
1945 *The San Simon Branch: Excavations at Cave Creek and in the San Simon Valley, Volume 1: Material Culture.* Medallion Paper 34. Gila Pueblo, Globe, Arizona.

1983 *The Cochise Cultural Sequence in Southeastern Arizona.* Anthropological Papers of the University of Aizona No. 42. University of Arizona Press, Tucson.

Schroeder, Alfred H.
1953 The Problem of Hohokam, Sinagua, and Salado Relations in Southern Arizona. *Plateau* 26(2):75-83.

Schroeder, Albert H.
1955 Fray Marcos de Niza, Coronado and the Yavapai. *New Mexico Historical Review* 30(4):265-296.

1956 Fray Marcos de Niza, Coronado and the Yavapai. *New Mexico Historical Review* 31(1):24-37.

Schumm, S.A.
1977 The Fluvial System: New York, John Wiley and Sons, 338 p.

Sellers, W.B., and Hill, R.H.
1974 Arizona Climate 1931-1972, 2nd Edition: Tucson, University of Arizona Press, 616 p.

Sellers, W.D.
1960 Precipitation Trends in Arizona and New Mexico, Proc. 28th Annual Snow Conference, pp. 81-94.

Seymour, Deni J.

1988 Sobaipuri Settlement Along the Upper San Pedro River Valley, Arizona. Paper presented at the 53rd annual meeting of the Society for American Archaeology, Phoenix.

1989 The Dynamics of Sobaipuri Settlement in the Eastern Pimeria Alta. *Journal of the Southwest* 31:205-222.

1993 In Search of the Sobaipuri Pima: Archaeology of the Plain and Subtle. *Archaeology in Tucson* 7(1):1-4.

Shafiqullah, M., Damon, P.E., Lynch, D.J., Reynolds, S.J., Rehrig, W.A., and Raymond, R.H.

1980 K-Ar geochronology and geologic history of southwestern Arizona and adjacent areas. *In* Jenney, J.P., and Stone, C. (eds.), Studies in Western Arizona: Arizona Geological Society Digest. vol. 12, p. 201-260.

Smith, D.G.

1963 Pleistocene Geology and Geomorphology of the San Pedro River Valley, Cochise County, Arizona. Univ. of Arizona M.S. Thesis.

Smith, Fay Jackson, John L. Kessell, and Francis J. Fox

1966 *Father Kino in Arizona.* Arizona Historical Foundation, Phoenix.

Smith, L.P. and Stockton, C.W.

1981 Reconstructed Stream Flow for the Salt and Verde Rivers from Tree-Ring Data. Water Resources Bulletin, Vol. 17, #6 pp 939-947.

Stetson Engineers

1988 The Interrelationships of Basin Ground Water and Surface and Subsurface Flow of the San Pedro River Basin, Arizona. Report to the U.S. Department of Justice. October 2, 1987, 28 p. plus appendixes.

Stockton, C.W.

1975 Long term streamflow records reconstructed from tree rings, Laboratory for Tree Ring Research Paper No. 5: Tucson, University of Arizona Press.

Stone, Jerome

1941 The History of Fort Grant. University of Arizona M.S. Thesis.

Teague, Lynn S.

1974 *The Archaeological Resources of the Winkelman and Black Hills Unit of the Bureau of Land Management.* Arizona State Museum Archaeological Series No. 47. University of Arizona, Tucson.

Tevis, James H.
1954 *Arizona in the '50s*. University of New Mexico Press, Albuquerque.

Thomas, Alfred Barnaby
1932 *Forgotten Frontiers: A Study of the Spanish Indian Policy of Don Juan Bautista de Anza, Governor of New Mexico, 1777-1787.* University of Oklahoma Press, Norman.

1941 *Teodoro de Croix and the Northern Frontier of New Spain, 1776-1783.* University of Oklahoma Press, Norman.

Thompson, William
1895 Beset in Aravaipa Canyon. *Lippincott's Monthly Magazine* 60 (June 1895):845-851.

Tiller, Kerry S.
1982 Charleston townsite revisited. *Journal of Arizona History 23.* 242-248.

Tiller, Kerry S.
1982 Charleston Townsite Revisited. *Journal of Arizona History* 23:242-248.

Trischka, C.
1933 Hohokam: A Chapter in the History of the Red-on-Buff Culture. *Scientific Monthly* 37:417-433.

Turner, Samuel F.
1961 *Water Resources of the Benson Area.* Turner and Associates, Consulting Geologists and Engineers, Phoenix, Arizona.

Turner, Samuel F.
None *Water Resources of the Cascabel Area.*

Tuthill, Carr
1947 *The Tres Alamos Site on the San Pedro River, Southeastern Arizona.* The Amerind Foundation 4. Dragoon, Arizona.

1950 Notes on the Dragoon Complex. In *For the Dean, Essays in Anthropology in Honor of Byron Cummings*, edited by E. Reed and D. King, pp. 51-61. Southwestern Monuments Association, Santa Fe.

Tuan, Y.
1962 Structure, climate, and basin landforms in Arizona and New Mexico: Associatin of American Geographers Annals, vol. 52, p. 51-68.

Tyler, D. S.
1881 *A Concise History of the Mormon Battalion in the Mexican War.* The Rio Grande Press, Chicago (1964 Reprint).

Udall, Stewart L.
1984 In Coronado's Footsteps. *Arizona Highways Magazine* 60(4)[April]:1-13, 20-49.

1987 *To the Inland Empire: Coronado and Our Spanish Legacy.* Doubleday, Garden City, New York.

Undreiner, George J.
1947 Fray Marcos de Niza and his Journey to Cibola. *The Americas* 7(4):415-486.

U.S. Bureau of Land Management
1987 *(Draft) Assessment of Water Conditions and Management Opportunities in Support of Riparian Values, San Pedro River.* U.S. Department of Interior, Bureau of Land Management, Denver, Colorado.

U.S. Bureau of Reclamation
1974 *San Pedro - Santa Cruz Project, Arizona, Concluding Report.* U.S. Department of the Interior, Bureau of Reclamation.

U.S. Department of Agriculture
1940 *Water Facilities Area Plan for Upper San Pedro Watershed, Arizona.* Water Utilization Section, Division of Land Economics, Department of Agriculture.

U.S. Department of Agriculture - Soil Conservation Service
1977 Santa Cruz-San Pedro River Basin, Arizona, Main Report and Resource Inventory. U.S. Government Printing Office, Washington, D.C. p. 1-24- and 1-323.

U.S. Department of Health Services
\- *Upper Gila and San Pedro River Basins Water Quality and Study Report and Recommendations.* Bureau of Water Control, Arizona.

U.S. Department of the Interior
1988 San Pedro River Riparian Management Plan and Environmental Impact Statement, Draft. Bureau of Land Management, Safford District.

U.S. Department of the Interior-Fish and Wildlife Service
1978 Unique Wildlife Ecosystems of Arizona, US F&W, Region II, Albuquerque, New Mexico, 47 p.

U.S. Geological Survey
1901 Twenty-first Annual Report of the U.S. Geological Survey to the Secretary of the Interior, 1899-1900: Part IV - Hydrography. Government Printing Office, Washington, D.C.

1914 Surface Water Supply of the United States, 1912, Part IX: Colorado River Basin. US Geological Survey Water Supply Paper 329. Washington, D.C.

1950 Water Supply Paper No. 1103, *Use of Water by Bottom-Land Vegetation.* Lower Safford Valley, Arizona.

1954 Compilation of Records of Surface Waters of the United States Through September 1950, Part 9: Colorado River Basin. U.S. Geological Survey Water Supply Paper 1313, Washington, D.C.

1991 Basin Characteristics and Streamflow Statistics in Arizon as of 1989. USGS Water Resources Investigations Report 91-4041. Prepared in cooperation with ADWR and FCDMC.

U.S. War Department, Surgeon General's Office
1870 *A Report on Barracks and Hospitals, With Descriptions of Military Posts.* U.S. Government Printing Office, Washington, D.C.

University of Arizona
1961 *Suspended Sediment and Chemical Analysis of the San Pedro River at Charleston, Arizona.* Agricultural Experiment Station, University of Arizona.

Varney, Philip
1980 *Arizona's Best Ghost Towns: A Practical Guide by Philip Varney.* Northland Press, Flagstaff.

Vionnet, L.B.
1992 Modeling of the Ground-Water Flow and Surface Water/Ground-Water Interactions of the San Pedro River Basin, Cochise County, Arizona. Univ. of Arizona M.S. Thesis, Dept. of Hydrology and Water Resources.

Wagoner, Jay J.
1975 *Early Arizona: Prehistory to Civil War.* The University of Arizona Press, Tucson, Arizona.

Walker, Henry P., and Don Bufkin
1986 *Historical Atlas of Arizona.* Second edition. University of Oklahoma Press, Norman.

Wallace W. Elliot & Co.
1884 *History of Arizona Territory Showing its Resources and Advantages with Illustrations: Descriptive of its Scenery, Residences, Farms, Mines, Mills, Hotels, Business, Houses, Schools, Churches, Etc.* Wallace W. Elliot & Co., Publishers, San Francisco.

Waters, Michael R.
1986 The Geoarchaeology of Whitewater Draw, Arizona. Anthropological Papers of the University of Arizona No. 45. University of Arizona Press, Tucson.

Waters, M.R.
1988 The impact of fluvial processes and landscape evolution on archaeological sites and settlement patterns along the San Xavier reach of the Santa Cruz River, Arizona: Geoarchaeology, An International Journal, Vol 3, p. 205-219.

Webb, R.H.
1985 Late Holocene flooding on the Escalante River, south central Utah: Tucson, University of Arizona Ph.D. Dissertation.

Webb, R.H., and Betancourt, J.L.
1992 Climatic variability and flood frequency of the Santa Cruz River, Pima County, Arizona: U.S. Geological Survey Water Supply Paper 2379, 40 p.

Whalen, Norman M.
1971 *Cochise Culture Sites in the Central San Pedro Drainage, Arizona.* Unpublished Ph.D. dissertation, University of Arizona, Tucson.

1979 Prehistoric Sites and Activities in the Dragoon-San Pedro Area of Southeastern Arizona. Ms. on file, Museum of Northern Arizona, Flagstaff.

White, T.
1881 General Land Office survey notes, Book 889: microfiche on file at Bureau of Land Management, Phoenix.

1873 General Land Office survey notes, Books 804, 811, 845: microfiche on file at Bureau of Land Management, Phoenix.

Wilken, D.E., and Galante, J.C.
1987 Land Use History: Upper San Pedro River Valley. U.S. Department of the Interior, Bureau of Land Management, Arizona State Office.

Williams, Jack S.
1986 The Presidio of Santa Cruz de Terrenate: A Forgotten Fortress of Southern Arizona. *The Smoke Signal*, nos. 47 and 48 (combined). Tucson Corral of the Westerners.

Winship, George Parker

1896 The Coronado Expedition. In *Fourteenth Annual Report of the Bureau of American Ethnology, Smithsonian Institution, for the Years 1892-1893*, Part 1, pp. 329-613. Smithsonian Institution, Washington.

Wolman, M.G., and Gerson, R.

1978 Relative scales of time and effectiveness of climate in watershed geomorphology: Earth Surface Processes, vol. 3, p. 189-208.

Wyllys, Rufus K.

1931 Padre Luís Velarde's Relación of Pimería Alta, 1717. *New Mexico Historical Review* 6(2) [April]:111-157.

Zarbin, Earl

n.d. Index to Water-Related Articles in Early Central Arizona Newspapers, 1859 thru 1918. Ms. on file with the author and Mary Lu Moore, Historian, Arizona State Attorney General's Office, Phoenix.

Appendix A
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Agency Contact List

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1970 *Cultural Implications from the Statistical Analysis of a Prehistoric Lithic Site in Arizona.* Unpublished Master's Thesis, Department of Anthropology, University of Arizona, Tucson.

1978 Cultural Implications from the Distributional Analysis of a Lithic Site, San Pedro Valley. In *Discovering Past Behavior: Experiments in the Archaeology of the American Southwest*, edited by P. Grebinger, pp. 55-71. Gordon and Breach, New York.

Altschul, Jeffrey H.

1992 The Formative Period in the San Pedro River Valley. Paper presented at the 17th Simposio de Historia y Antropología de Sonora, Hermosillo.

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1990 *Settlement Trends in the Middle San Pedro Valley: A Cultural Resources Sample Survey of the Fort Huachuca Military Reservation.* Statistical Research Technical Series No. 19. Tucson.

Bandelier, Adolf F.

1892 *Final Report of Investigations Among the Indians of the Southwestern United States, Carried on Mainly in the Years from 1880-1885.* Papers of the Archaeological Institute of America, American Series 3 and 4. John Wilson and Son, Cambridge.

Breternitz, Cory D.

1978 *An Archaeological Survey of the Continental Copper Company 69 and 115 KV Transmission Line in the Lower San Pedro Valley, Arizona.* Arizona State Museum Archaeological Series No. 121. University of Arizona, Tucson.

Bronitsky, Gordon, and James D. Merritt

1986 *The Archaeology of Southeast Arizona: A Class I Cultural Resource Inventory.* Cultural Resource Series Monograph No. 2. Bureau of Land Management, Arizona State Office, Phoenix.

DiPeso, Charles C.

1951 *The Babocomari Village Site on the Babocomari River, Southeastern Arizona.* The Amerind Foundation 5. Dragoon, Arizona.

1953 *The Sobaipuri Indians of the Upper San Pedro River Valley, Southeastern Arizona.* The Amerind Foundation 6. Dragoon, Arizona.

1958 *The Reeve Ruin of Southeastern Arizona: A Study of a Prehistoric Western Pueblo Migration into the Middle San Pedro Valley.* The Amerind Foundation 8. Dragoon, Arizona.

Eddy, Frank W., and Maurice E. Cooley
1983 *Cultural and Environmental History of Cienega Valley, Southeastern Arizona.* University of Arizona Press, Tucson.

Ferg, Alan
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Franklin, Hayward Hoskins
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Franklin, Hayward H., and W. Bruce Masse
1976 The San Pedro Salado: A Case of Prehistoric Migration. *The Kiva* 42:47-56.

Fulton, William Shirley
1934 *Archaeological Notes on Texas Canyon, Arizona.* Contributions from the Museum of the American Indian, Heye Foundation 12(1-3). New York.

Fulton, William S., and Tuthill, Carr
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Gerald, R. E.
1975 *Drought Correlated Changes in Two Prehistoric Pueblo Communities in Southeastern Arizona.* Unpublished Master's Thesis, University of Chicago.

Gladwin, Winifred, and Harold S. Gladwin
1935 *The Eastern Range of the Red-on-Buff Culture.* Medallion Paper 16. Gila Pueblo, Globe, Arizona.

Hammack, Laurens C.
1970 Second Canyon Ruin. Ms. on file, Arizona State Museum, University of Arizona, Tucson.

1971 The Peppersauce Wash Project: A Preliminary Report on the Salvage Excavation of Four Archaeological Sites in the San Pedro Valley, Southeastern Arizona. Arizona State Museum, University of Arizona, Tucson. Submitted to the Arizona State Highway Department.

Haury, Emil W.
1953 Artifacts with Mammoth Remains, Naco, Arizona. *American Antiquity* 19:1-14.

Haury, Emil W., E. B. Sayles, and W. W. Wasley
1959 The Lehner Mammoth Site, Southeastern Arizona. *American Antiquity* 25:2-30.

Haynes, C. V.
1981 Geochronology and Paleoenvironments of the Murray Springs Clovis Site, Arizona. *National Geographic Society Research Reports* 13:243-251.

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Hemmings, E. T.
1970 *Early Man in the San Pedro Valley, Arizona.* Unpublished Ph.D. Dissertation, University of Arizona, Tucson.

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1969 The Escapule Mammoth and Associated Projectile Points, San Pedro Valley, Arizona. *Journal of the Arizona Academy of Science* 5(3):184-188.

Hevly, R. H., and Paul S. Martin
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Irwin-Williams, Cynthia
1979 Post-Pleistocene Archeology, 7000-2000 B.C. In *Southwest*, edited by Alfonso Ortiz, pp. 31-42. Handbook of North American Indians, vol. 9, William G. Sturtevant, general editor. Smithsonian Institution, Washington, D.C.

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Lensink, Stephen C.
1976 *An Archaeological Survey of the West Coast/Mid-Continent Pipeline Project, El Paso Natural Gas Company*. Arizona State Museum Archaeological Series No. 105. University of Arizona, Tucson.

Madsen, John H., and James M. Bayman
1989 An Archaeological Survey of Kartchner Caverns State Park. Ms. on file, Arizona State Museum, University of Arizona, Tucson.

Masse, W. Bruce
1980 The Hohokam of the Lower San Pedro Valley and the Northern Papagueria: Continuity and Variability in Two Regional Populations. In *Current Issues in Hohokam Prehistory*, edited by David E. Doyel and Fred Plog, pp. 205-223. Arizona State University Anthropological Research Paper No. 23. Tempe.

Phillips, David A., Jr., Mark C. Slaughter, and Susan B. Bierer
1993 *Archaeological Studies at Kartchner Caverns State Park, Cochise County, Arizona*. SWCA Archaeological Report No. 93-26. SWCA, Inc., Tucson. Submitted to Arizona State Parks, Phoenix.

Russell, Frank
1908 *The Pima Indians*. 26th Annual Report of the Bureau of American Ethnology. Washington, D.C.

Sauer, Carl, and Donald Brand
1930 *Pueblo Sites in Southeastern Arizona*. University of California Publications in Geography Vol. 7, No. 3.

Sayles, E. B.
1945 *The San Simon Branch: Excavations at Cave Creek and in the San Simon Valley, Volume 1: Material Culture*. Medallion Paper 34. Gila Pueblo, Globe, Arizona.

1983 *The Cochise Cultural Sequence in Southeastern Arizona*. Anthropological Papers of the University of Aizona No. 42. University of Arizona Press, Tucson.

Schroeder, Alfred H.
1953 The Problem of Hohokam, Sinagua, and Salado Relations in Southern Arizona. *Plateau* 26(2):75-83.

Seymour, Deni J.
1988 Sobaipuri Settlement Along the Upper San Pedro River Valley, Arizona. Paper presented at the 53rd annual meeting of the Society for American Archaeology, Phoenix.

1989 The Dynamics of Sobaipuri Settlement in the Eastern Pimeria Alta. *Journal of the Southwest* 31:205-222.

1993 In Search of the Sobaipuri Pima: Archaeology of the Plain and Subtle. *Archaeology in Tucson* 7(1):1-4.

Teague, Lynn S.
1974 *The Archaeological Resources of the Winkelman and Black Hills Unit of the Bureau of Land Management*. Arizona State Museum Archaeological Series No. 47. University of Arizona, Tucson.

Trischka, C.
1933 Hohokam: A Chapter in the History of the Red-on-Buff Culture. *Scientific Monthly* 37:417-433.

Tuthill, Carr
1947 *The Tres Alamos Site on the San Pedro River, Southeastern Arizona*. The Amerind Foundation 4. Dragoon, Arizona.

1950 Notes on the Dragoon Complex. In *For the Dean, Essays in Anthropology in Honor of Byron Cummings*, edited by E. Reed and D. King, pp. 51-61. Southwestern Monuments Association, Santa Fe.

Waters, Michael R.
1986 The Geoarchaeology of Whitewater Draw, Arizona. Anthropological Papers of the University of Arizona No. 45. University of Arizona Press, Tucson.

Whalen, Norman M.
1971 *Cochise Culture Sites in the Central San Pedro Drainage, Arizona*. Unpublished Ph.D. dissertation, University of Arizona, Tucson.

1979 Prehistoric Sites and Activities in the Dragoon-San Pedro Area of Southeastern Arizona. Ms. on file, Museum of Northern Arizona, Flagstaff.

HISTORY

Adams, Ward R.
1930 *History of Arizona*, Vol. 1. Record Publishing Co., Phoenix.

Main theme: History of Arizona prior to 1930.

Aldrich, Lorenzo D.
1950 *A Journal of the Overland Route to California and the Gold Mines*. Dawson's Book Shop, Los Angeles.

Arizona Office of Economic Planning and Development
1977 *Benson, Arizona Community Prospectus*. Arizona Office of Economic Planning and Development, Phoenix.

Main theme: An economic development report on Benson, AZ.

Bancroft, Hubert Howe
1888 The Works of Hubert Howe Bancroft, Volume XVII: History of Arizona and New Mexico, 1530-1888. The History Company, Publishers, San Francisco.

Main theme: Classic on the history of Arizona and New Mexico.

Bandelier, Adolph F.A.
1890 *Hemenway Southwestern Archaeological Expedition: Contributions to the History of the Southwestern Portion of the United States*. Papers of the Archaeological Institute of America, American Series 5. Cambridge, Mass.

1890-92 *Final Report of Investigations Among the Indians of the Southwestern United States, Carried on Mainly in the Years from 1880 to 1885*. 2 Vols. Papers of the Archaeological Institute of America, American Series 3 and 4. Cambridge, Mass.

1892 Outline of the Documentary History of the Zuñi Tribe. *Journal of American Ethnology and Archaeology* 3(1):1-115.

Barnes, Will C.
1988 *Arizona Place Names*. University of Arizona Press, Tucson.

Bartlett, John Russell
1854 *Personal Narrative of Exploration and Incidents in Texas, New Mexico, California, Sonora, and Chihuahua, connected with the United States and Mexico Boundary Commission, during the Years 1850, '51, '52, and '53* (2 Vols.). D. Appleton & Co., New York.

Basso, Keith H.
1983 Western Apache. In *Handbook of North American Indians, Volume 10, Southwest*, edited by Alfonso Ortiz, pp. 462-488. Smithsonian Institution, Washington, D.C.

Batman, Richard
1984 *James Pattie's West: The Dream and the Reality*. University of Oklahoma Press, Norman.

Main theme: Historical account of the mountain man, James O. Pattie.

Bell, James G.
1932 A Log of the Texas-California Cattle Trail, 1854, edited by J.Evetts Haley. *Southwestern Historical Quarterly* 35:290-316; 36:47-66.

Bell, William A.
1869 *New Trails in North America*. Vols. 1 and 2. Chapman and Hall, London.

Main theme: Bell followed Graham's route south of the international border, but he did report on the headwaters of the San Pedro.

Bigler, Henry
1932 Extracts from the Journal of Henry W. Bigler. *Utah Historical Quarterly* 5 (2, 3, 4):35-64, 87-112, 134-160.

Main theme: Journal of member of the Mormon Battalion.

Bliss, Robert S.
1931 The Journal of Robert S. Bliss, With the Mormon Battalion. *Utah Historical Quarterly* 4 (3, 4):67-96, 110-128.

Bolton, Herbert Eugene
1916 *Spanish Exploration in the Southwest, 1542-1706.* C. Scribner's, New York.

1936 *Rim of Christendom: A Biography of Eusebio Francisco Kino, Pacific Coast Pioneer.* McMillan, New York.

1948 *Kino's Historical Memoir of Pimeria Alta.* University of California Press, Berkeley.

1949 *Coronado, Knight of Pueblos and Plains.* University of New Mexico Press, Albuquerque.

1960 *Rim of Christendom: A Biography of Eusebio Francisco Kino, Pacific Coast Pioneer.* Russell and Russell, New York.

1990 *Coronado, Knight of Pueblos and Plains.* University of New Mexico Press, Albuquerque.

Bourke, John Gregory
1971 *On the Border with Crook.* (Reprint, 1891 edition) Rio Grande Press, Glorietta, New Mexico.

Browning, Sinclair
1982 *Enju: The Live and Struggle of an Apache Chief from the Little Running Water.* Northland Press, Flagstaff.

Burrus, Ernest J., S.J.
1965 *Kino and the Cartography of Northwestern New Spain.* Arizona Pioneers Historical Society, Tucson.

1971 *Kino and Manje, Explorers of Sonora, Their Vision of the Future, A Study of the Expeditions and Plans.* Sources and Studies for the History of the Americas, Vol. 10. St. Louis University and Jesuit Historical Institute, St. Louis, Missouri.

Chamberlain, William H.
1945 From Lewisburg to California in 1849. Edited by Lansing B. Bloom. *New Mexico Historical Review* 20 (1, 2, 3, 4):14-57, 144-180, 239-268, 336-357.
Main theme: Chamberlain was a forty-niner who followed the Kearny-Emory route, leaving the Rio Grande at San Antonio (south of Socorro) and going straight over the mountains to the headwaters of the Gila, then following the Gila to the Colorado, and not traveling along the San Pedro.

Clarke, Asa B.
1852 *Travels in Mexico and California: Comprising a Journal of a Tour from Brazos Santiago through Central Mexico by Way of Monterrey, Chihuahua, the Country of the Apaces, and the Gila River to the Mining Districts of California.* Wright & Hasty's Steam Press, Boston. Reprint edited by Anne M. Perry published by Texas A&M Press, College Station, Texas, 1988.

Clarke, Dwight L.
1961 *Stephen Watts Kearny, Soldier of the West.* University of Oklahoma Press.

Conkling, Roscoe P., and Margaret B. Conkling
1947 *The Butterfield Overland Mail, 1857-1869.* 3 vols. Arthur H. Clark Co., Glendale.

Cooke, Philip St. George
1848 *Report of Lieut. Col. P. St. George Cooke of his March from Santa Fe, New Mexico to San Diego, Upper California.* In U.S. Engineer Dept. Notes of a Military Reconnaissance. U.S. 30th Cong. 1st Sess. House Exec. Doc. 41.

1938 Cooke's Journal of the March of the Mormon Battalion, 1846-1847. In *Exploring Southwest Trails, 1846-1854*, by Philip St. George Cooke, William Henry Chase Whiting, and Francois Xavier Aubry (Vol. VII of Southwest Historical Series), edited by Ralph P. Bieber in Collaboration with Averam B. Bender, pp. 65-240. Arthur H. Clark Co., Glendale.

1964 *The Conquest of New Mexico and California in 1846-1848.* Horn and Wallace, Albuquerque.

1974 Cooke's Journal of the March of the Mormon Battalion, 1846-1847. In *Exploring Southwest Trails, 1846-1854*, by Philip St. George Cooke, William Henry Chase Whiting, and Francois Xavier Aubry (Vol. VII of Southwest Historical Series), edited by Ralph P. Bieber in Collaboration with Averam B. Bender, pp. 65-240. Arthur H. Clark Co., Glendale (revised edition).

Cox, Cornelius C.
1902 Reminiscences of C.C. Cox. *Southwestern Historical Quarterly* 6(2, 3):113-138, 204-235.

Main theme: everything but his trip to California as a forty-niner, which is recounted in Cox (1925).

1925 *From Texas to California in 1849*, edited by Mabelle Eppart Martin. Southwestern Historical Quarterly 29 (1-3):36-50, 128-146, 201-223.

Davis, Goode P.
1982 *Man and Wildlife in Arizona: The American Exploration Period, 1824-1865.* Arizona Fish and Wildlife Service in cooperation with the Arizona Cooperative Wildlife Research Unit. Somers Graphics, Scottsdale.

Main theme: Observations on fish, wildlife, and natural conditions by early American explorers and travelers.

Day, A. Grove
1964 *Coronado's Quest: The Discovery of the Southwestern States.* University of California Press, Berkeley.

Main theme: Coronado expedition, although this is a secondary work.

Di Peso, Charles
1951 *The Babocomari Village Site on the Babocomari River, Southeastern Arizona.* Publication No. 5. The Amerind Foundation, Dragoon, Arizona.

Main theme: primarily a prehistoric site report, although it does have a historic ranch component.

1953 *Sobaipuri Indians of the Upper San Pedro River.* Publication No. 6. Amerind Foundation, Dragoon, Arizona.

Dobyns, Henry
1981 *From Fire to Flood: Historic Human Destruction of Sonoran Desert Riverine Oases.* Ballena Press Anthropological Papers, No. 20. Ballena Press, Socorro, New Mexico.

Durivage, John E.
1937 "Journal," In *Southern Trails to California in 1849*, Vol. V of Southwest Historical Series, edited by Ralph P. Bieber, pp. 159-255. Arthur H. Clark Co., Glendale.

Eaton, W. Clement
1933 Frontier Life in Southern Arizona, 1858-61. *Southwestern Historical Quarterly* 36(3):173-192.

Main theme: background and excerpts from the diary of Phocian R. Way, an executive with Santa Rita Mining Company, who went to Tucson in 1858. Deals mostly with Tucson.

Eccleston, Robert
1950 *Overland to California on the Southwestern Trail: 1849.* Edited by George P. Hammond and Edward H. Howes. University of California Press, Berkeley.

Emory, William Hensley
1848 *Notes of a Military Reconnoissance from Fort Leavenworth, in Missouri to San Diego in California, Including Parts of the Arkansas, Del Norte, and Gila Rivers.* 30th Cong., 1st Sess., Sen. Exec. Doc. 7, H.R. Ex. Doc. No. 41, Washington, D.C.

1857 *Report on the U.S. and Mexican Boundary Survey, Vols I-II.* U.S. 34th Congress, 1st Sess., Sen. Exec. Doc. 108, H.R. Exec. Doc. 135, Washington, D. C.

1857 Sketch of Territory Acquired by Treaty of December 30, 1853. In *Report on the U.S. and Mexican Boundary Survey, Vol I*, by William H. Emory, Chaper 6, Part 1:93-100.

1951 *Lieutenant Emory Reports: A Reprint on Lieutenant W.H. Emory's Notes of a Military Reconnoissance.* University of New Mexico Press, Albuquerque.

Evans, George W.B.
1945 *Mexican Gold Trail: The Journal of a Forty-Niner.* Edited by Glenn S. Dumke. Huntington Library, San Marino, California.

Ezell, Paul H.
1983 History of the Pima. In *Handbook of North American Indians, Volume 10, Southwest*, edited by Alfonso Ortiz, ppl 149-160. Smithsonian Institution, Washington, D.C.

Farish, Thomas Edwin
1915 *History of Arizona*, Vol. 1-8. The Filmer Brothers Electrotype Company, San Francisco.

Main theme: The history of Arizona comprising eight volumes.

Fontana, Bernard L.
1983 Pima and Papago: Introduction. In *Handbook of North American Indians, Volume 10, Southwest*, edited by Alfonso Ortiz, pp. 125-136. Smithsonian Institution, Washington, D.C.

Fulton, Richard W.
1966 Milleville-Charleston, Cochise County, 1878-1889. *Journal of Arizona History* 7:9-22.

Fulton, Richard W. and Conrad J. Bahre
1967 Charleston, Arizona: A Documentary Reconstruction. *Arizona and the West* 9:41-64.

Golder, Frank Alfred, Thomas A. Bailey, and J. Lyman Smith
1928 *The March of the Mormon Battalion.* The Century Company, New York.

Graham, J.D.
1852 Report of the Secretary of War, Communicating, in Compliance with a Resolution of the Senate, the Report of Lieutenant Colonel Graham on the Subject of the Boundary Line between the United States and Mexico. U.S. 32nd Congress, 1st Sess., Sen. Exec. Doc. 121. A. Boyd Hamilton, Washington, D.C.

Granger, Byrd Howell
1985 *Will C. Barnes' Arizona Place Names.* The University of Arizona Press, Tucson.

Main theme: Lists names of places alphabetically within county categories. Gives brief description about how place was established and how it got its name.

1984 *Arizona's Names (X Marks the Place).* The Falconer Publishing Company, Tucson Arizona.

Main theme: Lists names of places alphabetically and gives brief description of place.

Gray, Andrew B.
1856 Survey of a Route for the Southern Pacific Railroad on the 32nd Parallel. Wrightson and Co., Printer, Cincinnati.

Greever, William S.
1957 Railway Development in the Southwest. *New Mexico Historical Review* 32(2):151-203.

Griffin, John S.
1943 *A Doctor Comes to California.* California Historical Society, San Francisco.

Griffiths, D.A.
1901 *Range Improvement in Arizona.* USDA Bureau of Plant Industry Bulletin 4. Government Printing Office, Washington, D.C.

Hackenburg, Robert A.
1983 Pima and Papago Ecological Adaptations. In *Handbook of North American Indians, Volume 10, Southwest*, edited by Alfonso Ortiz, pp. 161-177. Smithsonian Institution, Washington, D.C.

Hadley, Diana, Peter Warshall, and Don Bufkin
1991 *Environmental Change in Aravaipa, 1870-1970: An Ethoecological Survey.* Cultural Resource Series, No. 7. Arizona State Office, Bureau of Land Management, Phoenix.

Hamilton, Patrick
1884 *The Resources of Arizona.* Third edition. A. L. Bancroft and Company, Printers, San Francisco.

Main theme: Book relates the climate, history, culture, and resources of Arizona in such as a way to encourage people to move there.

Hammond, George P.
1929 Pimaría Alta After Kino's Time. *New Mexico Historical Review* 4(3):220-238.

Harris, Benjamin Butler
1960 *The Gila Trail: The Texas Argonauts and the California Gold Rush.* University of Oklahoma Press, Norman.

Hastings, James R.
1959a The Tragedy of Camp Grant in 1871. *Arizona and the West* 1(2):146-160.

1959b Vegetation Change and Arroyo Cutting in Southeastern Arizona. *Journal of the Arizona Academy of Science* 1:60-67.

Hastings, James Rodney, and Raymond M. Turner
1965 *The Changing Mile: An Ecological Study of Vegetation Change With Time in the Lower Mile of an Arid and Semiarid Region.* The University of Arizona Press, Tucson.

Haury, Emil W.
1984 The Search for Chichilticale. *Arizona Highways* 60(4):14-19.

Hayes, Benjamin
1850 Diary of Judge Benjamin Hayes. Ms. on file, Bancroft Library, University of California, Berkeley, and Arizona Historical Society, Tucson.

Herbert, Harold E., and Erick Campbell
1986 Time Line/Social History of the Upper San Pedro River Valley (1540 through 1986). Ms. on file, Cochise County Historical and Archaeological Society, Douglas, Arizona.

Hereford, Richard, and Julio Betancourt
1993 Historic Geomorphology of the San Pedro River: Archival and Physical Evidence. University of Arizona Press, Tucson (in press).

Hine, Robert V.
1968 *Bartlett's West:Drawing the Mexican Boundary.* Yale University Press, New Haven and London.

Main theme: Secondary work publishing Bartlett's art and that of the artists accompanying him, along with summary background information on Bartlett's survey.

Hinton, R.J.
1878 Handbook of Arizona.

Hodge, Frederick Webb
1933 Introduction. In *The Journey of Francisco Vázquez de Coronado, 1540-1542,* by George P. Winship, pp. i-xxvii. Grabhorn Press, San Francisco.

Hodge, Frederick Webb, and Theodore H. Lewis, editors

1907 The Narrative of the Expedition of Coronado, by Pedro de Castaneda. In *Spanish Explorers in the Southern United States, 1528-1543*. Charles Scribner's Sons, New York.

Hodge, Hiram C.

1877 *Arizona As It Is*. Hurd & Houghton, New York.

Main theme: Intention of the book is to encourage people to move to Arizona. Title page reads, "To the inhabitants of Arizona and to all others who take an interest in the development and prosperity of that wonderful country." There is a chapter on rivers of Arizona but there is no reference to their use.

Hoffman, Michael Howard

1982 *The Role of Intermittent Rivers and Streams in the National Wild and Scenic Rivers System*. National Park Service and University of Arizona.

Main theme: This is a technical report on the role of intermittent streams and rivers in the Wild a Scenic River System. It touches on rivers in Arizona in chapters 6-7. Rivers and streams covered are the Gila, Eagle Creek-San Francisco-Tonto Creek, Little Colorado and San Pedro. There is no mention of navigability on any of these waterways. It focuses a lot on biology and hydrology, and culture historical sequence is described.

Hunter, William H.

n.d. Transcript of a Diary-Journal of Events, Etc. on a Journey from Missouri to California in 1849. Ms. Special Collections, University of Arizona Library, Tucson, Arizona.

Main theme: Concerns the Missouri Company of Capt. Samuel W. Berry.

Hutton, N.H.

1859 Engineers Report--El Paso and Fort Yuma Wagon Road. In Records of the Office of the Secretary of the Interior Relating to Wagon Roads, 1857-1881. Nation. Archives film microcopies, M-95, roll 3.

1859 *Report of Superintendent James B. Leach upon the El Paso and Fort Yuma Wagon Road Constructed under the Direction of the Department of the Interior, 1857-1858*. House Ex. Doc. 108-107. Government Printing Office, Washington, D.C.

Jackson, William L.

1987 *Assessment of Water Condition and Management Opportunities in Support of Riparian Values: BLM San Pedro River Properties, Arizona*. Project Completion Report. U.S. Department of the Interior, BLM, Denver.

Kessell, John L.
1966a Peaceful Conquest in Southern Arizona. In *Father Kino in Arizona,* by Fay Jackson Smith, John L. Kessell, and Francis J. Fox, S.J, pp. 53-95. Phoenix Historical Foundation, Phoenix.

1966b The Puzzling Presidio: San Phelipe de Guevavi, Alias Terrenate. *New Mexico Historical Review 41*:21-46.

1976 *Friars, Soldiers, and Reformers: Hispanic Arizona and the Sonora Mission Frontier, 1767-86.* University of Arizona Press, Tucson.

Leach, James B.
1858 Itinerary of the El Paso and Fort Yuma Wagon Road Expedition under the Superintendence of James B. Leach. 1858. Film Microcopies of Records in the National Archives, No. M-95, Roll 3. "Records of the Office of the Secretary of the Interior relating to Wagon Roads, 1857-1881."

Mann, Dean E.
1963 *The Politics of Water in Arizona.* University of Arizona Press, Tucson.

Main Theme: Treatise of the conflicts over control of water in Arizona.

Mattison, R.H.
1946 Early Spanish and Mexican Settlements in Arizona. *New Mexico Historical Review* 21:282, 286, 288-289.

McClintock, James
1916 *Arizona: Prehistoric-Aboriginal, Pioneer-Modern,* Vol. I and II. S. J. Clark Publishing Co., Chicago.

Main theme: History of Arizona.

Myrick, David F.
1968 Brief Survey of the Histories of Pioneer Arizona Railroads.

1975 *Railroads of Arizona, Vol. I: the Southern Roads.* Howell-North Books, Berkeley, California.

Main theme: Historical information on the railroads of southern Arizona.

National Park Service
1991 *National Trail Study, Environmental Assessment, Coronado Expedition: Arizona/New Mexico/Texas/Oklahoma/Kansas*. United State Department of the Interior, National Park Service, Denver Service Center.

Officer, James E.
1987 *Hispanic Arizona, 1536-1856.* University of Arizona Press, Tucson.

Ogle, Ralph Hedrick
1970 *Federal Control of the Western Apaches, 1848-1886.* (Reprint, 1940 edition) University of New Mexico Press, Albuquerque.

Ormsby, Waterman L.
1962 *The Butterfield Overland Mail,* edited by Lyle H. Wright and Josephine M. Bynum. The Huntington Library, San Marino, California.

Main theme: account of the only through passenger on the first Butterfield Stage west.

Pancoast, Charles
1930 *A Quaker Forty-Niner:The Adventures of Charles Edward Pancoast on the American Frontier*, edited by Anna Paschal Hannum. University of Pennsylvania Press, Philadelphia.

Parke, John G.
1857 Report of the Explorations for That Portion of a Railroad Route, Near the Thirty-Second Parallel of North Latitude, Lying Between Dona Ana, on the Rio Grande and Pimas Villages, on the Gila, by Lt. John G. Parke. In *Reports of Explorations and Surveys, to Ascertain the Most Practicable and Economic Route for a Railroad from the Mississippi River to the Pacific Ocean*. Vol. II, 33rd Cong., 2nd Sess., Senate Exec. Doc. No. 78 (Serial No. 759). Beverly Tucker, Printer, Washington, D.C. (1855), and Vol. VII, Part I, No. 2, 33rd Cong, 2nd Sess, Senate Exec. Doc. No. 78 (Serial No. 764). Beverley Tucker, Printer, Washington, D.C. (1857).

1857 Report of Explorations for Railroad Routes from San Francisco Bay to Los Angeles, California, West of the Coast Range, and from the Pimas Villiages on the Gila to the Rio Grande, near the 32nd Parallel of North Latitude, in *Pacific Railroad Reports*, 7, Pt. I, pp. 19-42. Volume VII of Reports of Explorations and Surveys. U.S. Congress, House Exec. Doc. 91, 2nd session. A.D.P. Nicholson, Washington, D.C.

Pattie, James Ohio
1883 *The Personal Narrative of James O. Pattie of Kentucky*, edited by Timothy Flint. E.H. Flint, Cincinnati.

Powell, H.M.T.
1931 *The Santa Fe Trail to California, 1849-1852: The Journal and Drawings of H.M.T. Powell*, edited by Douglas S. Watson. Book Club of California, San Francisco.

Powell, Lawrence Clark
1980 *Where Water Flows: The Rivers of Arizona.* Northland Press, Flagstaff.

Main theme: Book is a narrative on particular rivers as of 1980 as seen through the eyes of the author.

Richardson, Rupert N.
1925 Some Details of the Southern Overland Mail. *Southwestern Historical Quarterly* 24(1):1-18.

Main theme: Butterfield stage line through Texas. Richardson recommends reading the St. Louis and San Francisco newspapers, especially the St. Louis *Missouri Republican*, 1858-1859, for accounts of the early trips. Newspaper reporters waited at the stations and reported passenger lists as well as descriptions of the trip.

Riley, Carroll L.
1985 The Location of Chichilticale. In *Southwestern Culture History: Collected Papers in Honor of Albert H. Schroeder*, edited by Charles H. Lange, pp.153-162. Papers of the Archaeological Society of New Mexico, No. 10. Ancient City Press, Santa Fe.

Rodgers, William M.
1965 Historical Land Occupance of the Upper San Pedro Valley Since 1870. M.A. thesis, University of Arizona, Tucson.

San Manuel Copper Corporation.
1955 *San Manuel.* San Manuel Copper Corporation, Arizona. (no publisher).

Main theme: A brief sketch of the mine's operations and production. No mention of San Pedro River. Water supply was provided by a series of artesian wells along San Pedro Valley below plant site.

Sauer, Carl Ortwin
1932 The Road to Cibola. *Ibero-Americana* 3. University of California Press, Berkeley.

1937 The Discovery of New Mexico Reconsidered. *New Mexico Historical Review* 12(3):270-287.

Main theme: Fray Marcos got only as far north as northern Sonora.

Schroeder, Albert H.
1955 Fray Marcos de Niza, Coronado and the Yavapai. *New Mexico Historical Review* 30(4):265-296.

1956 Fray Marcos de Niza, Coronado and the Yavapai. *New Mexico Historical Review* 31(1):24-37.

Smith, Fay Jackson, John L. Kessell, and Francis J. Fox
1966 *Father Kino in Arizona.* Arizona Historical Foundation, Phoenix.

Tevis, James H.
1954 *Arizona in the '50s.* University of New Mexico Press, Albuquerque.

Thomas, Alfred Barnaby
1932 *Forgotten Frontiers: A Study of the Spanish Indian Policy of Don Juan Bautista de Anza, Governor of New Mexico, 1777-1787.* University of Oklahoma Press, Norman.

1941 *Teodoro de Croix and the Northern Frontier of New Spain, 1776-1783.* University of Oklahoma Press, Norman.

Thompson, William
1895 Beset in Aravaipa Canyon. *Lippincott's Monthly Magazine* 60 (June 1895):845-851.

Tiller, Kerry S.
1982 Charleston Townsite Revisited. *Journal of Arizona History* 23:242-248.

Tyler, D. S.
1881 *A Concise History of the Mormon Battalion in the Mexican War.* The Rio Grande Press, Chicago (1964 Reprint).

Udall, Stewart L.
1984 In Coronado's Footsteps. *Arizona Highways Magazine* 60(4)[April]:1-13, 20-49.

1987 *To the Inland Empire: Coronado and Our Spanish Legacy.* Doubleday, Garden City, New York.

Undreiner, George J.
1947 Fray Marcos de Niza and his Journey to Cibola. *The Americas* 7(4):415-486.

U.S. War Department, Surgeon General's Office
1870 *A Report on Barracks and Hospitals, With Descriptions of Military Posts.* U.S. Government Printing Office, Washington, D.C.

Varney, Philip
1980 *Arizona's Best Ghost Towns: A Practical Guide by Philip Varney.* Northland Press, Flagstaff.

Wagoner, Jay J.
1975 *Early Arizona: Prehistory to Civil War.* The University of Arizona Press, Tucson, Arizona.

Walker, Henry P., and Don Bufkin
1986 *Historical Atlas of Arizona.* Second edition. University of Oklahoma Press, Norman.

Wallace W. Elliot & Co.
1884 *History of Arizona Territory Showing its Resources and Advantages with Illustrations: Descriptive of its Scenery, Residences, Farms, Mines, Mills, Hotels, Business, Houses, Schools, Churches, Etc.* Wallace W. Elliot & Co., Publishers, San Francisco.

Main theme: Detailed description of Arizona history from the first Spanish entradas to a description of its natural resources, early expeditions, missions, pioneers, Spanish territories, military campaigns, civil war in Arizona, public lands, counties, metals, Indians.

Williams, Jack S.
1986 The Presidio of Santa Cruz de Terrenate: A Forgotten Fortress of Southern Arizona. *The Smoke Signal*, nos. 47 and 48 (combined). Tucson Corral of the Westerners.

Winship, George Parker
1896 The Coronado Expedition. In *Fourteenth Annual Report of the Bureau of American Ethnology, Smithsonian Institution, for the Years 1892-1893*, Part 1, pp. 329-613. Smithsonian Institution, Washington.

Wyllys, Rufus K.
1931 Padre Luís Velarde's Relación of Pimería Alta, 1717. *New Mexico Historical Review* 6(2) [April]:111-157.

Zarbin, Earl
n.d. Index to Water-Related Articles in Early Central Arizona Newspapers, 1859 thru 1918. Ms. on file with the author and Mary Lu Moore, Historian, Arizona State Attorney General's Office, Phoenix.

Oral History

Fischer, Al, and Mildred Fischer
1993 *Arizona Museums: Your Guide to Arizona's Treasures!* Golden West Publishers, Phoenix.

Hastings, James Rodney, and Raymond M. Turner
1965 *The Changing Mile: An Ecological Study of Vegetation Change With Time in the Lower Mile of an Arid and Semiarid Region.* The University of Arizona Press, Tucson.

Zarbin, Earl
n.d. Index to Water-Related Articles in Early Central Arizona Newspapers, 1859 thru 1918. Ms. on file with the author and Mary Lu Moore, Historian, Arizona State Attorney General's Office, Phoenix.

Geology

Agenbroad, L.D.
1967 Cenozoic Stratigraphy and Paleo-Hydrology of the Redington-San Manuel Area, San Pedro Valley, Arizona: Tucson, Ph.D. Dissertation, University of Arizona, 119 p.

Bahr, C.J.
1991 A Legacy of Change: Tucson, University of Arizona Press, 231 p.

Bartlett, J.R.
1854 Personal Narrative of Explorations and Incidents in Texas, New Mexico, California, Sonora, and Chihuahua: New York, D. Appleton and Co.

Betancourt, J.L.
1990 Tucson's Santa Cruz River and the Arroyo Legacy: Tucson, University of Arizon Ph.D. Dissertation, 239 p.

Brice, J.D.
1984 Planform properties of rivers, In Elliot, C.M. (ed), River Meandering: NewYork, American Society of Civil Engineers, p. 1-15.

Brown, D.E. g(ed)
1982 Biotic Communities of the American Southwest, United States and Mexico, In Desert Plants, vol. 4: Tucson, University of Arizona Press.

Brown, D.E., Carmony, N.B., and Turner, R.M.
1981 Drainage map of Arizona showing perennial streams and some important wetlands, (1:1,000,000): Phoenix: Arizona Game and Fish Department.

Bryan, K.,
1926 San Pedro Valley, Arizona, and the geographic cycle [abstr]: Geological Society of America Bulletin, v. 37, p. 169-170.

Bryan, K., Smith, G.E.P, and Waring, G.A.
1934 Geology and water resources of the San Pedro Valley, Arizona: Tucson, U.S. Geological Survey Open-File Report, 167 p.

Bull, W.B.
1991 Geomorphic Responses to Climate Change: New York, Oxford University Press, 326 p.

Burkham, D.E.
1976 Effects of changes in an alluvial channel on the timing, magnitude, and transformation of flood waves, southeastern Arizona: U.S. Geological Survey Professional Paper 655-K, 25 p.

1972 Channel changes of the Gila River in Safford Valley, Arizona: U.S. Geological Survey Professional Paper 655-G, 24 p.

1970 Precipitation, streamflow, and major floods at selected sites in the Gila River drainage basin above Coolidge Dam, Arizona: U.S. Geological Survey Professional Paper 655-B, 33 p.

Burrus, E. J.
1971 Kino and Manje: Explorers of Sonora and Arizona; Their Vision of the Future: Jesuit Historical Institute, Rome and St. Louis, 793 p.

Carpenter, E.J., and Bransford, W.S.
1921 Soil Survey of the Benson Area, Arizona: Washington D.C., U.S. Department of Agriculture, Field Operations, Bureau of Soils, p. 247-280.

Chronic, H.
1983 Roadside Geology of Arizona: Missoula, Montanta Press Publishing Co., 314 p.

Contzen, P.
1901 General Land Office survey notes, Books 935, 983, and 989: Microfiche on file at Bureau of Land Management, Phoenix.

Cooke, Philip St. George
1938 Cooke's journal of the march of the Mormon Battalion, 1846-1847, In Bieber, R.P. (ed), Exploring Southwest Trails, 1846-1854: Glendale, California, Arthur H. Clark Company, Southwest Historical Series, v. 7, p. 65-240.

Cooke, R.U., and Reeves, R.W.
1976 Arroyos and environmental change: Oxford, Clarendon Press, Oxford Research Studies in Geography, 213 p.

Damon, P.E., Lynch, D.J., Shafiqullah, M.
1984 Cenozoic landscape development in the Basin and Range province of Arizona, *In* Smiley, T.L., Nations, J.D., Pewe, T.L., and Shafer, J.P. (eds), Landscapes of Arizona: the Geological Story, p. 175-206: Lanham, MD, University Press of America.

Dobyns, H. F.
1981 From fire to flood: historic human destruction of Sonoran desert riverine oases: Socorro, New Mexico, Ballena Press Anthropological Papers 20, 222 p.

Dubois, S.M., and Smith, A.W.
1980 The 1887 Earthquake in San Bernardino Valley, Sonora: Historic Accounts and Intensity Patterns in Arizona, Arizona Geological Survey Special Paper 3, Tucson, 112 p.

Ely, L.L.
1992 Large Floods in the Southwestern United States in Relation to Late-Holocene Climate Variations: Tucson, University of Arizona, Ph.D. Dissertation, 326 p.

Emory, W.H.
1848 Notes of a Military Reconnaissance from Fort Leavenworth in Missouri to San Diego in California: 30th Congress, 1st Session, House Executive Document No. 41.

Graf, W.L.
1988 Fluvial Processes in Dryland Rivers: New York, Springer-Verlag, 346 p.

Harris, J.L.
1879 General Land Office survey notes, Books 721, 739, 752, 762, 763, 780, and 1474: Microfiche on file at Bureau of Land Management, Phoenix.

1877 General Land Office survey notes, Books 633, 672, 686, 698, 699, 733, and 1477: Microfiche on file at Bureau of Land Management, Phoenix.

Hastings, J.R.
1959 Vegetation change and arroyo cutting in southeastern Arizona: Arizona Academy of Sciences, v. 1, p. 60-67.

Hastings, J.R., and Turner, R.M.
1965 The Changing Mile; An Ecological Study of Vegetation Change with Time in the Lower Mile of an Arid and Semiarid Region: Tucson, University of Arizona Press, 317

Haury, E., Sayles, E.B., and Wasley, W.W.
1959 The Lehner Mammoth site, southeastern Arizona: American Antiquity, vol. 25, p. 2-30.

Haynes, C. V., Jr.
1987 Curry Draw, Cochise County Arizona: A late Quaternary stratigraphic record of Pleistocene extinction and paleo-Indian activities: Geological Society of America Field Guide, p. 23-38.

Heindl, L.A.
1952 Upper San Pedro basin (groundwater), In Ground Water in the Gila River Basin and Adjacent Areas - A Summary: Tucson, U.S. Geological Survey Open-file Report, pp. 69-86.

1952 Lower San Pedro basin (groundwater):In Ground Water in the Gila River Basin and Adjacent Areas - A Summary: Tucson, U.S. Geological Survey Open-file Report, pp. 87-100.

Hereford, R.
1993 Entrenchment and Widening of the Upper San Pedro River, Arizona: Geological Socity of America Special Paper 282, 46 p.

Hendrickson, D.A., and Minckley, W.L
1985 Cienega - vanishing climax communities of the American Southwest, Desert Plants, vol. 6, p. 130-175: Tucson, University of Arizona Press.

Hereford, R., and Betancourt, J.L.
1993 Historic geomorphology of the San Pedro River: archival and physical evidence, *In* Haynes, C.V. and Huckell, B. (eds), The First Arizonans: Clovis Occupation of the San Pedro Valley, Manuscript in preparation.

Hirschboek, K.K.
1985 Hydroclimatology of Flow Events in the Gila River Basin, Central and Southern Arizona: Tucson, University of Arizona, Unpublished Ph.D. Dissertation, 335 p.

Huckleberry, G.A.
1993 Late-Holocene Stream Dynamics on the Middle Gila River, Pinal County, Arizona: Tucson, University of Arizona, Ph.D. Dissertation, 135 p.

Hutton, N.H.
1859 Report on the El Paso and Fort Yuma Wagon Road. In Report upon the Pacific Wagon Roads. A.H. Campbell (ed), 35th Congress, 2nd Session, House Executive Document 108.

Johnson, N.M., Opdyke, N.D., and Lindsay, E.H.
1975 Magnetic polarity stratigraphy of Pliocene-Pleistocene terrestial deposits and vertebrate faunas, San Pedro Valley, Arizona: Geological Society of America Bulletin, vol. 86, p. 5-12.

Johnston, A.R.
1848 Journal of Captain A.R. Johnston, 1st Dragoons: 30th Congress, 1st Session, House Executive Document No. 41.

Kessell, John L.
1966 The puzzling presidio: San Phelipe de Guevavi, alias Terrenate. New Mexico Historical Review, vol. 41, p. 21-46.

Knighton, D.
1984 Fluvial Forms and Processes: London, Edward Arnold (Publishers), Ltd., 218 p.

Kottlowski, F., Cooley, M.E., and Ruhe, R.
1965 Quaternary geology of the Southwest, *In* Wright, H.E., and Frey, D.G. (eds), The Quaternary of the United States: Princeton, Princeton University Press, p. 287-298.

Leach, J.B.
1858 Itenerary of the El Paso and Fort Yuma wagon road expedition: Washington D.C., National Archives film microcopies, no. M95, roll 3.

Lee, W.T.
1905 Notes on the underground water of the San Pedro Valley, Arizona, *In* Newell, F.H., 58th Congress, 3rd Session, HR Document 28, p. 165-170.

Leopold, L.B.
1951 Vegetation of the southwestern watersheds in the nineteenth century: Geographical Review, vol. 41, p. 295-316.

Leopold, L.B., and Bull, W.B.
1979 Base level, aggradation, and grade: Proceedings of the American Philosophical Society, vol. 123, p. 168-202.

Leopold, L.B., and Wolman, M.G.
1957 River channel patterns: braided, meandering and straight: U.S. Geological Survey Professional Paper 282B, p. 39-85.

Mackin, J.H.
1948 Concept of a graded river: Geological Society of America Bulletin, vol. 59, p. 463-512.

Melton, M.A.
1965 The geomorphic and paleoclimatic significance of alluvial deposits in southern Arizona: Journal of Geology, vol. 73, p. 1-38.

Menges, C.M. and Pearthree, P.A.
1989 Late Cenozoic tectonism in Arizona and its impact on regional landscape evolution. In Jenney, J.P., and Reynolds, S.J. (eds), Geologic Evolution of Arizona: Arizona Geological Society Digest 17, p. 649-680.

Meyer, D.F.
1989 The significance of sediment transport in arroyo development: U.S. Geological Survey Water-Supply Paper 2349.

Morrison, R.B.
1985 Pliocene/Quaternary geology, geomorphology, and tectonics of Arizona, *In* Weide, D. (ed), Soils and Quaternary Geology of the Southwestern United States: Geological Soceity of America Special Paper 203, p. 123-146.

North American Commision on Stratigraphic Nomenclature
1983 North American stratigraphic code: American Association of Petroleum Geologists Bulletin, vol. 67, p. 841-875.

Olmstead, F.H.
1919 Gila River flood control: a report on floods of the Gila River in Graham County, Arizona: U.S. 65th Congress, 3d Session, Document 436, 94 p.

Oppenheimer, J.M., and Sumner, J.S.
1980 Depth-to-Bedrock Map, BAsin and Range Province, Arizona: Tucson, Laboratory of Geophysics, University of Arizona, (scale 1:1,000,000).

Parke, J.G.
1857 Report of explorations for railroad routes. In Explorations and surveys to ascertain the most practicable and economical route for a railroad from the Mississippi River to the Pacific Ocean. U.S. 33rd Congress, 2nd Session, Senate Executive Document 78, Vo. 7: 1-469.

Pattie, J.O.
1905 The personal narrative of James O. Pattie. In Volume 18, Early western travels, 1748-1846. R.G. Thwaites (ed). Arthur H. Clarke Co., Cleveland, 379 p.

Pearthree, M.S., and Baker, V.R.
1987 Channel change along the Rillito Creek System of southeastern Arizona, 1941 through 1983; Implications for flood-plain management: Arizona Geological Survey Special Paper 6, 58 p.

Reynolds, S.J.
1988 Geologic Map of Arizona: Arizona Geological Survey Map 26, scale 1:1,000,000.

Richards, K.
1982 Rivers, Form and Process in Alluvial Channels: London, Methuen and Co., Ltd., 358 p.

Ritter, D.F.
1986 Process Geomorphology, 2nd Edition: Dubuque, IA, William C. Brown Publishers, 579 p.

Rodgers, W.M.
1965 Historical Land Occupance of the Upper San Pedro Valley Since 1870: Tucson, University of Arizona, M.A. Thesis, 167 p.

Schumm, S.A.
1977 The Fluvial System: New York, John Wiley and Sons, 338 p.

Sellers, W.B., and Hill, R.H.
1974 Arizona Climate 1931-1972, 2nd Edition: Tucson, University of Arizona Press, 616 p.

Shafiqullah, M., Damon, P.E., Lynch, D.J., Reynolds, S.J., Rehrig, W.A., and Raymond, R.H.
1980 K-Ar geochronology and geologic history of southwestern Arizona and adjacent areas. *In* Jenney, J.P., and Stone, C. (eds.), Studies in Western Arizona: Arizona Geological Society Digest. vol. 12, p. 201-260.

Smith, D.G.
1963 Pleistocene geology and geomorphology of the San Pedro River Valley, Cochise County, Arizona: Tucson, University of Arizona, MS Thesis, 73 p.

Stockton, C.W.
1975 Long term streamflow records reconstructed from tree rings, Laboratory for Tree Ring Research Paper No. 5: Tucson, University of Arizona Press.

Tuan, Y.
1962 Structure, climate, and basin landforms in Arizona and New Mexico: Associatin of American Geographers Annals, vol. 52, p. 51-68.

Waters, M.R.
1988 The impact of fluvial processes and landscape evolution on archaeological sites and settlement patterns along the San Xavier reach of the Santa Cruz River, Arizona: Geoarchaeology, An International Journal, Vol 3, p. 205-219.

Webb, R.H.
1985 Late Holocene flooding on the Escalante River, south central Utah: Tucson, University of Arizona Ph.D. Dissertation.

Webb, R.H., and Betancourt, J.L.
1992 Climatic variability and flood frequency of the Santa Cruz River, Pima County, Arizona: U.S. Geological Survey Water Supply Paper 2379, 40 p.

White, T.
1881 General Land Office survey notes, Book 889: microfiche on file at Bureau of Land Management, Phoenix.

1873 General Land Office survey notes, Books 804, 811, 845: microfiche on file at Bureau of Land Management, Phoenix.

Wolman, M.G., and Gerson, R.
1978 Relative scales of time and effectiveness of climate in watershed geomorphology: Earth Surface Processes, vol. 3, p. 189-208.

Hydrology

Arizona State Parks
1989 Arizona Rivers, Streams, and Wetlands Study: Draft: Statewide Comprehensive Outdoor Recreation Plan. Phoenix, Arizona.

Selected References

Anderson, F., and Hopkinson, A.
1982 Rivers of the Southwest: A Boaters Guide to the Rivers of Colorado, New Mexico, Utah, and Arizona. Pruett Publishing, Boulder, Colorado.

Arizona Department of Water Resources (ADWR)
1991 Hydrographic Survey Report for the San Pedro Watershed, v. 1.1- General Assessment. ADWR. Phoenix AZ.

Arizona State Parks Department

1989 Arizona Rivers, Streams, and Wetlands Study: Draft: Statewide Comprehensive Outdoor Recreation Plan. Phoenix, Arizona.

Central Arizona Paddlers Club
1992 Boating Survey of Arizona Rivers, Document distributed at ANSAC Meeting of April 13, 1993.

Cooke, Ronald U. and Richard W. Reeves
1976 Arroyos and environmental change in the American Southwest. Clarenden Press, Oxford. 213 p.

Davis, G.
1982 "Man and Wildlife in Arizona: The American Exploration Period 1824-1865." Carmody, N. and D. Brown, Edits. Published by Arizona Game and Fish. 232 p.

Dobyns, Henry F.
1981 From Fire to Flood: Historic Human Destruction of Sonoran Desert Riverine Oases. Anthropological Papers No. 20. Ballena Press, Socorro, New Mexico.

Hastings, James R. and Raymond M. Turner
1965 The Changing Mile: An Ecological Study of Vegetation Change with Time in the Lower Mile of an Arid and Semi-arid Region. University of Arizona Press, Tucson.

Haury, E., Sayles, E.B., and Wasley, W.W.
1959 The Lehner Mammoth Site, Southeastern Arizona: American Antiquity, Vol. 25, p. 2-30.

Hereford R., and Betancourt, J.L.
Historic Geomorphology of the San Pedro River: Archival and Physical Evidence.

Huckleberry, G.
1993 Historical Changes on the San Pedro River, Arizona. Manuscript prepared for CH2M HILL on behalf of the Arizona State Land Department. Not published.

Owen-Joyce, S.J. and Bell, C.K.
1983 Appraisal of Water Resources in teh Upper Verde RIver rea, Yavapai and Coconino Counties. Arizona Department of Water Resources Bulletin No. 2. 219 p.

Sellers, W.D.
1960 Precipitation Trends in Arizona and New Mexico, Proc. 28th Annual Snow Conference, pp. 81-94.

Smith, L.P. and Stockton, C.W.
1981 Reconstructed Stream Flow for the Salt and Verde Rivers from Tree-Ring Data. Water Resources Bulletin, Vol. 17, #6 pp 939-947.

Stetson Engineers
1988 The Interrelationships of Basin Ground Water and Surface and Subsurface Flow of the San Pedro River Basin, Arizona. Report to the U.S. Department of Justice. October 2, 1987, 28 p. plus appendixes.

U.S. Geological Survey
1901 Twenty-first Annual Report of the U.S. Geological Survey to the Secretary of the Interior, 1899-1900: Part IV - Hydrography. Government Printing Office, Washington, D.C.

1914 Surface Water Supply of the United States, 1912, Part IX: Colorado River Basin. US Geological Survey Water Supply Paper 329. Washington, D.C.

1954 Complilation of Records of Surface Waters of the United States Through September 1950, Part 9: Colorado River Basin. U.S. Geological Survey Water Supply Paper 1313, Washington, D.C.

1991 Basin Characteristics and Streamflow Statistics in Arizon as of 1989. USGS Water Resources Investigations Report 91-4041. Prepared in cooperation with ADWR and FCDMC.

Wilken, D.E., and Galante, J.C.
1987 Land Use History: Upper San Pedro River Valley. U.S. Department of the Interior, Bureau of Land Management, Arizona State Office.

General References

History/Archeology

Bahre, Conrad J. and Charles F. Hutchinson
1985 The impact of historic fuelwood cutting on the semidesert woodlands of southeastern Arizona. *Journal of Forest History 30.* 176-186 p.

Bartlett, John Russell
1854 *Personal Narrative of Explorations and Incidents in Texas, New Mexico, California, Sonora, and Chihuahua.*

Beiber, Ralph P.
1936 Marching with the Army of the West, Journal of Johnston, Edwards, and Ferguson. Arthur H. Clark Co., Cleveland, Ohio.

Betancourt, Julio L. and Richard Hereford
None *Historic Geomorphology of the San Pedro River: Archival and Physical Evidence.*

Christiansen, L.D.
1983 The Mormon batallion in Cochise County and adjacent areas. *The Cochise Quarterly 13.* 47 p.

Cooke, P. St. G.
1938 Cooke's journal of the march of the Mormon batallion, 1946-1847. (Bieber, R.P. and Averam, B.B., eds.). Arthur H. Clark Co., Glendale, California.

Duffen, W.A.
1936 Development of Human Culture in the San Pedro River Valley, Arizona. Univ. of Arizona M.A. Thesis.

Eccleston, R.
1950 Overland to California on the Southwestern trail, 1849. *Diary of Robert Eccleston.* G.P. Hammond and E.H. Howes (eds) University of California Press, Berkeley.

Finch, George Robert
1903 *The Life of a Pioneer.* Unpublished manuscript by early Arizona pioneer lived in San Pedro Valley and later operated ferry at Tempe.

Forbes, R.H.
1919 *The Penningtons, Pioneers of Early Arizona.* Arizona Archaeology and Historical Society.

Fulton, Richard W.
1966 Milleville-Charleston, Cochise County, 1878-1889. *Journal of Arizona History 7.* 9-22 p.

Fulton, Richard W. and Conrad J. Bahre
1967 Charleston, Arizona: A documentary reconstruction. *Arizona and the West 9.* 41-64 p.

Goetzmann, William H.
1959 Army Exploration in the American West, 1803-1863. Yale Univeristy Press, New Haven, Conn., 509 p.

Hutton, N.H.
1859 Report on the El Paso and Fort Yuma Wagon Road. In Report upon the Pacific Wagon Roads. A.H. Campbell, (ed) 35th Congress, 2nd Session, House Executive Document 108.

Hvorek, Pamela
1981 Typewritten transcript of oral history interview with Ms. Clara Curtis Kimball, 1890- , lifetime San Pedro Valley resident, on July 23, 1981.

Karns, H.J.
1954 *Unknown Arizona and Sonora 1693-1721.* (Luz de Tierra Incognita by Captain Juan Mateo Manje), Part II. Arizona Silhouettes, Tucson.

Leach, J.B.
1858 Itinerary of the El Paso and Fort Yuma Wagon Road Expedition. National Archives Film Microcopies, No. M95, Roll 3.

Mattison, R.H.
1946 Early Spanish and Mexican settlements in Arizona. *New Mexico Historical Review 21*: 282, 286, 288-289.

McClintock, J.H.
1921 Mormon settlement in Arizona. Manufacturing Stationers, Phoenix.

Rodgers, William M.
1965 Historical land occupance of the upper San Pedro Valley since 1870. M.A. thesis, University of Arizona, Tucson, 167 p.

Stone, Jerome
1941 The History of Fort Grant. University of Arizona M.S. Thesis.

Tiller, Kerry S.
1982 Charleston townsite revisited. *Journal of Arizona History 23.* 242-248.

Hydrology/Environmental

Arizona Department of Water Resources
? Application and Documentation for San Pedro River Instream Flow Permit.

1991 Hydrographic Survey Report for the San Pedro River Watershed, Vol 1. General Assessment. See also Volumes 2-9. November 20.

Bryan, Kirk, G.E.P. Smith, and G.A. Waring
1934 *Ground-water supplies and irrigation in the San Pedro Valley, Arizona.* U.S.G.S. Open-File Report 67-31.

Bryan, Kirk
1925 Date of channel trenching (arroyo-cutting) in the arid Southwest. Science 62: 338-344.

Bryan, Kirk, G.E.P. Smith, and G.A. Waring
1934 *Ground-water Supplies and Irrigation in San Pedro Valley, Arizona.* U.S. Geological Survey Open-File Report, 167 p.

Burkham, D.E.
1970 *Precipitation, Streamflow, and Major Floods of Selected Sites in the Gila River Drainage Basin above Coolidge Dam, Arizona.* U.S. Geological Survey Professional Paper 655-B. Washington, D.C.: U.S. Government Printing Office.

Burkham, D.E.
1971 *Channel Changes of the Gila River in Safford Valley, Arizona, 1946-1970.* An Open-File Report of the U.S. Geological Survey, Department of the Interior.

Cole, W.R.
1937 Dates of Floods in the San Pedro Valley, Arizona.

Cooke, Ronald U. and Richard W. Reeves
1976 Arroyos and environmental change in the American Southwest. Clarenden Press, Oxford. 213 p.

DeCook, K.J., D.K. Kreamer, S.B. Keith, S.F. Mack, and J.P. Hutton
1977 Surface Water Quality Monitoring, San Pedro River Basin, Arizona: A Report to the Arizona Department of Health Services, Bureau of Water Quality Control. Submitted by the Water Research Center, University of Arizona, Tucson, Arizona.

DuBois, Susan M. and A.W. Smith
1980 The 1887 earthquake in San Bernardino Valley, Sonora: Historic accounts and intensity patterns in Arizona. Bureau of Geology and Mineral Technology, University of Arizona. Special Paper 3. 112 p.

Eberhardt, Sandra
1980 San Pedro River Basin Water Quality Status Report for Period 1973-1979.

Evans, Henry R. and W.T. Lee
1921 *3rd Annual Report of U.S. Reclamation Services.* 157 ff p.

Federal Committee on Ecological Reserves
1977 A Directory of Research Natural Areas on Federal Lands of the United States of America. USFS Forest Service, Washington, D.C.

Freethey, G.W.
1982 *Hydrologic Analysis of the Upper San Pedro Basin from the Mexico-United States International Boundary to Fairbank, Arizona.* U.S. Geological Survey Open-File Report, 82-752, 64 p.

Gillilan, D.M.
1992 Institutional Alternatives for Managing Water Resources in the Upper San Pedro River Basin, Arizona. Univ. of Arizona M.S. Thesis, Dept. of Hydrology and Water Resources.

Glinski, R.L.
1977 An Introduction to the Raptors and Habitat of the San Pedro River. Arizona State University, Dept. of Zoology, Tempe, Arizona.

Hastings, James R. and Raymond M. Turner
1965 *The Changing Mile: An Ecological Study of Vegetation Change with Time in the Lower Mile of an Arid and Semi-arid Region.* University of Arizona Press, Tucson.

Hastings, J.R.
1959 Vegetation change and arroyo-cutting in southeastern Arizona. *Journal of Arizona-Nevada Academy of Sciences 1.* 60-67 p.

Hendrickson, Dean A. and William L. Minckley
1984 Clenegas-vanishing climax communities of the American Southwest. *Desert Plants 6.* 130-175 p.

Hereford, Richard
1991 Geomorphic evolution of the San Pedro River channel since 1900 in the San Pedro River Riparian National Conservation Area, southeast Arizona. U.S. Geological Survey Open-File Report 91.
1993 Entrenchment and Widening of the Upper San Pedro River, Arizona. Geological Society of Arizona Special Paper 282. Geological Society of America, Boulder, Colorado.

Hereford, R. and J. Betancourt
1993 Historic Geomorphology of the San Pedro River: Archival and Physical Evidence, in Haynes, C.V. and B.M. Huckell, "Spunge and Clovis Hunters of the San Pedro Valley," University of Arizona Press, Tucson, Arizona.

International Boundary & Water Commission, U.S. and Mexico
1972 Flow of the Colorado River and other Western Boundary Streams and Related Data: Colorado River, Tijuana River, Santa Cruz River, Whitewater Draw, San Pedro River. Western Water Bulletin, 98 p.

Keith, S.J.
1978 Ephemeral Flow and Water Quality Problems - A Case Study of the San Pedro River in Southeastern Arizona. Hydrology and Water Resources in Arizona and the Southwest. Vol. 8, No. 3, p. 42-50.

Lee, W.T.
1905 Notes on the Underground Water of the San Pedro Valley, Arizona. U.S. 58th Congress, 3rd Session, House Document 28, 2nd Edition. Washington, D.C., p. 165-170.

McReynolds, Kim
1988 Riparian Inventory: San Pedro River, San Rafael del Valle and San Juan de la Boquillas y Nogales Land Grants. San Pedro Technical Report #4, Bureau of Land Management, Safford District.

Montegomery, E.L.
1963 The Geology and Ground Water Investigation of the Tres Alamos Dam Site Area of the San Pedro River, Cochise County, Arizona. Univ. of Arizona M.S. Thesis, 61 p.

Newell, F. H.
1904 *Annual Report of Reclamation Service 1902-03.*

Page, H.G.
1963 *Water Regimen of the Inner Valley of the San Pedro River near Mammoth, Arizona (A Pilot Study).* U.S. Geological Survey Water-Supply Paper 1669-I, 22 p.

Putnam, F., et al.
1987 *Water Resources of the Upper San Pedro River Basin, Arizona.* Arizona Department of Water Resources.

Reichardt, K.L., B. Schladweiler, and J.L. Sterling
1978 An Inventory of Riparian Habitats Along the San Pedro River. University of Arizona Office of Arid Lands Studies, Tucson, Arizona, 23 p.

Roeske, R.H. and W.L. Werrell
1971 *Hydrologic Conditions in the San Pedro Valley, Arizona.* U.S. Geological Survey and Arizona Water Commission Bulletin 4, Phoenix, Arizona: Arizona Water Commission, 76 p.

Roeske, R.H. and W.L. Werrell
1973 *Hydrologic Conditions in the San Pedro River Valley, Arizona.* Arizona Water Commission Bulletin 4, 76 p.

San Pedro Interdisciplinary Study Team
1991 *A Study of Water Resources of San Pedro Basin and Options for Efficient-Equitable Water Management.* Water Resources Research Center.

Smith, D.G.
1963 Pleistocene Geology and Geomorphology of the San Pedro River Valley, Cochise County, Arizona. Univ. of Arizona M.S. Thesis.

Stetson Engineers
1988 The Interrelationships of Basin Ground Water and Surface and Subsurface Flow of the San Pedro River Basin, Arizona. Report to the U.S. Department of Justice. October 2, 1987, 28 p. plus appendixes.

Turner, Samuel F.
1961 *Water Resources of the Benson Area.* Turner and Associates, Consulting Geologists and Engineers, Phoenix, Arizona.

Turner, Samuel F.
None *Water Resources of the Cascabel Area.*

U.S. Bureau of Land Management
1987 *(Draft) Assessment of Water Conditions and Management Opportunities in Support of Riparian Values, San Pedro River.* U.S. Department of Interior, Bureau of Land Management, Denver, Colorado.

U.S. Bureau of Reclamation
1974 *San Pedro - Santa Cruz Project, Arizona, Concluding Report.* U.S. Department of the Interior, Bureau of Reclamation.

U.S. Department of Agriculture
1940 *Water Facilities Area Plan for Upper San Pedro Watershed, Arizona.* Water Utilization Section, Division of Land Economics, Department of Agriculture.

U.S. Department of Agriculture - Soil Conservation Service
1977 Santa Cruz-San Pedro River Basin, Arizona, Main Report and Resource Inventory. U.S. Government Printing Office, Washington, D.C. p. 1-24- and 1-323.

U.S. Department of Health Services
- *Upper Gila and San Pedro River Basins Water Quality and Study Report and Recommendations.* Bureau of Water Control, Arizona.

U.S. Department of the Interior
1988 San Pedro River Riparian Management Plan and Environmental Impact Statement, Draft. Bureau of Land Management, Safford District.

U.S. Department of the Interior-Fish and Wildlife Service
1978 Unique Wildlife Ecosystems of Arizona, US F&W, Region II, Albuquerque, New Mexico, 47 p.

University of Arizona
1961 *Suspended Sediment and Chemical Analysis of the San Pedro River at Charleston, Arizona.* Agricultural Experiment Station, University of Arizona.

Vionnet, L.B.
1992 Modeling of the Ground-Water Flow and Surface Water/Ground-Water Interactions of the San Pedro River Basin, Cochise County, Arizona. Univ. of Arizona M.S. Thesis, Dept. of Hydrology and Water Resources.

U.S. Geological Survey
1950 Water Supply Paper No. 1103, *Use of Water by Bottom-Land Vegetation.* Lower Safford Valley, Arizona.

Maps

Alexander, W.B.
- Property of the Bayless and Beralew Company Situated Along the San Pedro River, Arizona.

Arizona State Water Commission
1972 Land Ownership and Administration, Santa Cruz-San Pedro River Basins, Arizona.

Brown, David E., Neil B. Carmony, and Raymond M. Turner
1981 *Drainage map of Arizona showing perennial streams and some important wetlands.* Arizona Game and Fish Department.

1974 Erosion Classification of the Santa Cruz- San Pedro River Basins, Arizona. July.

Appendix C
Note on Historical Sources

A Note on Historical Sources for San Pedro River

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 San Pedro 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 San Pedro 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.

The San Pedro River and Valley are one of the key case studies in Hastings and Turner's (1965) *The Changing Mile*, a study of environmental changes in southern Arizona during historic times. Hastings and Turner reviewed virtually all of the historical descriptions of the San Pedro and rephotographed historic views of southern Arizona landscapes to document arroyo cutting and changes in vegetation. Dobyns (1981), Hastings (1959b), and Hereford and Betancourt (1993) also explore the theme of environmental changes along Sonoran Desert rivers. A similar study by Davis (1982) documents wildlife observed by American explorers in Arizona, and contains numerous and extensive accounts of the San Pedro. Hadley, Warshall, and Bufkin (1991) prepared a history of the ecology of Aravaipa Creek, a major tributary of the San Pedro. This volume deals tangentially with the San Pedro from prehistoric times to the present, and is especially useful in discussing the history of Camp Grant, which is located at the junction of the Aravaipa and the San Pedro.

Other secondary sources that provide general overviews on the history of the San Pedro River include Walker and Bufkin's (1986) *Historical Atlas of Arizona* and Herbert and Campbell's (1986) timeline and social history of the San Pedro River. Hoffman (1982), Jackson (1987), and Powell (1980) are similar secondary works that reference San Pedro River history. Barnes (1988) and Granger (1984; 1985) contain historical information on place names in Arizona. Fulton (1966), Fulton and Bahre (1967), Tiller (1982), and Varney (1980) have information on the mining and milling towns along the San Pedro.

Di Peso (1953) is the best overview of Native American use of the San Pedro Valley. Other useful sources on the historic Native American occupation of the valley are Basso (1983), Bandelier (1890, 1890-92, 1892), Browning (1982), Ezell (1983), Fontana (1983), Hackenburg (1983), and Ogle (1970).

The Coronado expedition has an extensive bibliography (Bolton 1916, 1949, 1990; Day 1964; Di Peso 1951; Haury 1984; Hodge 1933; Hodge and Lewis 1907; Riley 1985; Sauer 1932, 1937; Schroeder 1955, 1956; Udall 1984, 1987; Undreiner 1947; Winship 1896), but a recent study by the National Park Service (NPS 1991) indicates a great deal of uncertainty about Coronado's Route through the region. Di Peso (1953) is a historical archeaological study of Spanish attempts first to missionize and then to colonize the San Pedro and is a thorough account of the history of the San Pedro from the late 1600s to 1800. The missionary activities of Father Eusebio Kino are discussed in many books and articles (Bolton 1916, 1936, 1948, 1960; Burrus 1965, 1971; Kessell 1966a; Smith, Kessell, and Fox 1966). Officer's (1987) study of the Spanish and Mexican period in Arizona provides information on the Spanish and Mexican exploration of the area and is a useful source on Mexican land grants. Hammond (1929), Kessell (1966b, 1966b), Mattison (1946), Thomas (1932, 1941), Williams (1986), and Wyllys (1931) contain information on the San Pedro Valley in the Spanish Period.

James Ohio Pattie's (1883) journal is essentially the only firsthand account of early nineteenth-century fur trappers' use of the San Pedro, but given Pattie's tendency to exaggerate, secondary assessments of his writings (for example, Batman 1984) are useful.

During the Mexican War, topographical engineer William H. Emory accompanied Steven Watts Kearny down the Gila and commented on the lower San Pedro (Emory 1848). John S. Griffen, a surgeon with the expedition also mentioned the San Pedro (Griffen 1943). Philip St. George Cooke (1848, 1938, 1964, 1974), commander of the Mormon Battalion on their journey from Fort Leavenworth, Kansas, to San Diego, California, during the Mexican War, provided relevant observations about the conditions of the San Pedro River Valley in the mid-nineteenth century. Other accounts of the Mormon Battalion include Bigler (1932), Bliss (1931), Golder, Bailey and Smith (1928), and Tyler (1881). One of the principal routes for the forty-niners on their way to the gold fields of California ran along the present border between Arizona and Mexico, and the San Pedro was described by a number of chroniclers (Aldrich 1950; Chamberlain 1945; Clarke 1852; Cox 1925; Durivage 1937; Eccleston 1950; Evans 1945; Harris 1960; Hunter n.d.; Pancoast 1930; Powell 1931). In the 1850s, the international boundary between the United States and Mexico was formally surveyed, and the San Pedro was described again (Bartlett 1854; Emory 1857). Still later, surveys for a railroad (Parke 1857) and a wagon road (Hutton 1859; Leach 1858) resulted in descriptions of the area. Other early travelers' descriptions of the San Pedro include Bell (1932), Bell (1869), Gray (1856), Ormsby (1952), and Tevis (1954). The Surgeon General's (1870) evaluation of Camp Grant includes descriptions of the San Pedro River, as do Bourke's (1891) accounts of life at Camp Grant.

A number of early histories and boosters' descriptions of Arizona (Adams 1930; Bancroft 1888; Farish 1915; Hamilton 1884; Hodge 1877; McClintock 1916; Wallace W. Elliot & Co. 1884) 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. Secondary sources on the history of transportation in the San Pedro Valley include Conkling and Conkling (1947) and Richardson (1925) on the Butterfield Stage and Greever (1957) and Myrick (1968, 1975) on railroads.

Newspapers were the greatest source of accounts of boating on the Salt River, but contained no accounts of boating on the San Pedro. 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 1873 and 1918. Maps were not made for national forests, Indian reservations, or land grants. These maps provide information on activities along the river--including Camp Grant, a parade ground, towns, a Mormon settlement, ranches, houses, barns, corrals, acequias, irrigation ditches, fields, roads, stage stations, a railroad, telegraph lines, a telephone line, a pipeline, and other sites--during the period around the time of statehood. The maps showing the San Pedro River did not illustrate any sites associated with boating.

Sanborne 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 San Pedro River did not illustrate any sites associated with navigation.

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. According to museum photo-archivist Boyd Nichol, the Bisbee Mining and Historical Museum has a 1908 photograph of a bridge over the San Pedro and photographs of picnics held along the river.

Appendix D
San Pedro River Oral History

THIS IS A GENERAL SAMPLE LETTER SENT OUT TO INDIVIDUALS AND INSTITUTIONS. SOME THINGS WERE ADDED AND OTHER THINGS DELETED DEPENDING ON WHO WAS TO GET THE LETTER.

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 Oral History Contacts

4/16/93

Bisbee Mining and Historical Museum
P.O. Box 14
Bisbee, AZ 85603
Tel: 602-432-7071

The Bisbee Mining and Historical Museum does not have relevant information on river navigation. Museum secretary said that the museum photo-archivist Boyd Nichol found a photo of a bridge over the (San Pedro) river during 1908. In addition, the museum has photos of picnics that were apparently an annual event near the river. The secretary also mentioned that a major earthquake occurred around the turn of the century, maybe 1908, that realigned the water table and most of the river went underground then. She said that it drastically changed the route of the river and water accessibility. Other reasons she mentioned for the change in water accessibility were overgrazing, drought, cattle.

[The actual date of the earthquake was 1887.]

4/14/93

Cochise County Historical and Archaeological Society
P.O. Box 818
Douglas, AZ 85607
Tel: 602-364-5226

The Cochise County Historical and Archaeological Society does not have any information on navigation on the San Pedro River. Cindy Hayostek, contact person, said that Douglas is a valley over from the San Pedro River Valley, but that the Society does have a time-line for the San Pedro River Valley done by Harold E. Herbert. She mentioned a copy of this time-line would be sent to SWCA. She mentioned two references on the time-line, but that these addresses and phone numbers may be old and out of date:

Harold E. Herbert
201 Cole Ave., #3
Bisbee, AZ 85603
Tel: 602-432-4538

Eric Campbell
BLM
Fairbank, AZ
Tel: 602-457-3395

Ms. Hayostek also provided the names of two people who would be good to contact for further information:

Jerry Pratt
3000 Meadowlark Drive
Sierra Vista, AZ
Tel: 602-458-0971

Mrs. Eva Moson-Bradshaw
Y Lightning Ranch
Hereford, AZ
Tel: 602-378-2204

Mr. Pratt is a retired wildlife biologist and is very knowledgeable about the San Pedro. Mrs. Moson-Bradshaw is an elderly resident of the area and may be able to give an eye-witness account of the San Pedro at the time of statehood. Ms. Hayostek said that Mrs. Bradshaw's family was associated with Col. Green. [Although Ms. Hayostek did not elaborate on Col. Green, he was prominent in the establishment of Douglas as a mining town.]

[The Cochise County Historical and Archaeological Society later sent a copy of the time-line.]

4/15/93

Gila County Historical Museum
P.O. Box 2891
Globe, AZ 85501
Tel: 602-425-7385

Staff person on duty, Bob Rosen, said that he didn't think that the museum had anything on navigation on the rivers in Arizona. He suggested we contact Mammoth or Winkelman because they would better places to check for information. He said that the San Pedro River was bone dry most of the time. It was the gateway into the area from Mexico and that both Father Kino and Coronado used the river as a travel corridor. He also thought that there might be a dam somewhere along it but he didn't know where it was located. He said that there were a couple of mines along the river but he didn't know how they would use the water.

7-29-93

Holy Trinity Monastery
1605 S. Saint Mary's Way
Saint David, Arizona 85630
Tel: 602-720-4642

Talked to Brother Tom of the Monastery. He said that their involvement with the San Pedro has been for conservation of riparian habitat. They don't have any information about the historical use of the river. He suggested calling the Benson Historical Museum (586-3070) or the BLM, which has a department that has collected information on the San Pedro Valley Riparian Area.

7-26-93

McFarland State Historic Park
P.O. Box 109
Florence, Arizona 85232
Tel: 602-868-5216

Talked to Dan Brown. He didn't know of any pertinent information at the Park for the San Pedro River. He said their information was probably all related to the Gila River.

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.

4-21-93

Pinal County Historical Society
P.O. Box 851
Florence, Arizona 85232
Tel: 602-868-4382

The Pinal County Historical Society does not have any information on river navigation in their records. Contacted Della Meadows (602-868-4184), historian for the Society, who said that she has no information on the rivers, knows of no historical use, but then she said she has not had a chance to verify, and will check soon. She mentioned there was farming along the San Pedro River, and that recent work regarding the preservation of the San Pedro has documented some San Pedro history. The Pinal County Museum is only 30-35 years old and has no pictures or any other type of information on mills, dams, reservoirs, etc. The museum has information on irrigation. Other information is through word of mouth. She mentioned the use of a ferry across the Gila River by Florence. The museum has the voter registration records from the late 1880s but that it was incomplete. She said that any information she would have on the river would be fairly recent.

[Ms. Meadows sent a letter on April 30, 1993, which included photographs of the Gila River ferry at Florence, copied from her book *"Where Two or Three Are Gathered": Centennial History, First Presbyterian Church, Florence, Arizona.*]

4-20-93

San Pedro Valley Arts & Historical Society Museum
P.O. Drawer 1090
Benson, AZ 85602
Tel: 602-586-3070

According to Helen Hume, President, the San Pedro Valley Arts & Historical Society Museum, does not have any information on pre-1912 use of the San Pedro River for navigation. She said that the museum does not have information on pre-statehood use of the river. Regarding early pioneer, trappers, etc. information she said that the museum had no information either. The former museum burned down in 1982, she said, and that a large amount of material was lost, but she is unsure about what is really in the museum's archives. Ms. Hume suggested contacting the monastery in Saint David. She said the monastery had just won an award for riparian conservation along the San Pedro. Address:

Holy Trinity Monastery
1605 S. Saint Mary's Way
Saint David, Arizona 85630
(602) 720-4642

She also mentioned that her neighbor and former museum director by the name of Nedra Sunderland, 602-586-3473, was doing an oral history of the area, and that she should be contacted. Ms. Hume provided the name of one person who might be of help, and who was being interviewed by Nedra as we spoke: Louise Larson, 602-586-2964.

8-25-93

Talked to Rose Land of the San Pedro Valley Arts & Historical Society Museum. She doesn't know of any documentation at the museum that would pertain to navigability. She suggested contacting the BLM office at Fairbank or the San Pedro Riparian Conservation District for information.

4-9-93

Tombstone Courthouse State Historic Park
P.O. Box 216
Tombstone, Arizona 85638
Tel: 602-457-3311

Hollis N. Cook, park manager, sent a letter describing the archival holdings of the Tombstone Courthouse State Historic Park. He mentioned irrigation, dams, and smelters along the San Pedro. He also stated, "We find the notion of the San Pedro being navigable preposterous, however perhaps `navigable' isn't defined in the obvious way."

7-15-93

Jay Bateman
Florence, Arizona
Tel:602-868-6442

He has lived in the area around the San Pedro all his life. He said that there used to be pretty good swimming holes in some spots along the river but he didn't know of any other recreational or commercial use of the river. His family used to joke to tourists about taking the ferry down the San Pedro and Gila to Yuma.

8-11-93

Carl Black
St. David, Az
602-720-4671

Mr. Black is a board member of the St. David Irrigation District. St. David was founded in 1877 and they started digging an irrigation canal that year. Originally irrigation was done from surface "ponds". The canal was finished in 1878. The District dug a new ditch in 1926; that was the last time that any major work was done by the District. A pump was put in in the early 1950s. The irrigation ditch takes water out of the river about 7 months of the year; water is pumped the rest of the time when the river is dry. The District probably has some records on the river around 1912 but Mr. Black doesn't know where they are. He thought that Lorena Merrill (720-4736), secretary of the Irrigation District, may know where the records are kept. He thinks that the LDS church in St. David probably has a lot of records on the river.

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 Tumanoc 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.

6-14-93

Mary Lou Heuett
Cultural and Environmental Systems, Inc.
Tucson, Arizona 85702-2324
(602) 622-2782

Ms. Heuett has done work on the Santa Cruz, Hassayampa and San Pedro, but all of this work has been archaeological. Her research has not uncovered any references on navigation for any of these rivers. She was very brief and to the point. This was all that she mentioned.

4-27-93

Ken Kimsey, Historian
P. O. Box 2549
Prescott National Forest
Prescott, Arizona 86301
Tel: 602-445-1762

Mr. Kimsey didn't feel he was knowledgeable enough regarding rivers, and suggested we consult James Ohio Pattie's journals, because Pattie rafted down the Salt River. He also suggested we talk with Mr. Polzer of the San Xavier del Bac Mission in Tucson for information on the uses of the San Pedro by Spaniards and Mexicans prior to U.S. occupation. He personally didn't think either one of those groups would have used the San Pedro for navigation because of the settlement patterns of these two groups, but that Mr. Polzer would know about specific uses of the river. He didn't have any other information but he wanted more time to think about this issue. Mr. Kimsey said he would call back as soon as he had more information.

7-27 and 28-93

Louise Larson
Benson
Tel: 602-586-2964

She has been a resident of the area for many years. Diversion dams have been built in the San Pedro river to get water for irrigation. When she was a child (she is now in her 70s) she remembers that there was only a small amount of water in the river. Only time now that there is a continual flow is when there is snow in the nearby mountains. Her parents talked about how the river used to be much narrower. When she was in 8th Grade in 1935, she made up a story for her class about taking a boat ride down the river. She said that there has never been much water in the river; irrigation, which is still practiced today, can only be done during particular seasons. A flood in 1926 washed out a diversion dam between St. David and Pomerene. The Benson Canal Company was formed in 1908 (she has some of the original records of that company). Around 1940, there was a tungsten mill on the river at Pomerene. The tungsten was mined from nearby mountains and processes at the mill but she didn't know exactly how the river water was used for the mill.

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.

8-13-93

Dora Ohnesorgen
204 E. Walker
Benson, AZ 85602
Tel: 602-586-2873
Her grandfather had a toll ferry (raft) on the San Pedro, right below Pomerene. He also had a stage coach that ran from Tombstone to Tucson; it lasted about 2 years. Her grandfather came to the area in the 1870s. He told her father stories about beaver in the river. The grandfather had written memoirs with the help of a women named Kit(?) and Mrs. Ohensorgen thought that her brother had a copy of these (Jerry Onhesorgen 586-9135). Also, Tom Peterson who works (possibly retired now) at the Arizona Historical Society in Tucson wrote a thesis or dissertation on the area and had interviewed the Ohnesorgen family. She also mentioned a man named Albert Bernal, who is familiar with the area.

10-13-93

Terry O'Sullivan
Bureau of Land Management
Tel: 602-650-0509

Mr. O'Sullivan was asked about research done by the Bureau of Land Management on suitability of the Hassayampa and the San Pedro for designation as National Wild and Scenic Rivers. Mr. O'Sullivan said that preliminary reports on the suitability of these two rivers had been completed. According to Mr. O'Sullivan, the reports did not contain much history; instead, they focused on resource values, land use, habitat, and so forth. Mr. O'Sullivan did not know of any reference to navigation or boating in either of the reports, but he suggested talking to the authors (Don Ducote [602-722-4289] for the San Pedro and Jack Ragsdale [602-780-8090] for the Hassayampa) to see if they came across anything relating to navigability during the studies. The preliminary determinations were that the Hassayampa was not suitable for inclusion in the National Wild and Scenic Rivers System, while the San Pedro was suitable. Copies of the two reports were supplied to the Arizona State Land Department.

7-15-93

Geoff Parker
Soil Conservation Service
Route 1
Box 226
Douglas, AZ 85607
364-2001

He had no specific information on the historical uses of the San Pedro. He suggested contacting the USGS in Tucson where he feels is a lot of data on this river.

7-19-93

Jerry Pratt
3000 Meadowlark Drive
Sierra Vista, AZ
Tel: 602-458-0971

Jerry Pratt is a retired wildlife biologist. He said that he had heard of early trappers who used to use boats on the San Pedro. Les Goodding, who moved to Bisbee from Kansas in 1906, told Pratt stories that had been related to him and that he had experienced. Pratt said he had heard of beaver dams on the river and that he thought the river had been navigable before the big earthquake, which changed the river. He said that a good source of information was a PhD dissertation: Goode P. Davis (1982) Man and Wildlife in Arizona: The American Exploration Period 1824-1865. Published by the Fish and Wildlife Service in cooperation with the University of Arizona. Pratt also mentioned that James Herrewig, a planner with the City of Sierra Vista, had been involved with some of the historical research done by the BLM along the San Pedro.

7-26-93

Nedra Sunderland
Tel: 602-586-3473

She is active in the local historical society but said that she didn't have much information. She said that the Benson Canal come off of the San Pedro some years ago. She also said that the Ohnesorgen family had information about the river (Doris Ohnesorgen 586-2873, 586-9135). The Ohnesorgen's grandfather had a ferry across the San Pedro.

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.

7-19-93

Dean Young
Chief Hydrologist
Arizona State Attorney General's Office
Tucson, Arizona
Tel: 602-628-8447

His experience has been with the fluvial geomorphology of the River. He doesn't have any historical data. He suggested contacting Mary Lu Moore, Research Historian for the Water Resource Adjudication Team (WRAT). Her number is 542-1401.

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. He also mentioned boating on Walnut Grove Reservoir on the Hassayampa. He did not know of any accounts of boating on the San Pedro.

Appendix E
San Pedro River Hydraulic Rating Curves

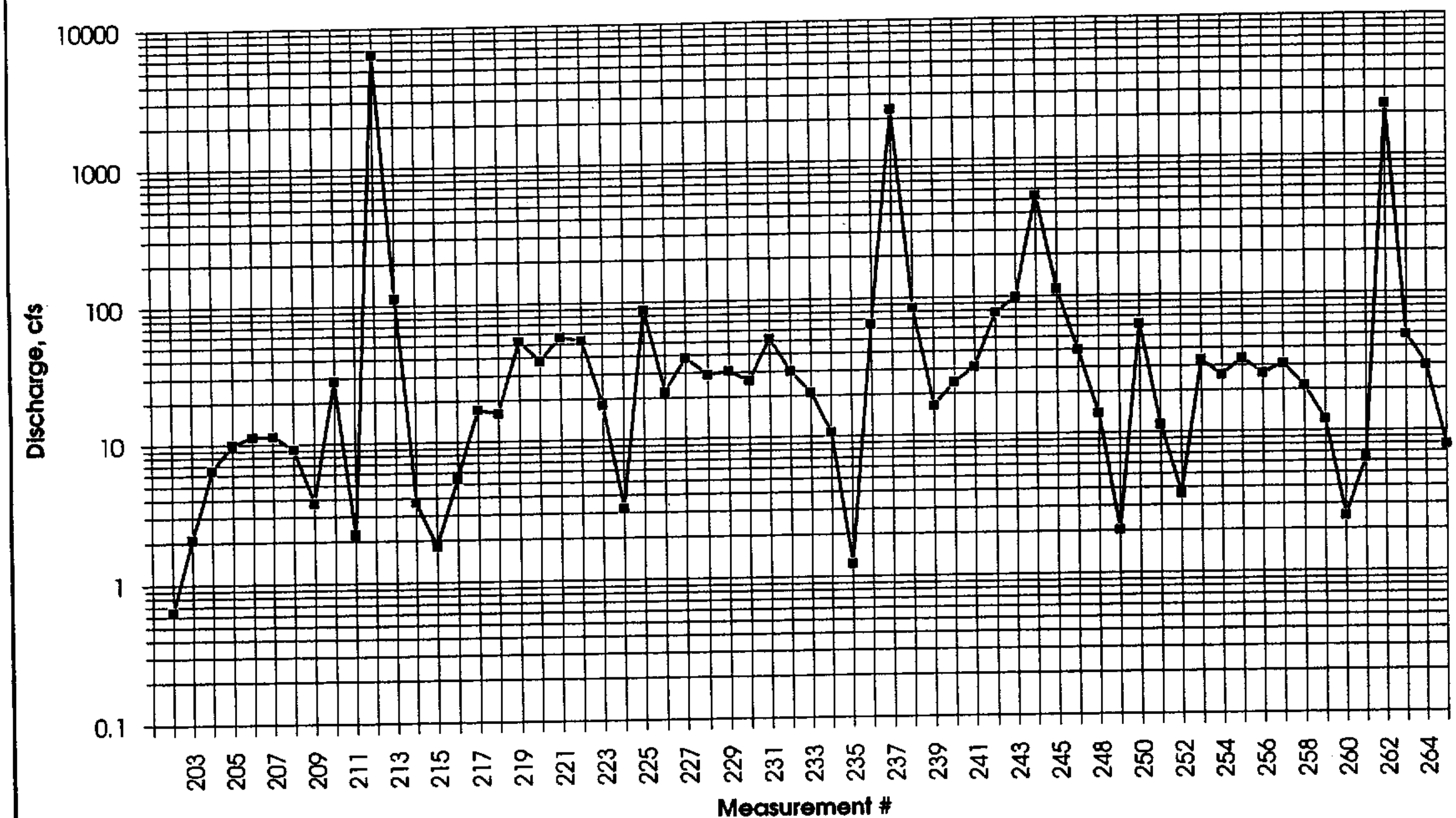
SAN PEDRO RIVER NEAR TOMBSTONE						
1981 - 1986						
Meas #	Width	Area	Velocity	Gage H.	Discharge	Depth
202	2.9	0.65	0.98	2.74	0.64	0.22
203	14	2.34	0.89	2.85	2.08	0.17
204	17.5	5	1.29	2.94	6.44	0.29
205	17	6.2	1.6	2.93	9.89	0.36
206	12.5	6.08	1.86	2.93	11.3	0.49
207	13.5	6.09	1.87	2.94	11.4	0.45
208	12.3	5.42	1.69	2.92	9.16	0.44
209	9.3	3.73	1.01	2.8	3.77	0.40
210	34.2	15.8	1.78	3.02	28.2	0.46
211	8	3.35	0.66	2.52	2.21	0.42
212				7.9	6500	
213	53.5	46	2.46	3.36	113	0.86
214	9	2.96	1.25	2.71	3.7	0.33
215	4.1	1.46	1.23	2.61	1.8	0.36
216	8.5	3.69	1.46	2.74	5.41	0.43
217	24.5	12.3	1.38	3.04	17	0.50
218	25.5	12	1.33	3.05	16	0.47
219	68.8	32.8	1.61	3.24	52.9	0.48
220	39.5	22.7	1.65	3.16	37.5	0.57
221	58.5	31.4	1.79	3.16	56.2	0.54
222	42	30.8	1.71	3.14	52.6	0.73
223	32.4	12.6	1.42	2.87	17.9	0.39
224	8.6	2.66	1.2	2.67	3.2	0.31
225	88	49	1.79	3.37	87.7	0.56
226	36	13.9	1.57	2.82	21.8	0.39
227	52	23	1.23	3.14	38.2	0.44
228	59	19.2	1.51	3.1	28.9	0.33
229	35.5	19	1.6	3.07	30.4	0.54
230	35.5	15.2	1.7	3.05	25.9	0.43
231	56.5	29.2	1.77	3.2	51.8	0.52
232	32	17.4	1.72	3.18	30	0.54
233	24.5	12.4	1.69	3.12	20.9	0.51
234	15.2	7.4	1.45	3.02	10.7	0.49
235	3.8	1.21	1.01	2.9	1.22	0.32
236	55	37	1.75	3.12	64.8	0.67
237	170	399	5.81	5.36	2320	2.35
238	75	43.5	1.93	3.12	84.1	0.58
239	44.5	13.9	1.17	2.92	16.3	0.31
240	34	15.9	1.51	2.89	24	0.47
241	30.4	16.6	1.86	2.95	30.8	0.55
242	80	39.3	1.93	3.25	76	0.49
243	62	50.2	1.98	3.24	99.5	0.81
244	97	169	3.17	4.2	536	1.74

245	80	60.5	1.85	3.38	112	0.76
247	42	24.5	1.62	3.09	39.6	0.58
248	30.4	9.17	1.5	2.85	13.8	0.30
249	7.7	1.76	1.14	2.68	2.01	0.23
250	80	33.8	1.8	3.3	60.9	0.42
251	20	8.3	1.36	2.88	11.3	0.42
252	10.1	3.04	1.18	2.57	3.61	0.30
253	44.8	20.3	1.62	3.01	32.8	0.45
254	35.6	15.4	1.66	2.93	25.6	0.43
255	45	20.3	1.64	3.03	33.3	0.45
256	44	16.6	1.57	2.99	26	0.38
257	44	19.2	1.59	3.04	30.5	0.44
258	36.8	14.9	1.42	3.01	21.1	0.40
259	23.5	8.11	1.48	2.88	12	0.35
260	5.8	1.94	1.27	2.56	2.46	0.33
261	9	4.37	1.43	2.82	6.25	0.49
262	167	405	5.67	5.63	2300	2.43
263	45	28.2	1.72	2.93	48.6	0.63
264	46.5	19.2	1.52	3.13	29.1	0.41
265	12.3	5.62	1.39	2.89	7.82	0.46

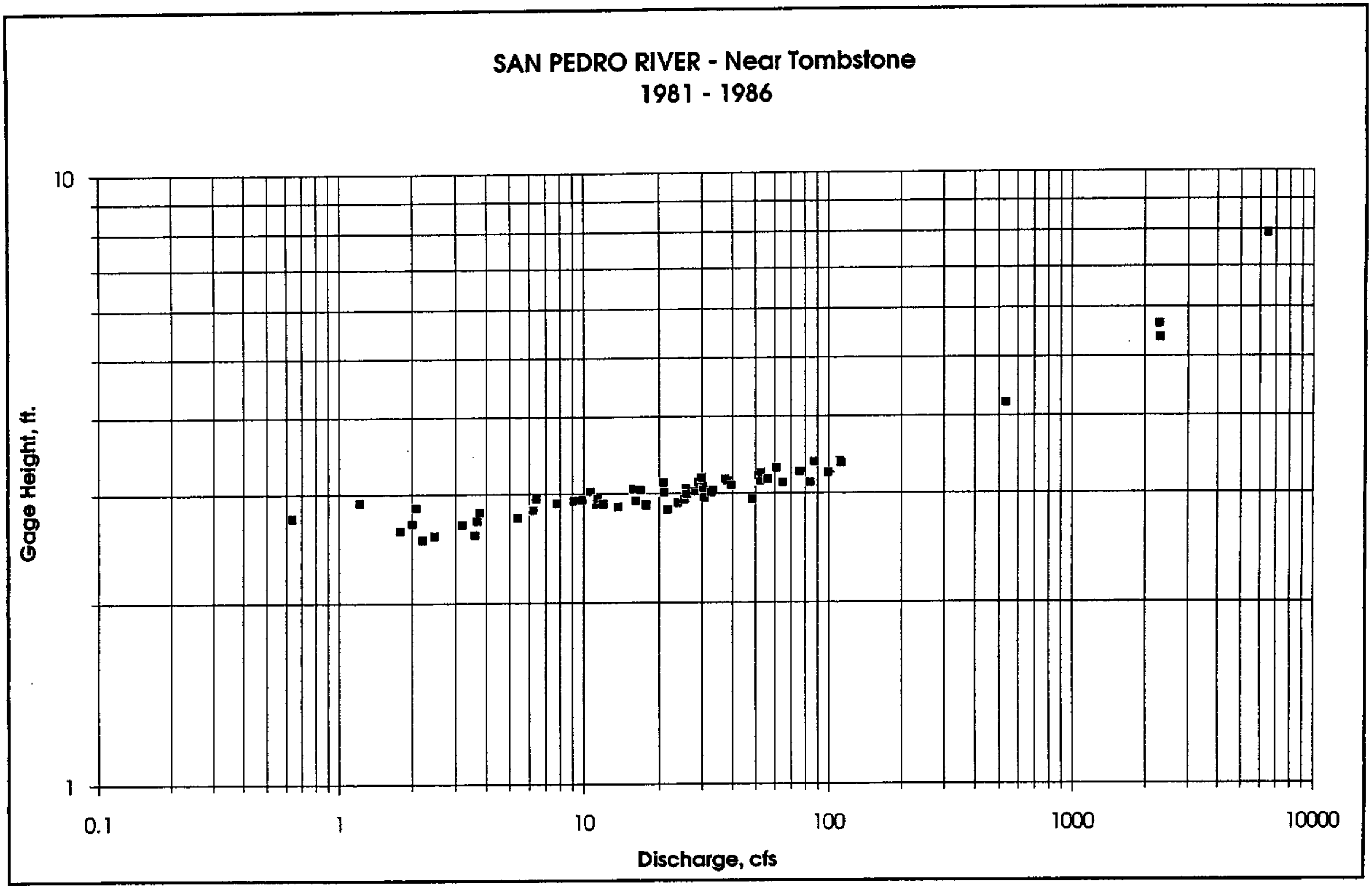
SAN PEDRO RIVER NEAR TOMBSTONE						
2) Sorted w.r.t. Q						
Meas #	Discharge	Width	Area	Velocity	Gage H.	Depth
202	0.64	2.9	0.65	0.98	2.74	0.22
235	1.22	3.8	1.21	1.01	2.9	0.32
215	1.8	4.1	1.46	1.23	2.61	0.36
249	2.01	7.7	1.76	1.14	2.68	0.23
203	2.08	14	2.34	0.89	2.85	0.17
211	2.21	8	3.35	0.66	2.52	0.42
260	2.46	5.8	1.94	1.27	2.56	0.33
224	3.2	8.6	2.66	1.2	2.67	0.31
252	3.61	10.1	3.04	1.18	2.57	0.30
214	3.7	9	2.96	1.25	2.71	0.33
209	3.77	9.3	3.73	1.01	2.8	0.40
216	5.41	8.5	3.69	1.46	2.74	0.43
261	6.25	9	4.37	1.43	2.82	0.49
204	6.44	17.5	5	1.29	2.94	0.29
265	7.82	12.3	5.62	1.39	2.89	0.46
208	9.16	12.3	5.42	1.69	2.92	0.44
205	9.89	17	6.2	1.6	2.93	0.36
234	10.7	15.2	7.4	1.45	3.02	0.49
206	11.3	12.5	6.08	1.86	2.93	0.49
251	11.3	20	8.3	1.36	2.88	0.42
207	11.4	13.5	6.09	1.87	2.94	0.45
259	12	23.5	8.11	1.48	2.88	0.35
248	13.8	30.4	9.17	1.5	2.85	0.30
218	16	25.5	12	1.33	3.05	0.47
239	16.3	44.5	13.9	1.17	2.92	0.31
217	17	24.5	12.3	1.38	3.04	0.50
223	17.9	32.4	12.6	1.42	2.87	0.39
233	20.9	24.5	12.4	1.69	3.12	0.51
258	21.1	36.8	14.9	1.42	3.01	0.40
226	21.8	36	13.9	1.57	2.82	0.39
240	24	34	15.9	1.51	2.89	0.47
254	25.6	35.6	15.4	1.66	2.93	0.43
230	25.9	35.5	15.2	1.7	3.05	0.43
256	26	44	16.6	1.57	2.99	0.38
210	28.2	34.2	15.8	1.78	3.02	0.46
228	28.9	59	19.2	1.51	3.1	0.33
264	29.1	46.5	19.2	1.52	3.13	0.41
232	30	32	17.4	1.72	3.18	0.54
229	30.4	35.5	19	1.6	3.07	0.54
257	30.5	44	19.2	1.59	3.04	0.44
241	30.8	30.4	16.6	1.86	2.95	0.55
253	32.8	44.8	20.3	1.62	3.01	0.45
255	33.3	45	20.3	1.64	3.03	0.45

220	37.5	39.5	22.7	1.65	3.16	0.57
227	38.2	52	23	1.23	3.14	0.44
247	39.6	42	24.5	1.62	3.09	0.58
263	48.6	45	28.2	1.72	2.93	0.63
231	51.8	56.5	29.2	1.77	3.2	0.52
222	52.6	42	30.8	1.71	3.14	0.73
219	52.9	68.8	32.8	1.61	3.24	0.48
221	56.2	58.5	31.4	1.79	3.16	0.54
250	60.9	80	33.8	1.8	3.3	0.42
236	64.8	55	37	1.75	3.12	0.67
242	76	80	39.3	1.93	3.25	0.49
238	84.1	75	43.5	1.93	3.12	0.58
225	87.7	88	49	1.79	3.37	0.56
243	99.5	62	50.2	1.98	3.24	0.81
245	112	80	60.5	1.85	3.38	0.76
213	113	53.5	46	2.46	3.36	0.86
244	536	97	169	3.17	4.2	1.74
262	2300	167	405	5.67	5.63	2.43
237	2320	170	399	5.81	5.36	2.35
212	6500				7.9	

SAN PEDRO RIVER - Near Tombstone
1981 - 1986

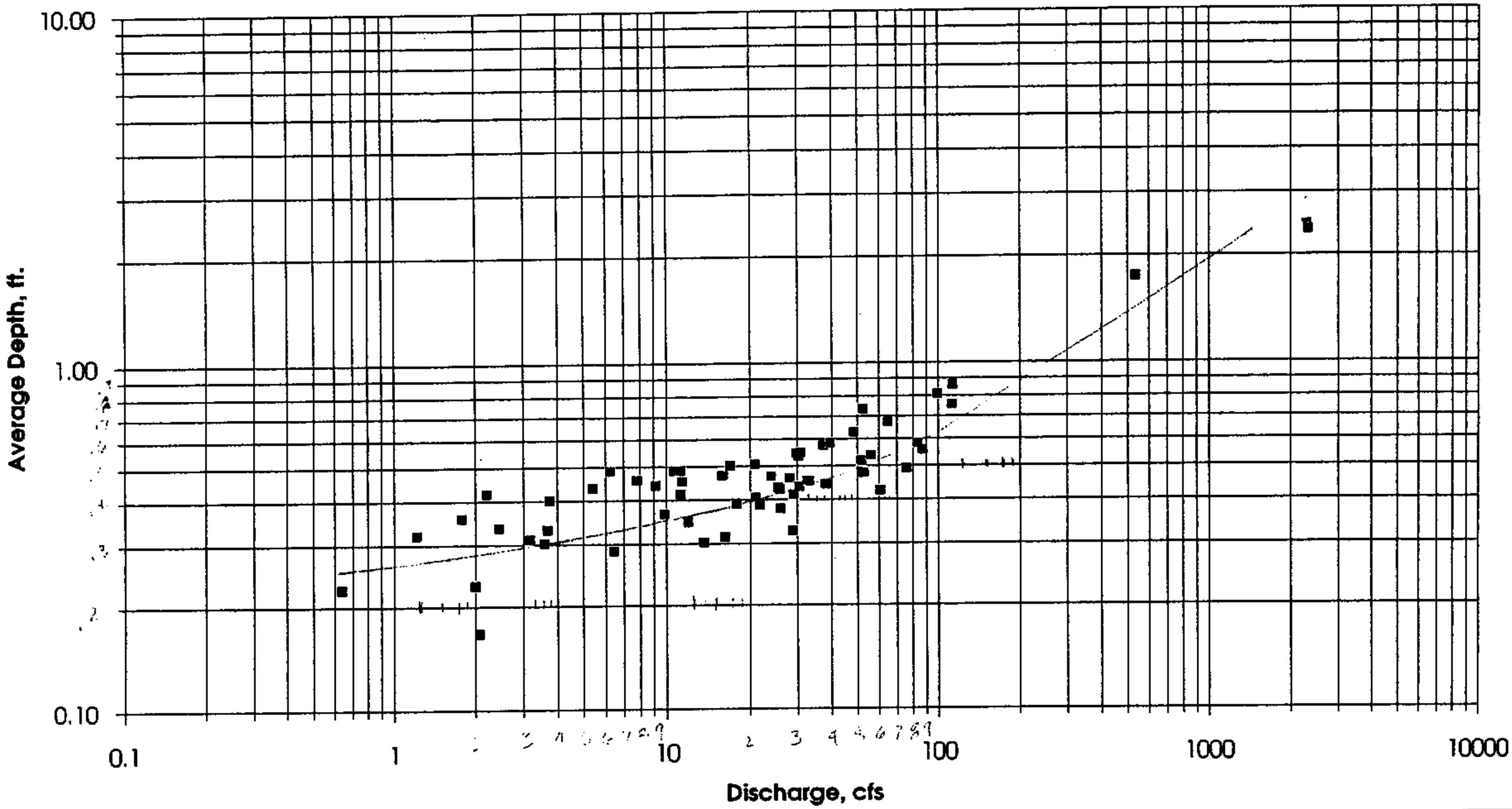


SPT-M-Q.XLC

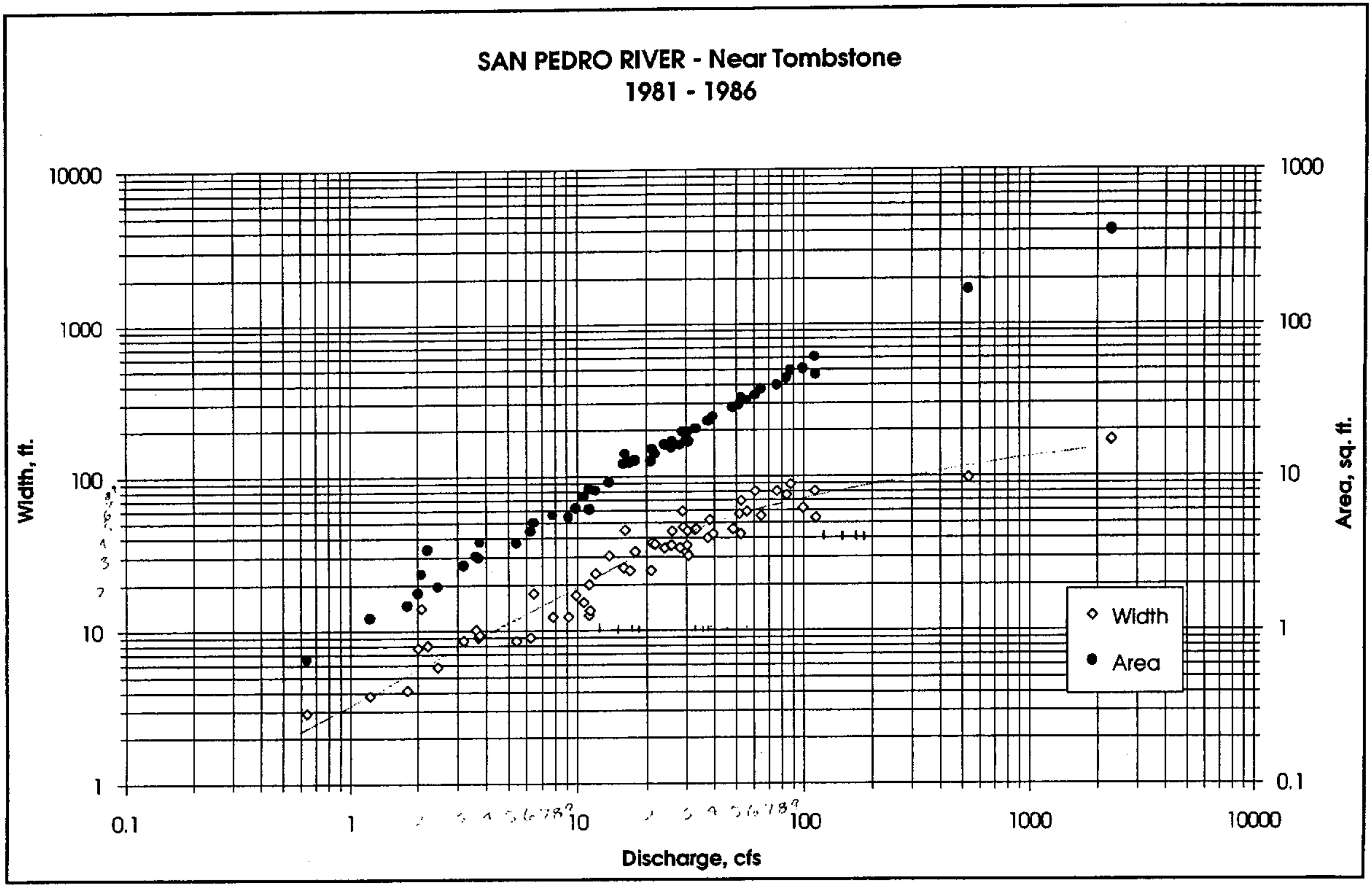

SAN PEDRO RIVER - Near Tombstone
1981 - 1986
Gage Height, ft.
10
1
0.1
1
10
100
1000
10000
Discharge, cfs

SPT-Q-GH.XLC

SAN PEDRO RIVER - Near Tombstone
1981 - 1986

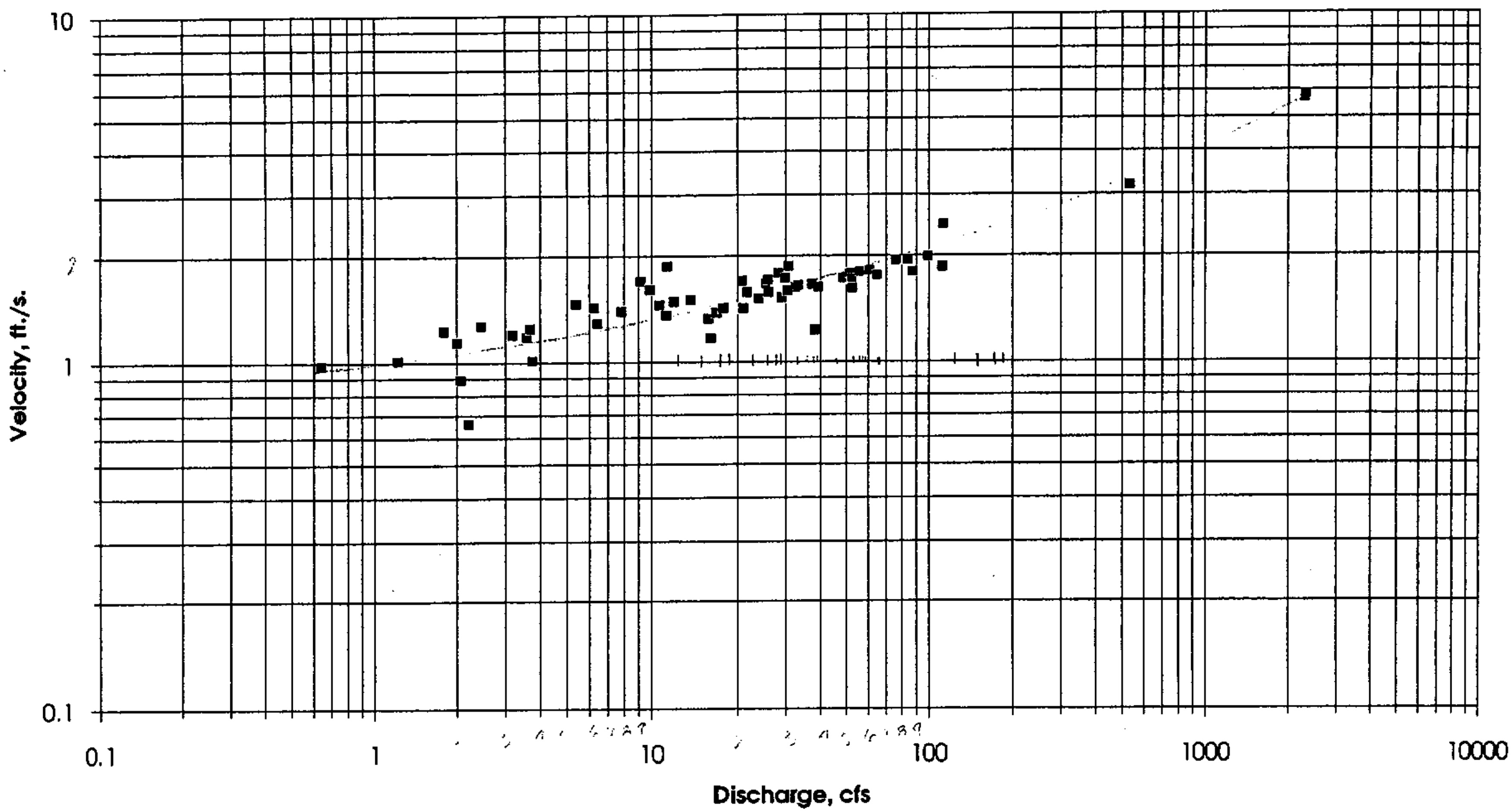


SPT-Q-D.XLC


SAN PEDRO RIVER - Near Tombstone
1981 - 1986
Width, ft.
Area, sq. ft.
Discharge, cfs
Width
Area
0.1
1
10
100
1000
10000

SPT-Q-WA.XLC

SAN PEDRO RIVER - Near Tombstone
1981 - 1986



SPT-Q-V.XLC

SAN PEDRO AT CHARLESTON

1982 - 1992

1) Original Data

date	width	area	velocity	gage h	discharge	depth
1/25/82	23	8.62	1.05	2.17	10.1	0.4
2/22/82	24	9.58	1.10	2.22	10.5	0.4
3/25/82	23	8.38	1.12	2.25	9.4	0.4
4/26/82	15.2	49	1.05	2.16	5.0	3.2
5/24/82	6	1.97	1.23	1.99	2.4	0.3
6/24/82	2	0.65	1.18	1.95	0.8	0.3
7/26/82	24	19.2	1.07	2.29	20.6	0.8
8/27/82	9.5	3.88	1.22	2.05	4.7	0.4
9/10/82	116	225	3.01	4.66	678.0	1.9
9/10/82	100	157	2.75	4.14	432.0	1.6
9/10/82				8.00	8700.0	
9/14/82	55	60	1.47	2.82	88.2	1.1
9/27/82	13	8.53	0.74	2.08	6.3	0.7
10/25/82	12.8	4.67	0.85	2.16	4.0	0.4
11/22/82	17	6.07	0.98	2.25	5.9	0.4
12/28/82	31.5	17.6	0.97	2.33	17.1	0.6
1/24/83	29	13.7	1.06	2.34	14.5	0.5
2/4/83				5.65	1900.0	
2/15/83	69.7	38.2	1.30	2.71	49.8	0.5
2/20/83	32	23.5	1.53	2.60	35.9	0.7
3/17/83	56.5	31.8	1.48	2.75	47.0	0.6
3/27/83	56	39	1.47	2.82	57.2	0.7
4/26/83	49	15.5	1.10	2.55	17.1	0.3
5/24/83	14.3	4.5	1.17	2.38	5.2	0.3
6/27/83	6.9	1.88	1.06	2.27	2.0	0.3
7/21/83	6.1	2.18	1.10	2.30	2.4	0.4
8/12/83	58	45.4	1.32	2.86	59.8	0.8
8/25/83	8.2	3.51	1.22	2.13	4.3	0.4
9/27/83	33.5	12.4	1.09	2.24	13.5	0.4
10/4/83	87	289	3.70	5.03	1070.0	3.3
10/12/83	54	44	1.39	2.78	61.2	0.8
10/25/83	36.6	19.1	1.34	2.47	25.6	0.5
11/28/83	36	24	1.25	2.69	29.9	0.7
12/29/83	36.2	18.4	1.21	2.64	22.2	0.5
1/25/84	36	23.1	1.71	2.74	39.6	0.6
2/26/84	36	16.1	1.42	2.63	22.8	0.4
3/27/84	20.9	13.5	1.15	2.60	15.5	0.6
4/24/84	11.6	8.58	1.14	2.46	9.8	0.7
5/27/84	5	3.06	1.13	2.20	3.4	0.6
6/25/84	3	2.96	1.20	2.30	3.1	1.0
7/22/84	44	52.9	1.64	2.93	86.6	1.2
8/6/84	85	292	4.45	5.48	1300.0	3.4

8/26/84	47	43.2	1.76	2.98	75.9	0.9
9/24/84	37	11.9	1.25	2.58	14.9	0.3
10/25/84	37	17.3	1.23	2.50	21.2	0.5
11/26/84	36.5	19.3	1.28	2.53	24.8	0.5
12/27/84	37.5	29.6	1.89	2.86	55.9	0.8
1/10/85	45.5	46.7	1.67	2.94	78.1	1.0
1/28/85	67	145	2.77	3.99	401.0	2.2
2/24/85	46.5	46.4	1.74	2.92	80.6	1.0
3/25/85	42	26.4	1.41	2.50	37.3	0.6
4/27/85	29	16.2	1.28	2.32	20.8	0.6
5/23/85	17.2	8.42	1.17	2.02	9.8	0.5
6/14/85	6.2	2.09	1.48	1.76	3.1	0.3
6/23/85	10	3.02	1.24	1.77	3.7	0.3
7/24/85	45	40.4	1.58	2.74	63.7	0.9
8/7/85	39.1	14.3	1.22	2.20	17.5	0.4
8/22/85	25	9.88	1.26	2.17	12.5	0.4
9/25/85	14.5	4.77	1.34	2.03	6.4	0.3
10/27/85	40.8	23.8	1.45	2.48	34.4	0.6
11/25/85	36	19.7	1.09	2.26	21.4	0.5
12/27/85	38	20.4	1.24	2.37	25.3	0.5
1/26/86	36.5	19	1.11	2.26	20.9	0.5
2/23/86	37.9	21.3	1.28	2.37	27.2	0.6
3/27/86	35.4	22.5	0.84	2.33	18.8	0.6
4/23/86	27	13.3	0.87	2.08	11.6	0.5
5/22/86	9.9	4.98	0.95	1.81	4.7	0.5
6/26/86	8	3.42	0.73	1.77	2.5	0.4
7/18/86	78	126	2.89	4.10	364.0	1.6
7/30/86	23.4	9.02	1.18	2.24	10.2	0.4
8/18/86	98	364	5.66	5.94	2090.0	3.7
8/18/86	117	530	5.87	6.75	3110.0	4.5
8/21/86	47	29.2	1.55	2.50	45.4	0.6
9/9/86	42	20.3	1.47	2.59	29.8	0.5
9/29/86	15.3	7.83	1.30	2.34	10.2	0.5
10/28/86	16.1	864	1.24	2.14	10.7	53.7
11/25/86	26	10.2	1.54	2.25	15.8	0.4
12/16/86	33.7	17	1.36	2.36	23.2	0.5
12/29/86	41	15.2	1.48	2.52	22.0	0.4
1/29/87	19	12.7	1.48	2.34	18.8	0.7
2/26/87	20	14.6	1.66	2.36	24.2	0.7
3/27/87	19.5	12.8	1.41	2.22	18.0	0.7
4/28/87	64	88		3.62	250.0	1.4
4/29/87	28.5	18.3	1.38	2.36	25.2	0.6
5/5/87	23.3	9.72	1.33	2.08	13.0	0.4
5/28/87	16.8	5.58	1.11	1.87	6.0	0.3
6/30/87	6.1	2.06	0.86	1.85	1.8	0.3
7/30/87	18	5.19	1.12	2.09	5.8	0.3
8/27/87	65	62.9	2.16	3.40	136.0	1.0
9/18/87	13	4.48	1.31	2.15	5.9	0.3
9/25/87	55	55.2	2.08	3.05	115.0	1.0

10/27/87	20	6.73	1.00	2.03	6.8	0.3
11/23/87	17.4	8.89	1.38	2.14	12.3	0.5
12/9/87	22	8.64	1.25	2.14	10.8	0.4
12/23/87	36	14.5	1.42	2.40	20.6	0.4
1/13/88	30.5	12.2	1.25	2.26	15.3	0.4
1/27/88	30	12.7	1.35	2.29	17.2	0.4
2/22/88	27.8	11.1	1.41	2.26	15.6	0.4
3/11/88	22.1	11.6	1.37	2.27	15.9	0.5
6/27/88	11	2.8	1.29	1.74	2.1	0.3
7/27/88	55	40.6	1.66	2.92	67.2	0.7
8/19/88	51	35.3	1.77	2.76	62.6	0.7
9/1/88	56	40.9	1.73	2.86	70.7	0.7
9/22/88	44	28.2	1.57	2.64	44.3	0.6
9/27/88	33.2	15.3	1.23	2.40	18.8	0.5
10/6/88	31	13.7	0.88	2.24	12.0	0.4
10/21/88	35	54.6	1.90	2.98	104.0	1.6
11/29/88	40	15.4	1.38	2.44	21.2	0.4
12/27/88	29	15	1.51	2.44	22.6	0.5
1/20/89	41	17.1	1.46	2.48	25.0	0.4
2/18/89	28.5	13.3	1.42	2.42	18.9	0.5
3/31/89	19.6	9.47	1.36	2.21	12.9	0.5
4/17/89	19.1	7.12	1.23	2.07	8.7	0.4
5/24/89	10	3.73	0.99	1.90	3.7	0.4
6/27/89	5.6	1.63	0.98	1.82	1.6	0.3
7/10/89	13.4	3.04	0.85	1.88	2.6	0.2
7/21/89	8.9	2.89	1.42	2.05	4.1	0.3
7/31/89	6	2.56	1.41	2.11	3.6	0.4
8/9/89	37.5	13.9	1.50	2.46	20.8	0.4
8/14/89	46.5	39.2	1.90	2.97	74.5	0.8
8/25/89	17.6	7.03	1.42	2.28	10.0	0.4
8/31/89	12.8	3.72	1.35	2.14	5.0	0.3
9/8/89	18.5	5.42	1.51	2.17	8.2	0.3
9/15/89	13.5	2.84	1.38	2.05	3.9	0.2
9/27/89	10.5	2.02	1.18	1.98	2.4	0.2
10/13/89	7	3.06	1.09	2.13	3.3	0.4
10/31/89	7.3	3.71	1.37	2.19	5.1	0.5
11/29/89	16.5	6.46	1.50	2.29	9.7	0.4
1/2/90	16	7.18	1.63	2.33	11.7	0.4
1/29/90	17.8	8.96	1.47	2.37	13.2	0.5
2/27/90	17.5	8.8	1.50	2.58	16.0	0.5
3/30/90	18	8.15	1.71	2.36	14.0	0.5
4/18/90	16.6	6.58	1.40	2.24	9.2	0.4
5/25/90	7.4	2.44	1.18	1.92	2.9	0.3
6/27/90	2.2	0.29	1.01	1.81	0.3	0.1
7/27/90	33	16.7	1.55	2.50	25.9	0.5
8/3/90	42	20.9	1.52	2.69	31.8	0.5
8/13/90	48	55.1	2.23	3.31	123.0	1.1
8/16/90	95	193	3.86	4.93	745.0	2.0
8/22/90	36	12.6	1.39	2.38	17.5	0.4

9/17/90	50.5	46.4	2.08	3.10	96.5	0.9
10/24/90	16.5	6.72	1.32	2.37	8.9	0.4
10/31/90	18.8	7.29	1.25	2.34	9.1	0.4
11/21/90	16.6	8.51	1.34	2.38	11.4	0.5
12/6/90	17.4	10.4	1.34	2.42	13.9	0.6
12/13/90	19	10.6	1.35	2.38	14.2	0.6
12/28/90	24.1	12.1	1.49	2.46	18.0	0.5
1/18/91	16.9	9.02	1.91	3.28	17.2	0.5
1/28/91	12.8	10.1	1.29	3.41	13.0	0.8
2/15/91	15.3	25.5	1.93	4.43	49.3	1.7
2/21/91	14.1	15.8	1.36	3.27	21.5	1.1
3/22/91	18.2	14	1.83	3.61	25.6	0.8
4/9/91	27.5	15.2	1.38	3.50	20.9	0.6
4/29/91	11.6	7.04	1.68	3.37	11.8	0.6
5/24/91	21.5	5.89	0.84	3.22	5.0	0.3
5/29/91	22.8	5.79	0.72	3.00	4.2	0.3
6/6/91	15.2	4.05	0.89	3.03	3.6	0.3
6/20/91	10	2.5	1.16	2.90	2.9	0.3
7/2/91	6.3	1.64	1.08	2.80	1.8	0.3
7/29/91	14.8	2.77	0.74	2.82	2.1	0.2
8/22/91	8.3	3.42	1.35	2.67	4.6	0.4
8/23/91	23	24.2	2.58	3.42	62.4	1.1
8/23/91	33	48	3.17	4.00	152.0	1.5
8/23/91	34	49	3.38	4.20	165.0	1.4
8/23/91	34	51.4	2.31	4.22	170.0	1.5
8/27/91	61	120	4.38	5.57	526.0	2.0
8/27/91	59	106	3.83	5.26	406.0	1.8
9/10/91	14.7	6.81	0.93	2.62	6.4	0.5
9/23/91	14.6	6.88	0.98	2.42	6.8	0.5
9/25/91	14.2	6.4	0.87	2.34	5.6	0.5
10/11/91	7.9	3.1	1.19	2.34	3.7	0.4
10/29/91	13.7	5.37	0.92	2.34	5.0	0.4
11/6/91	11.4	4.71	1.24	2.43	5.9	0.4
11/26/91	13.7			2.56	9.4	0.0
11/26/91	16.6	8.01	1.12	2.58	9.0	0.5
12/5/91	18.4	8.56	1.07	2.56	9.2	0.5
12/12/91	14.8	7.18	1.56	2.60	11.2	0.5
12/17/91	18.8	9.5	1.16	2.59	11.1	0.5
12/19/91	20.8	12.3	1.24	2.68	15.2	0.6
1/10/92	20.8	11.4	1.18	2.65	13.4	0.5
1/29/92	20.6	11.6	1.22	2.67	14.1	0.6
2/7/92	21.6	12.4	1.27	2.68	15.7	0.6
2/19/92	22.4	9.34	1.82	2.72	17.0	0.4
3/30/92	22.7	8.88	1.79	2.69	15.9	0.4
4/30/92	17.7	7.16	0.91	2.39	6.5	0.4
5/28/92	20.1	6.71	0.95	2.39	6.4	0.3
6/30/92	12.5	7.63	0.16	2.23	1.2	0.6
7/14/92	10.2	6.74	0.63	2.27	3.0	0.7
7/24/92	51	124	4.46	5.60	553.0	2.4

7/24/92	207	209	4.31	6.06	900.0	1.0
7/29/92	17	8.4	1.57	2.54	12.8	0.5
8/13/92	12	8.01	1.59	2.63	12.7	0.7
8/24/92	48	64.3	2.57	4.08	165.0	1.3
8/24/92	195	264	4.28	6.42	1130.0	1.4
8/28/92	23	25.3	1.08	2.91	27.4	1.1
9/25/92	14.8	4.43	1.02	2.41	4.5	0.3
9/29/92	16.5	6.09	0.63	2.43	3.0	0.4
10/30/92	16.4	6.92	0.75	2.58	5.2	0.4

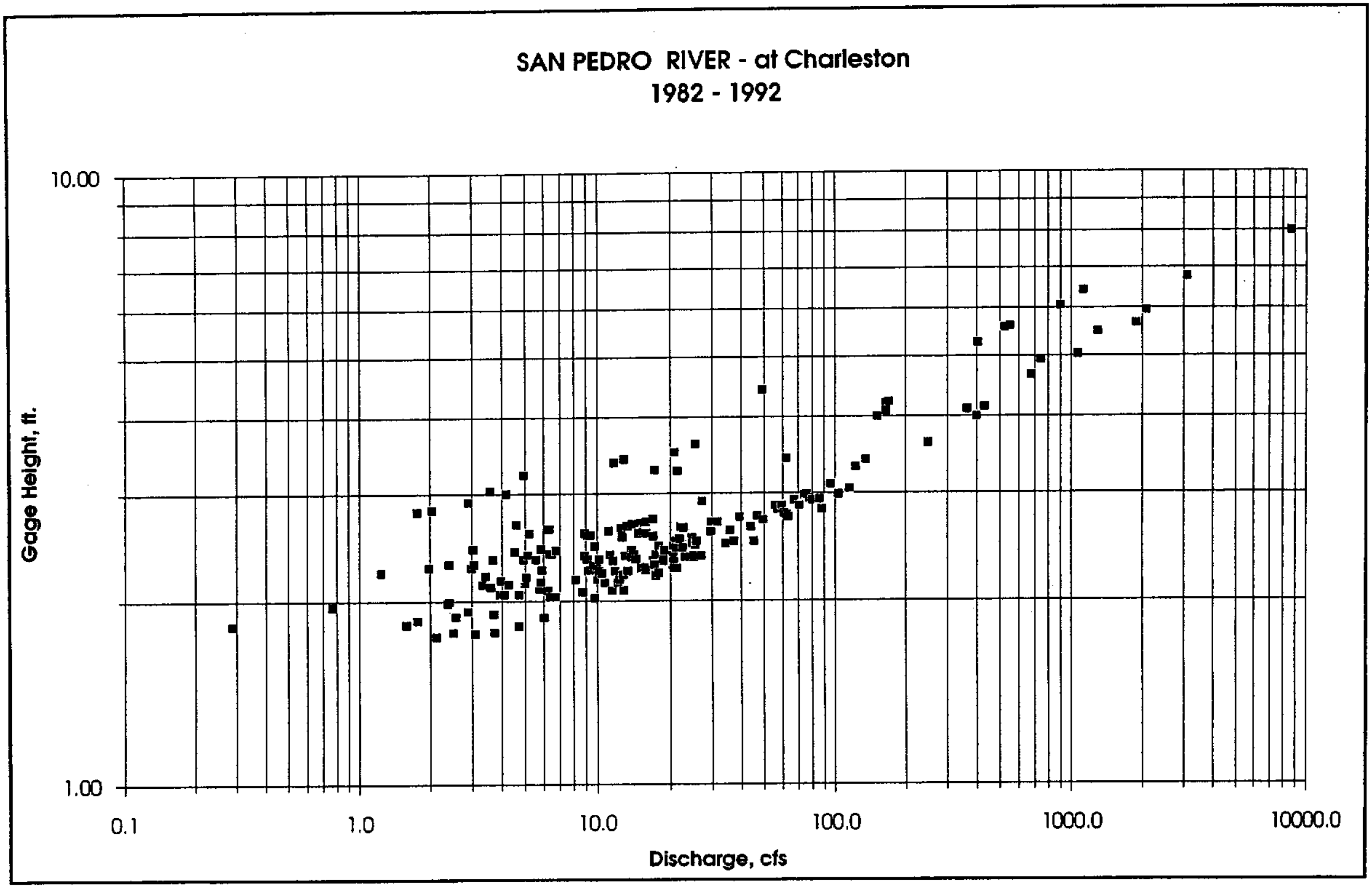
SAN PEDRO AT CHARLESTON						
1982 - 1992						
2) Sorted w.r.t. Q						
date	discharge	width	area	velocity	gage h	depth
6/27/90	0.3	2.2	0.29	1.01	1.81	0.13
6/24/82	0.8	2	0.65	1.18	1.95	0.33
6/30/92	1.2	12.5	7.63	0.16	2.23	0.61
6/27/89	1.6	5.6	1.63	0.98	1.82	0.29
7/2/91	1.8	6.3	1.64	1.08	2.80	0.26
6/30/87	1.8	6.1	2.06	0.86	1.85	0.34
6/27/83	2.0	6.9	1.88	1.06	2.27	0.27
7/29/91	2.1	14.8	2.77	0.74	2.82	0.19
6/27/88	2.1	11	2.8	1.29	1.74	0.25
9/27/89	2.4	10.5	2.02	1.18	1.98	0.19
7/21/83	2.4	6.1	2.18	1.10	2.30	0.36
5/24/82	2.4	6	1.97	1.23	1.99	0.33
6/26/86	2.5	8	3.42	0.73	1.77	0.43
7/10/89	2.6	13.4	3.04	0.85	1.88	0.23
5/25/90	2.9	7.4	2.44	1.18	1.92	0.33
6/20/91	2.9	10	2.5	1.16	2.90	0.25
7/14/92	3.0	10.2	6.74	0.63	2.27	0.66
9/29/92	3.0	16.5	6.09	0.63	2.43	0.37
6/25/84	3.1	3	2.96	1.20	2.30	0.99
6/14/85	3.1	6.2	2.09	1.48	1.76	0.34
10/13/89	3.3	7	3.06	1.09	2.13	0.44
5/27/84	3.4	5	3.06	1.13	2.20	0.61
6/6/91	3.6	15.2	4.05	0.89	3.03	0.27
7/31/89	3.6	6	2.56	1.41	2.11	0.43
10/11/91	3.7	7.9	3.1	1.19	2.34	0.39
5/24/89	3.7	10	3.73	0.99	1.90	0.37
6/23/85	3.7	10	3.02	1.24	1.77	0.30
9/15/89	3.9	13.5	2.84	1.38	2.05	0.21
10/25/82	4.0	12.8	4.67	0.85	2.16	0.36
7/21/89	4.1	8.9	2.89	1.42	2.05	0.32
5/29/91	4.2	22.8	5.79	0.72	3.00	0.25
8/25/83	4.3	8.2	3.51	1.22	2.13	0.43
9/25/92	4.5	14.8	4.43	1.02	2.41	0.30
8/22/91	4.6	8.3	3.42	1.35	2.67	0.41
8/27/82	4.7	9.5	3.88	1.22	2.05	0.41
5/22/86	4.7	9.9	4.98	0.95	1.81	0.50
5/24/91	5.0	21.5	5.89	0.84	3.22	0.27
10/29/91	5.0	13.7	5.37	0.92	2.34	0.39
8/31/89	5.0	12.8	3.72	1.35	2.14	0.29
4/26/82	5.0	15.2	49	1.05	2.16	3.22
10/31/89	5.1	7.3	3.71	1.37	2.19	0.51
5/24/83	5.2	14.3	4.5	1.17	2.38	0.31

	10/30/92	5.2	16.4	6.92	0.75	2.58	0.42
	9/25/91	5.6	14.2	6.4	0.87	2.34	0.45
	7/30/87	5.8	18	5.19	1.12	2.09	0.29
	9/18/87	5.9	13	4.48	1.31	2.15	0.34
	11/6/91	5.9	11.4	4.71	1.24	2.43	0.41
	11/22/82	5.9	17	6.07	0.98	2.25	0.36
	5/28/87	6.0	16.8	5.58	1.11	1.87	0.33
	9/27/82	6.3	13	8.53	0.74	2.08	0.66
	9/10/91	6.4	14.7	6.81	0.93	2.62	0.46
	9/25/85	6.4	14.5	4.77	1.34	2.03	0.33
	5/28/92	6.4	20.1	6.71	0.95	2.39	0.33
	4/30/92	6.5	17.7	7.16	0.91	2.39	0.40
	10/27/87	6.8	20	6.73	1.00	2.03	0.34
	9/23/91	6.8	14.6	6.88	0.98	2.42	0.47
	9/8/89	8.2	18.5	5.42	1.51	2.17	0.29
	4/17/89	8.7	19.1	7.12	1.23	2.07	0.37
	10/24/90	8.9	16.5	6.72	1.32	2.37	0.41
	11/26/91	9.0	16.6	8.01	1.12	2.58	0.48
	10/31/90	9.1	18.8	7.29	1.25	2.34	0.39
	12/5/91	9.2	18.4	8.56	1.07	2.56	0.47
	4/18/90	9.2	16.6	6.58	1.40	2.24	0.40
	11/26/91	9.4	13.7			2.56	0.00
	3/25/82	9.4	23	8.38	1.12	2.25	0.36
	11/29/89	9.7	16.5	6.46	1.50	2.29	0.39
	4/24/84	9.8	11.6	8.58	1.14	2.46	0.74
	5/23/85	9.8	17.2	8.42	1.17	2.02	0.49
	8/25/89	10.0	17.6	7.03	1.42	2.28	0.40
	1/25/82	10.1	23	8.62	1.05	2.17	0.37
	7/30/86	10.2	23.4	9.02	1.18	2.24	0.39
	9/29/86	10.2	15.3	7.83	1.30	2.34	0.51
	2/22/82	10.5	24	9.58	1.10	2.22	0.40
	10/28/86	10.7	16.1	864	1.24	2.14	53.66
	12/9/87	10.8	22	8.64	1.25	2.14	0.39
	12/17/91	11.1	18.8	9.5	1.16	2.59	0.51
	12/12/91	11.2	14.8	7.18	1.56	2.60	0.49
	11/21/90	11.4	16.6	8.51	1.34	2.38	0.51
	4/23/86	11.6	27	13.3	0.87	2.08	0.49
	1/2/90	11.7	16	7.18	1.63	2.33	0.45
	4/29/91	11.8	11.6	7.04	1.68	3.37	0.61
	10/6/88	12.0	31	13.7	0.88	2.24	0.44
	11/23/87	12.3	17.4	8.89	1.38	2.14	0.51
	8/22/85	12.5	25	9.88	1.26	2.17	0.40
	8/13/92	12.7	12	8.01	1.59	2.63	0.67
	7/29/92	12.8	17	8.4	1.57	2.54	0.49
	3/31/89	12.9	19.6	9.47	1.36	2.21	0.48
	5/5/87	13.0	23.3	9.72	1.33	2.08	0.42
	1/28/91	13.0	12.8	10.1	1.29	3.41	0.79
	1/29/90	13.2	17.8	8.96	1.47	2.37	0.50
	1/10/92	13.4	20.8	11.4	1.18	2.65	0.55

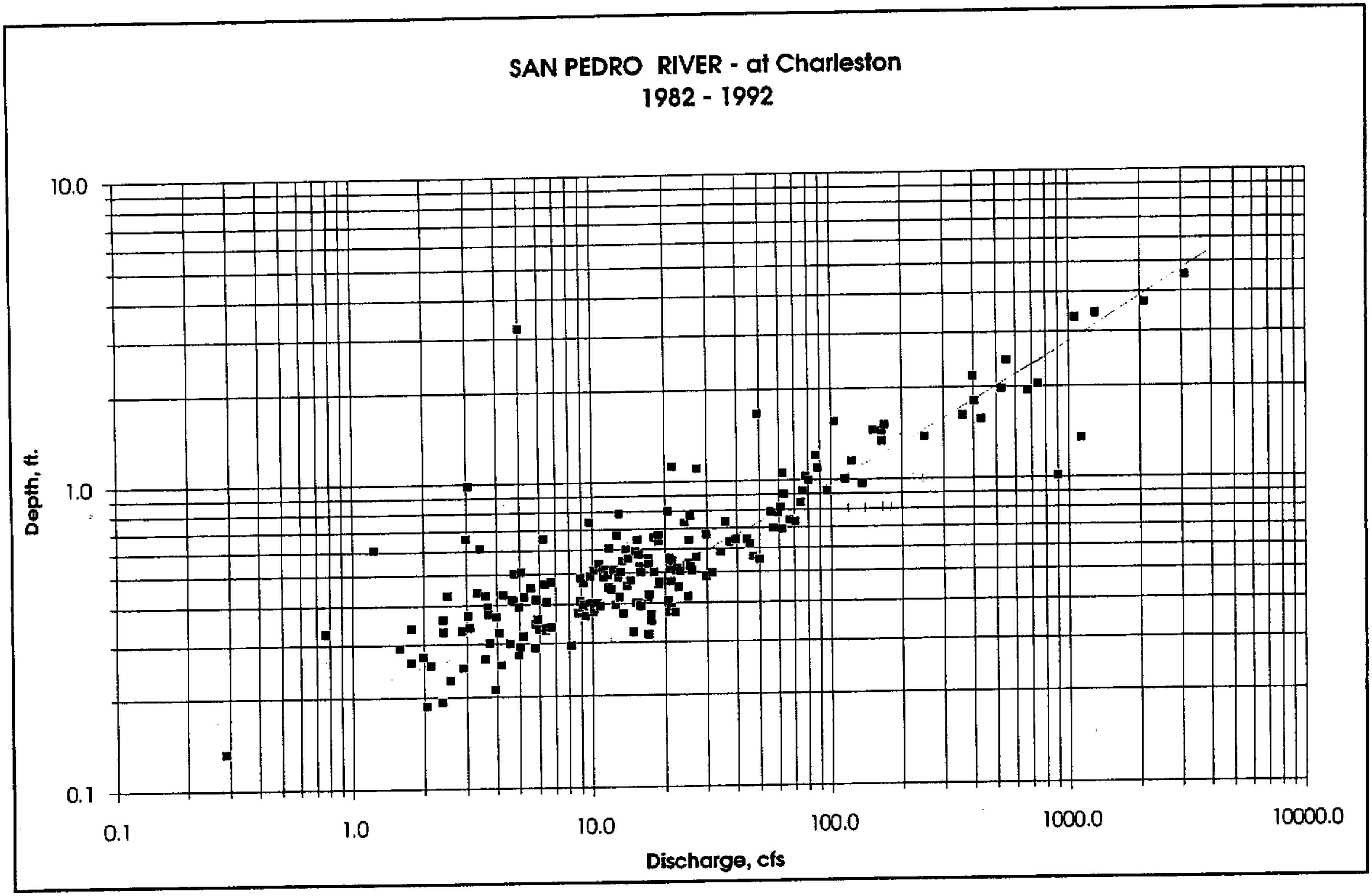
9/27/83	13.5	33.5	12.4	1.09	2.24	0.37
12/6/90	13.9	17.4	10.4	1.34	2.42	0.60
3/30/90	14.0	18	8.15	1.71	2.36	0.45
1/29/92	14.1	20.6	11.6	1.22	2.67	0.56
12/13/90	14.2	19	10.6	1.35	2.38	0.56
1/24/83	14.5	29	13.7	1.06	2.34	0.47
9/24/84	14.9	37	11.9	1.25	2.58	0.32
12/19/91	15.2	20.8	12.3	1.24	2.68	0.59
1/13/88	15.3	30.5	12.2	1.25	2.26	0.40
3/27/84	15.5	20.9	13.5	1.15	2.60	0.65
2/22/88	15.6	27.8	11.1	1.41	2.26	0.40
2/7/92	15.7	21.6	12.4	1.27	2.68	0.57
11/25/86	15.8	26	10.2	1.54	2.25	0.39
3/11/88	15.9	22.1	11.6	1.37	2.27	0.52
3/30/92	15.9	22.7	8.88	1.79	2.69	0.39
2/27/90	16.0	17.5	8.8	1.50	2.58	0.50
2/19/92	17.0	22.4	9.34	1.82	2.72	0.42
12/28/82	17.1	31.5	17.6	0.97	2.33	0.56
4/26/83	17.1	49	15.5	1.10	2.55	0.32
1/27/88	17.2	30	12.7	1.35	2.29	0.42
1/18/91	17.2	16.9	9.02	1.91	3.28	0.53
8/7/85	17.5	39.1	14.3	1.22	2.20	0.37
8/22/90	17.5	36	12.6	1.39	2.38	0.35
3/27/87	18.0	19.5	12.8	1.41	2.22	0.66
12/28/90	18.0	24.1	12.1	1.49	2.46	0.50
3/27/86	18.8	35.4	22.5	0.84	2.33	0.64
1/29/87	18.8	19	12.7	1.48	2.34	0.67
9/27/88	18.8	33.2	15.3	1.23	2.40	0.46
2/18/89	18.9	28.5	13.3	1.42	2.42	0.47
7/26/82	20.6	24	19.2	1.07	2.29	0.80
12/23/87	20.6	36	14.5	1.42	2.40	0.40
4/27/85	20.8	29	16.2	1.28	2.32	0.56
8/9/89	20.8	37.5	13.9	1.50	2.46	0.37
1/26/86	20.9	36.5	19	1.11	2.26	0.52
4/9/91	20.9	27.5	15.2	1.38	3.50	0.55
10/25/84	21.2	37	17.3	1.23	2.50	0.47
11/29/88	21.2	40	15.4	1.38	2.44	0.39
11/25/85	21.4	36	19.7	1.09	2.26	0.55
2/21/91	21.5	14.1	15.8	1.36	3.27	1.12
12/29/86	22.0	41	15.2	1.48	2.52	0.37
12/29/83	22.2	36.2	18.4	1.21	2.64	0.51
12/27/88	22.6	29	15	1.51	2.44	0.52
2/26/84	22.8	36	16.1	1.42	2.63	0.45
12/16/86	23.2	33.7	17	1.36	2.36	0.50
2/26/87	24.2	20	14.6	1.66	2.36	0.73
11/26/84	24.8	36.5	19.3	1.28	2.53	0.53
1/20/89	25.0	41	17.1	1.46	2.48	0.42
4/29/87	25.2	28.5	18.3	1.38	2.36	0.64
12/27/85	25.3	38	20.4	1.24	2.37	0.54

	10/25/83	25.6	36.6	19.1	1.34	2.47	0.52
	3/22/91	25.6	18.2	14	1.83	3.61	0.77
	7/27/90	25.9	33	16.7	1.55	2.50	0.51
	2/23/86	27.2	37.9	21.3	1.28	2.37	0.56
	8/28/92	27.4	23	25.3	1.08	2.91	1.10
	9/9/86	29.8	42	20.3	1.47	2.59	0.48
	11/28/83	29.9	36	24	1.25	2.69	0.67
	8/3/90	31.8	42	20.9	1.52	2.69	0.50
	10/27/85	34.4	40.8	23.8	1.45	2.48	0.58
	2/20/83	35.9	32	23.5	1.53	2.60	0.73
	3/25/85	37.3	42	26.4	1.41	2.50	0.63
	1/25/84	39.6	36	23.1	1.71	2.74	0.64
	9/22/88	44.3	44	28.2	1.57	2.64	0.64
	8/21/86	45.4	47	29.2	1.55	2.50	0.62
	3/17/83	47.0	56.5	31.8	1.48	2.75	0.56
	2/15/91	49.3	15.3	25.5	1.93	4.43	1.67
	2/15/83	49.8	69.7	38.2	1.30	2.71	0.55
	12/27/84	55.9	37.5	29.6	1.89	2.86	0.79
	3/27/83	57.2	56	39	1.47	2.82	0.70
	8/12/83	59.8	58	45.4	1.32	2.86	0.78
	10/12/83	61.2	54	44	1.39	2.78	0.81
	8/23/91	62.4	23	24.2	2.58	3.42	1.05
	8/19/88	62.6	51	35.3	1.77	2.76	0.69
	7/24/85	63.7	45	40.4	1.58	2.74	0.90
	7/27/88	67.2	55	40.6	1.66	2.92	0.74
	9/1/88	70.7	56	40.9	1.73	2.86	0.73
	8/14/89	74.5	46.5	39.2	1.90	2.97	0.84
	8/26/84	75.9	47	43.2	1.76	2.98	0.92
	1/10/85	78.1	45.5	46.7	1.67	2.94	1.03
	2/24/85	80.6	46.5	46.4	1.74	2.92	1.00
	7/22/84	86.6	44	52.9	1.64	2.93	1.20
	9/14/82	88.2	55	60	1.47	2.82	1.09
	9/17/90	96.5	50.5	46.4	2.08	3.10	0.92
	10/21/88	104.0	35	54.6	1.90	2.98	1.56
	9/25/87	115.0	55	55.2	2.08	3.05	1.00
	8/13/90	123.0	48	55.1	2.23	3.31	1.15
	8/27/87	136.0	65	62.9	2.16	3.40	0.97
	8/23/91	152.0	33	48	3.17	4.00	1.45
	8/23/91	165.0	34	49	3.38	4.20	1.44
	8/24/92	165.0	48	64.3	2.57	4.08	1.34
	8/23/91	170.0	34	51.4	2.31	4.22	1.51
	4/28/87	250.0	64	88		3.62	1.38
	7/18/86	364.0	78	126	2.89	4.10	1.62
	1/28/85	401.0	67	145	2.77	3.99	2.16
	8/27/91	406.0	59	106	3.83	5.26	1.80
	9/10/82	432.0	100	157	2.75	4.14	1.57
	8/27/91	526.0	61	120	4.38	5.57	1.97
	7/24/92	553.0	51	124	4.46	5.60	2.43
	9/10/82	678.0	116	225	3.01	4.66	1.94

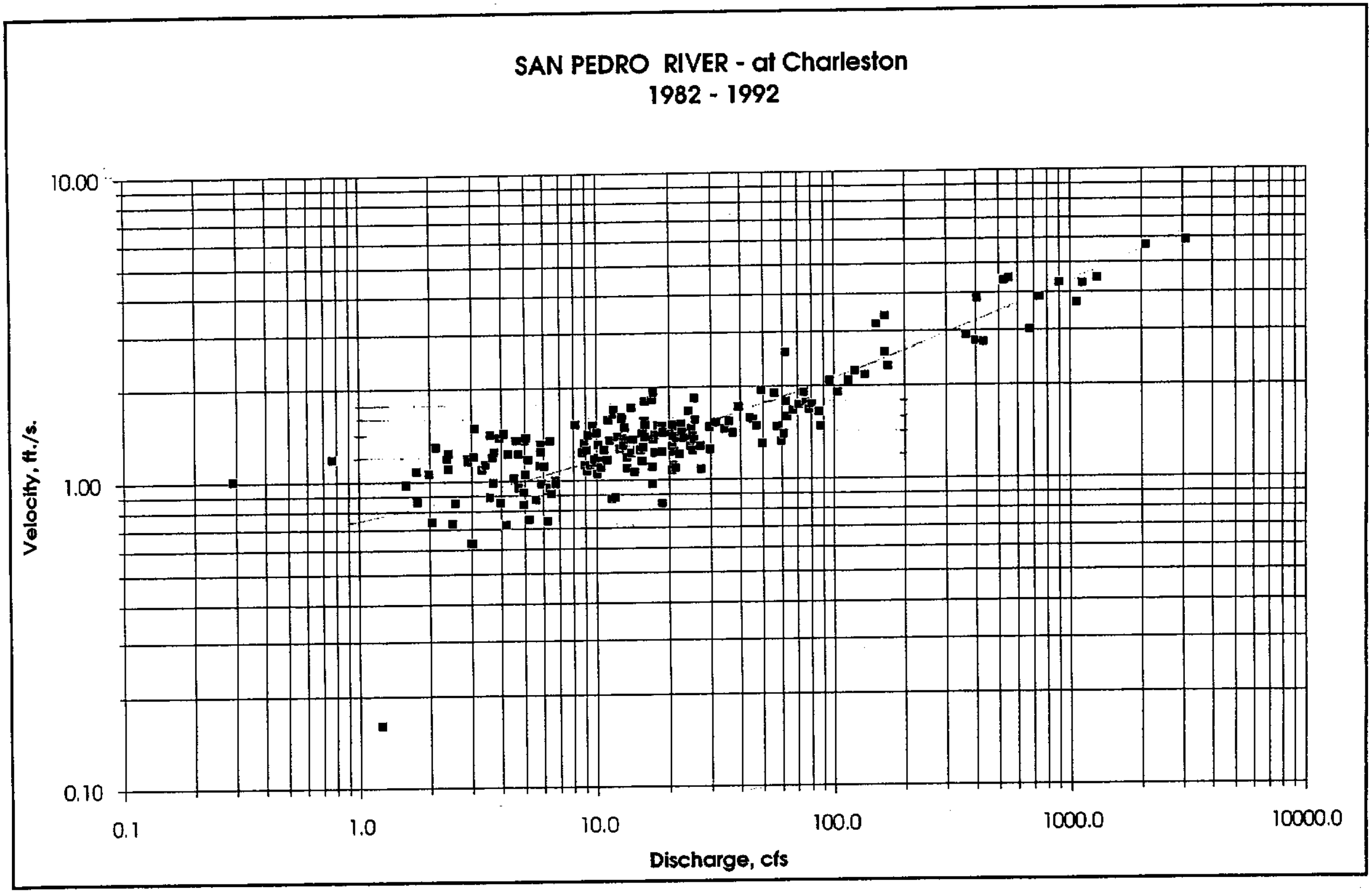
	8/16/90	745.0	95	193	3.86	4.93	2.03
	7/24/92	900.0	207	209	4.31	6.06	1.01
	10/4/83	1070.0	87	289	3.70	5.03	3.32
	8/24/92	1130.0	195	264	4.28	6.42	1.35
	8/6/84	1300.0	85	292	4.45	5.48	3.44
	2/4/83	1900.0				5.65	
	8/18/86	2090.0	98	364	5.66	5.94	3.71
	8/18/86	3110.0	117	530	5.87	6.75	4.53
	9/10/82	8700.0				8.00	


SAN PEDRO RIVER - at Charleston
1982 - 1992
10.00
1.00
Gage Height, ft.
0.1
1.0
10.0
100.0
1000.0
10000.0
Discharge, cfs

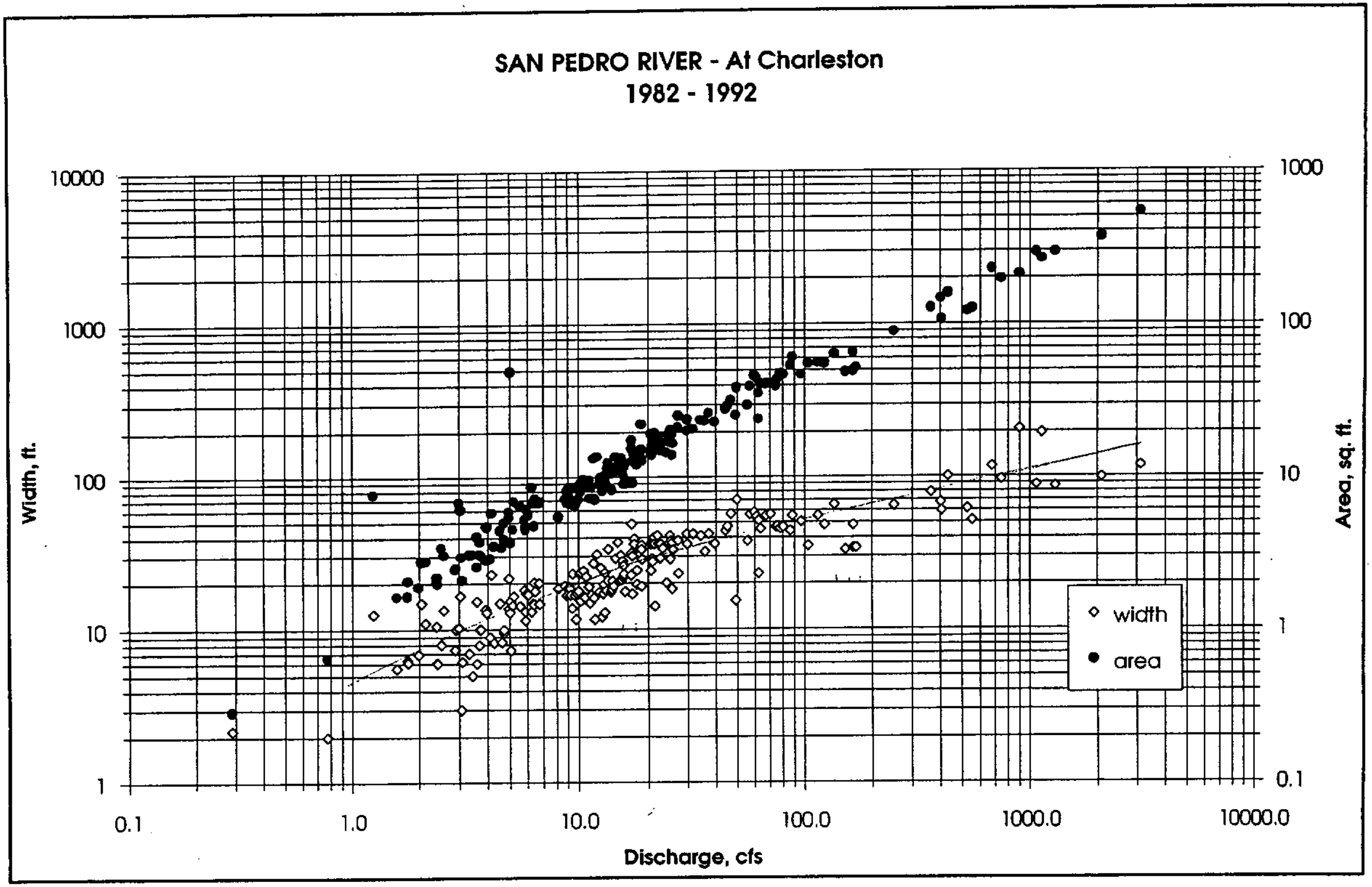
SPC-Q-GH.XLC


SAN PEDRO RIVER - at Charleston
1982 - 1992
Depth, ft.
10.0
1.0
0.1
0.1
1.0
10.0
100.0
1000.0
10000.0
Discharge, cfs

SPC-Q-D.XLC


SAN PEDRO RIVER - at Charleston
1982 - 1992
10.00
1.00
0.10
Velocity, ft./s.
0.1
1.0
10.0
100.0
1000.0
10000.0
Discharge, cfs

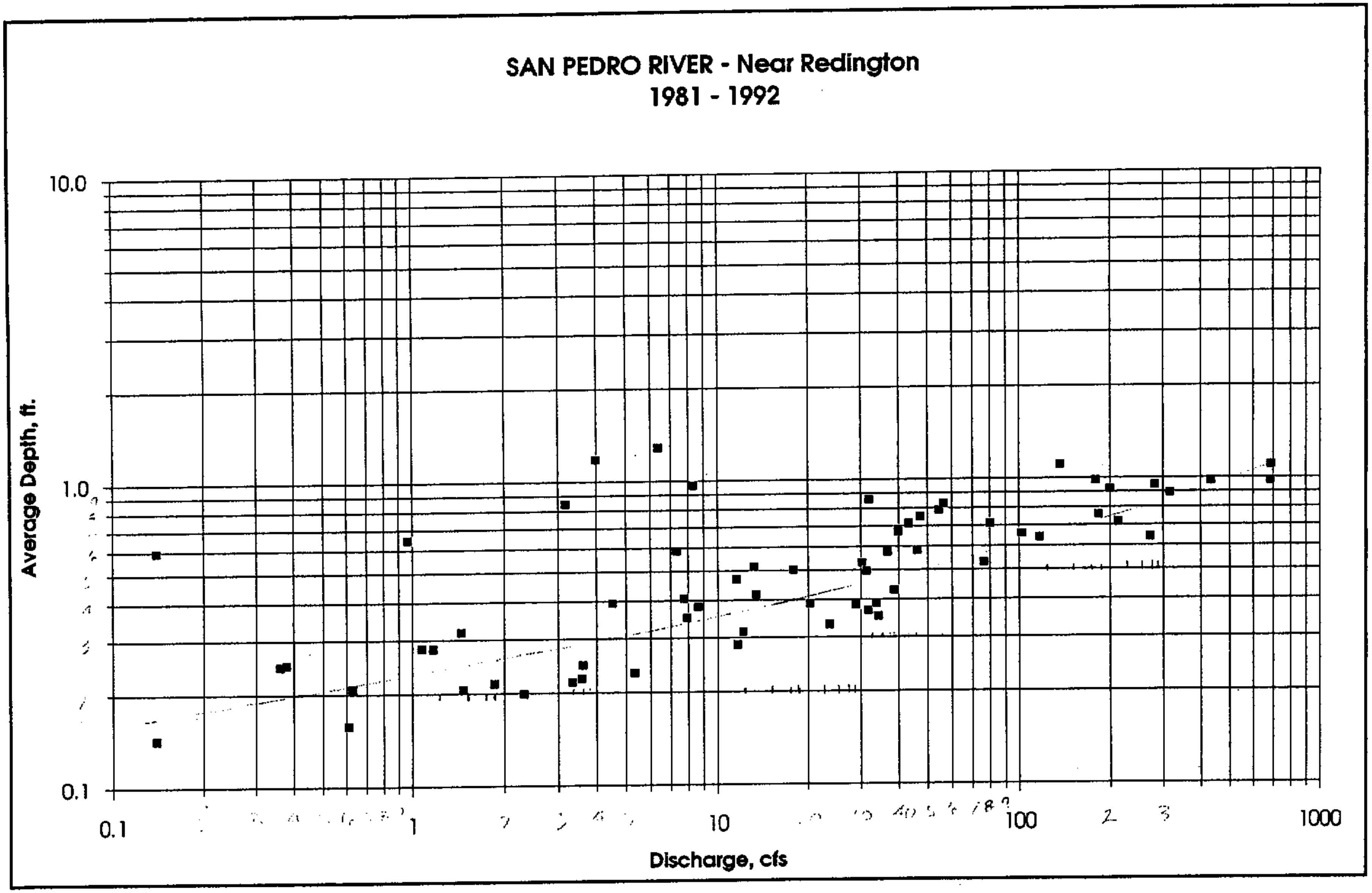
SPC-Q-V.XLC



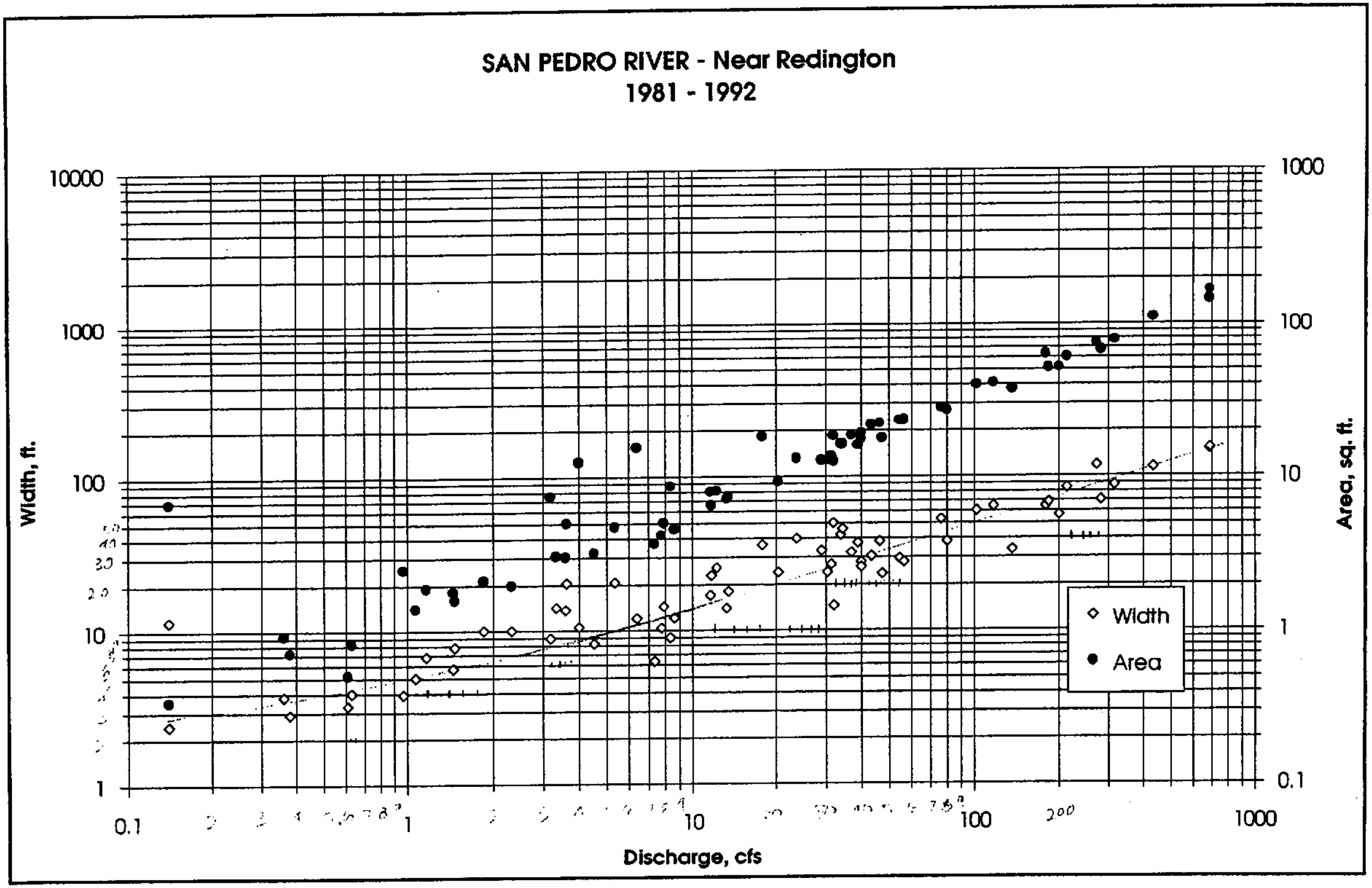
SAN PEDRO RIVER - At Charleston
1982 - 1992
Width, ft.
Area, sq. ft.
Discharge, cfs
10000
1000
100
10
1
1000
100
10
1
0.1
0.1
1.0
10.0
100.0
1000.0
10000.0
width
area

SPC-Q-WA.XLC

SAN PEDRO RIVER NEAR REDINGTON							
1) Original Data							
Meas #	Width	Area	Velocity	Gage H.	Discharge	Depth	
501	5.7	1.8	0.81	7.15	1.45	0.3	
502	10	1.98	1.18	7.48	2.33	0.2	
502C	3.9	2.52	0.38		0.97	0.6	
503				8.7	360		
504	50	18.3	1.74	7.76	31.8	0.4	
505				9.6	900		
506	70	66.3	4.27	8.61	283	0.9	
507	56	51.4	3.91	8.32	201	0.9	
508				10.5	2700		
509	64	62.8	2.87	8.25	180	1.0	
510	10	2.14	0.87	7.48	1.86	0.2	
511				14.75	8700		
512	113	110	3.95	8.88	434	1.0	
513	42	16.2	2.09	7.82	33.8	0.4	
514	33	12.6	2.3	7.76	29	0.4	
515				10.5	2000		
516	27	13.4	2.34	7.84	31.4	0.5	
517	53	28	2.73	8.35	76.5	0.5	
518	46	16.1	2.13	8.13	34.3	0.4	
519	12.1	4.6	1.88	8.14	8.64	0.4	
520				21.4	25400		
521	87	77.4	4.1	10.47	317	0.9	
522	64	40.9	2.86	9.84	117	0.6	
523	28	19	2.11	8.8	40	0.7	
524	26	17.4	2.3	9.15	40	0.7	
525				10.65	500		
526	33.5	37.1	3.69	9.23	137	1.1	
527	23.5	17.6	3.69	8.8	47.4	0.7	
528	24	12.7	2.39	8.5	30.4	0.5	
529	17	7.96	1.46	8.12	11.6	0.5	
530	150	165	4.18	10.5	689	1.1	
531					3800		
532	37	15.8	2.48	9.34	38.8	0.4	
533	148	144	4.77	10.85	687	1.0	
534	38	27	2.97	9.32	80.2	0.7	
535	116	74	3.69	9.67	273	0.6	
536	23	6.53	1.79	8.79	11.7	0.3	
537	24	9.27	2.2	8.83	20.4	0.4	
538				14.5	7000		
539	84	60	3.57	9.81	214	0.7	
540	38	22.1	2.1	9.1	46.3	0.6	
541	30.5	21.7	2	9.2	43.4	0.7	
542	14.2	3.06	1.09	8.78	3.34	0.2	
543				11.9	1550		

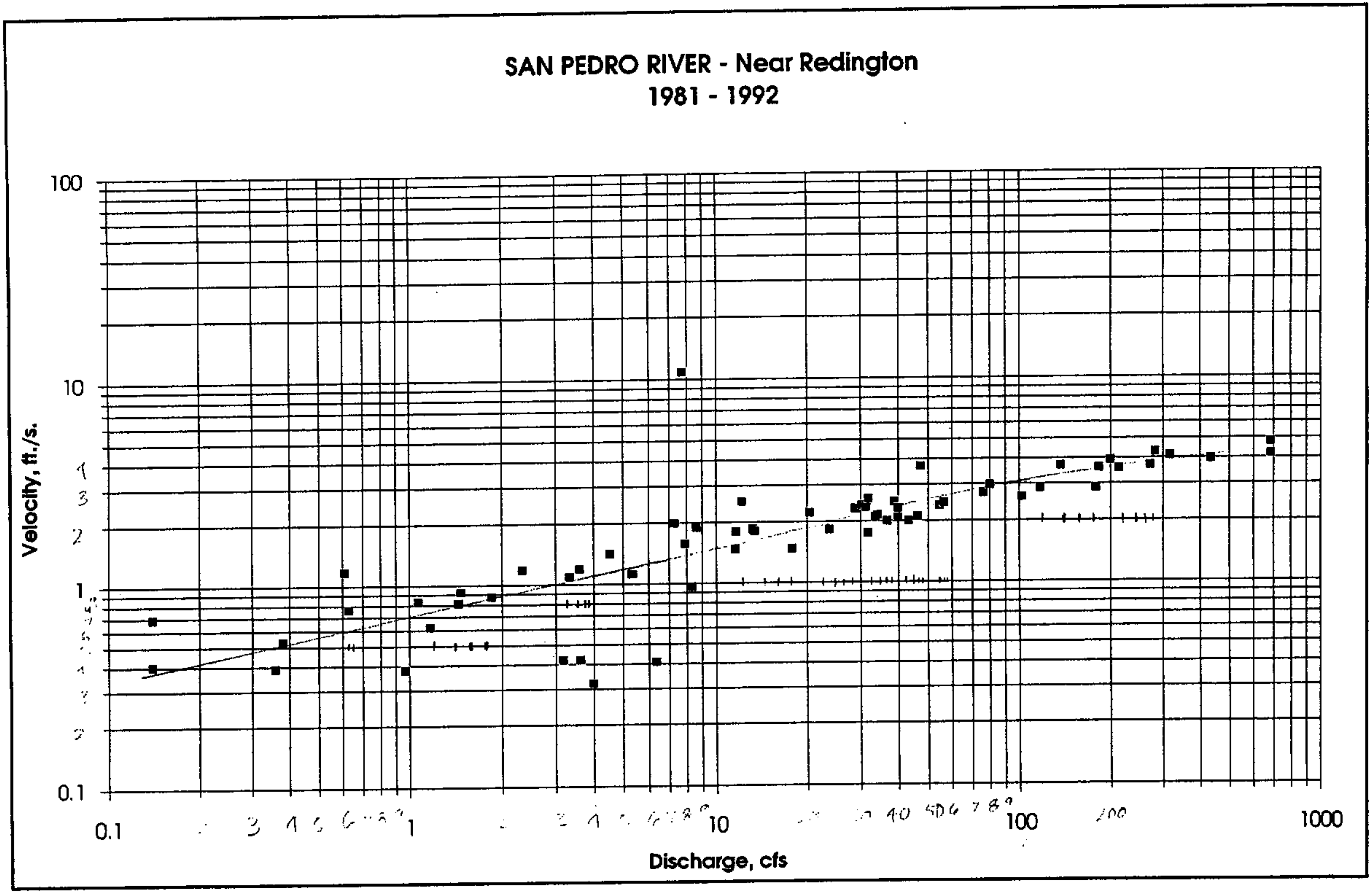

SAN PEDRO RIVER - Near Redington
1981 - 1992
Average Depth, ft.
10.0
1.0
0.1
0.1
1
10
100
1000
Discharge, cfs

SPR-Q-D.XLC



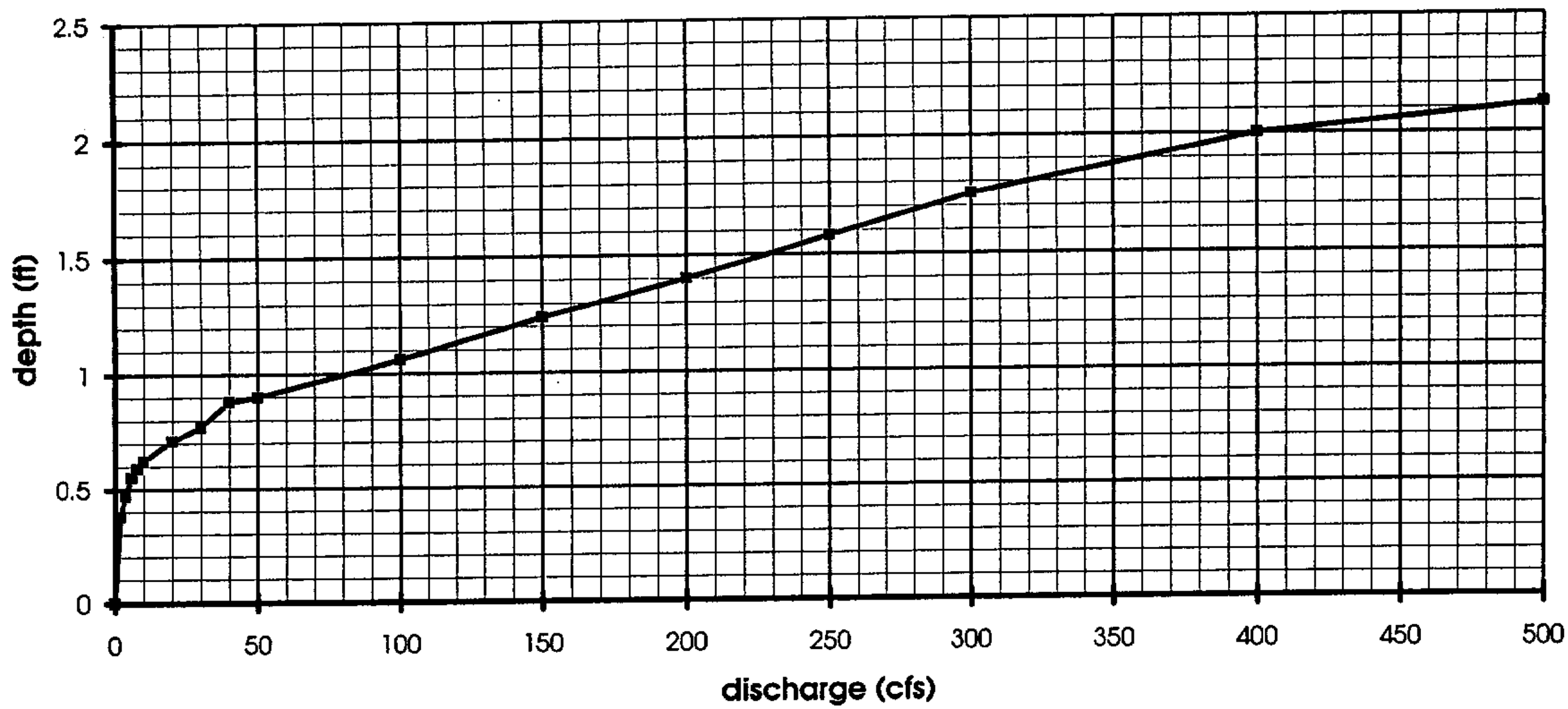
SAN PEDRO RIVER - Near Redington
1981 - 1992
Width, ft.
Area, sq. ft.
Discharge, cfs
10000
1000
100
10
1
0.1
Width
Area

SPR-Q-WA.XLC

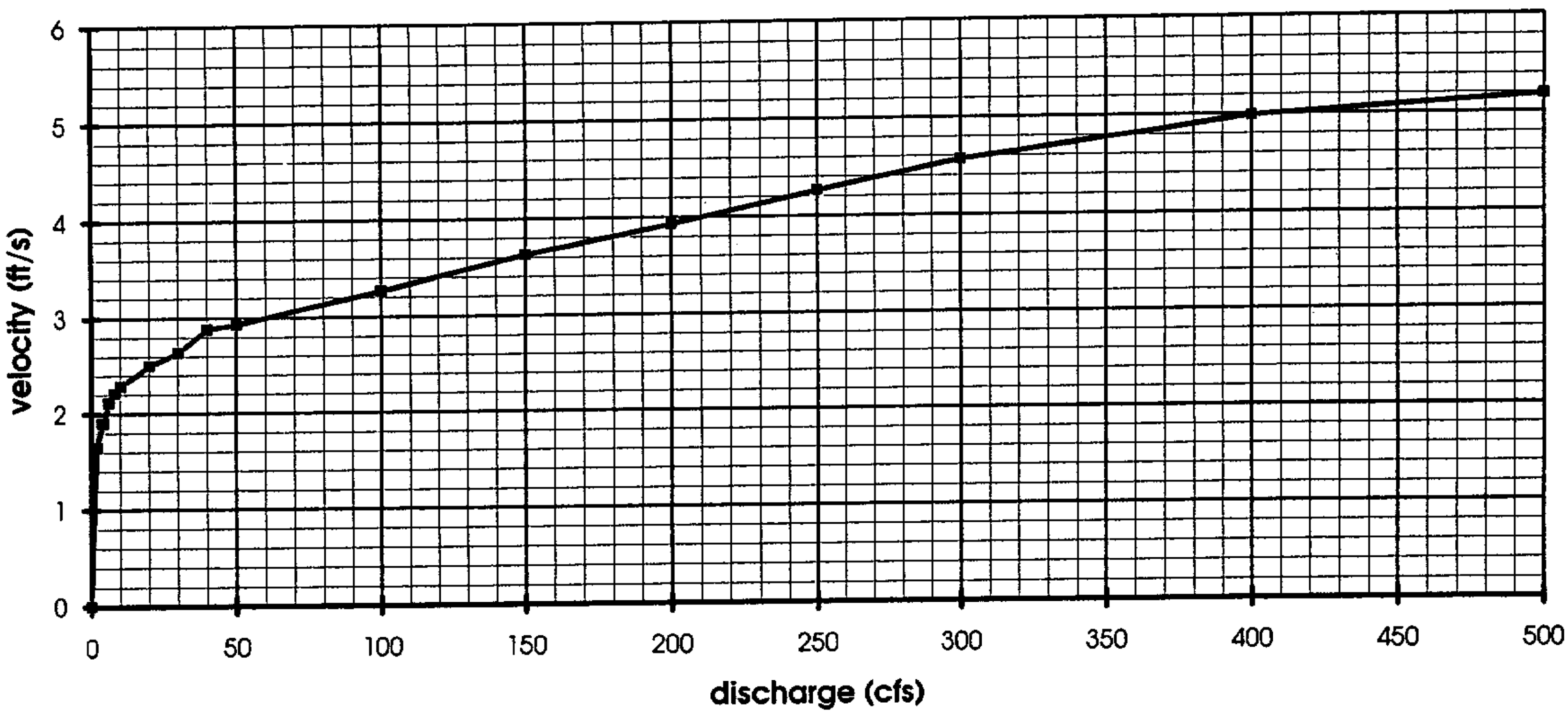

SAN PEDRO RIVER - Near Redington
1981 - 1992
Velocity, ft./s.
100
10
1
0.1
0.1
1
10
100
1000
Discharge, cfs

SPR-Q-V.XLC

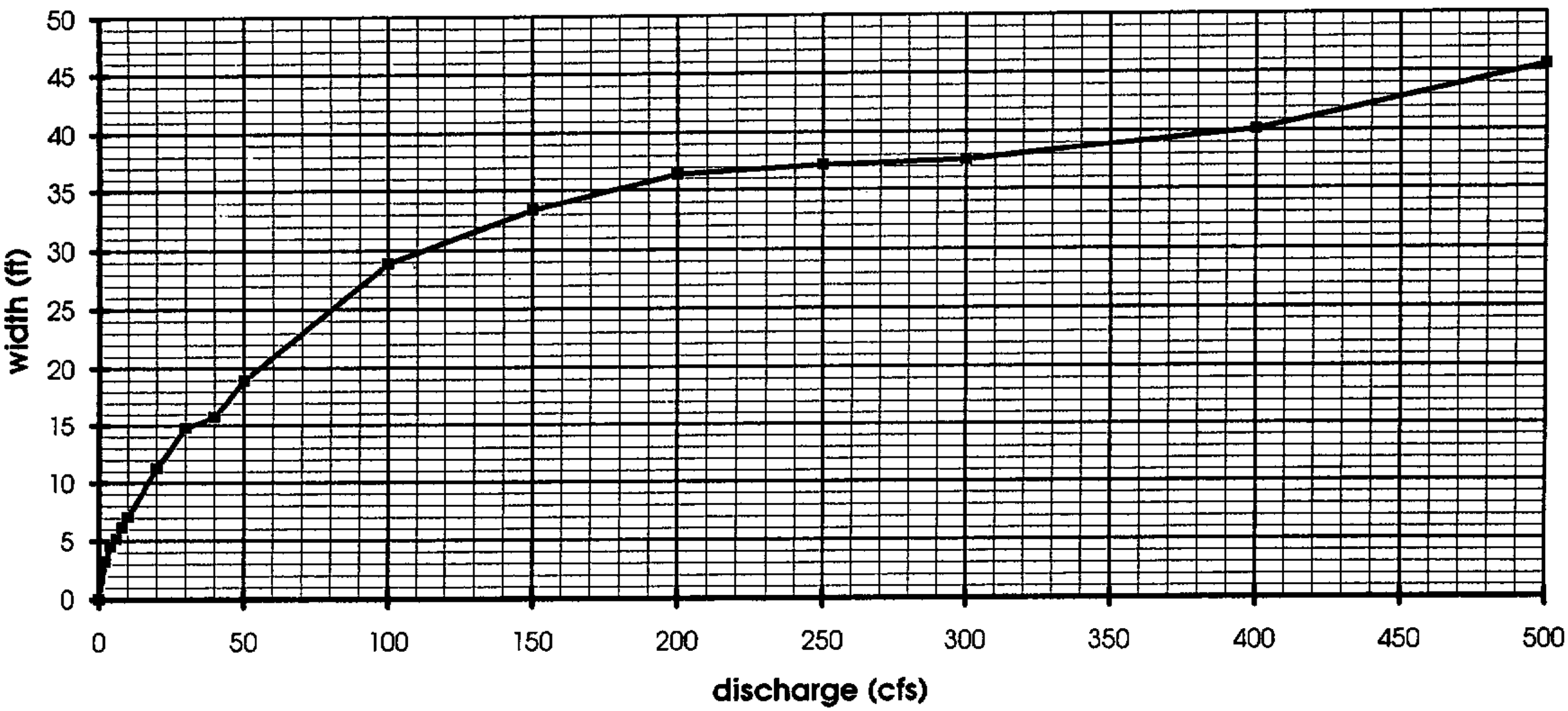
San Pedro River near Fairbank (1915 to 1924)



San Pedro River near Fairbank (1915 to 1924)

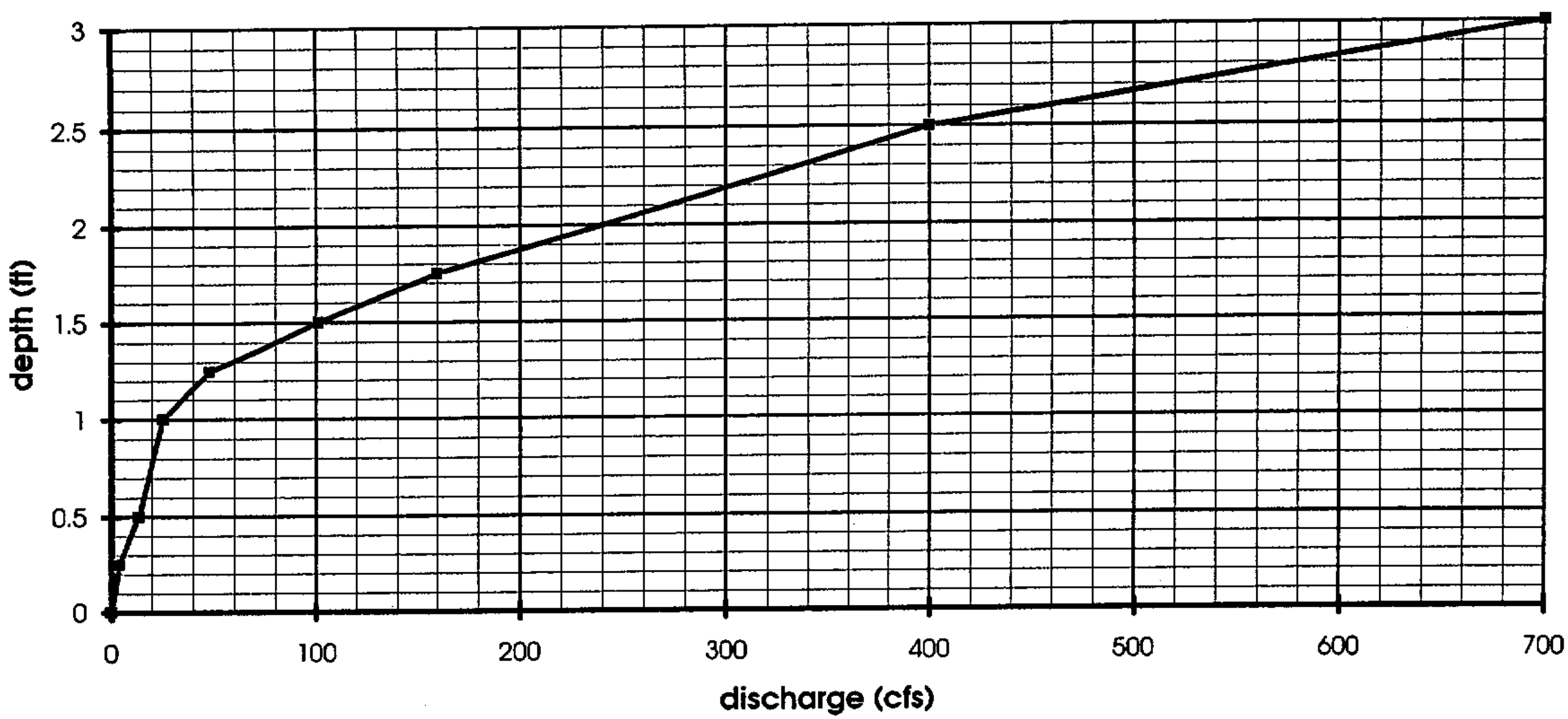


San Pedro River near Fairbank (1915 to 1924)

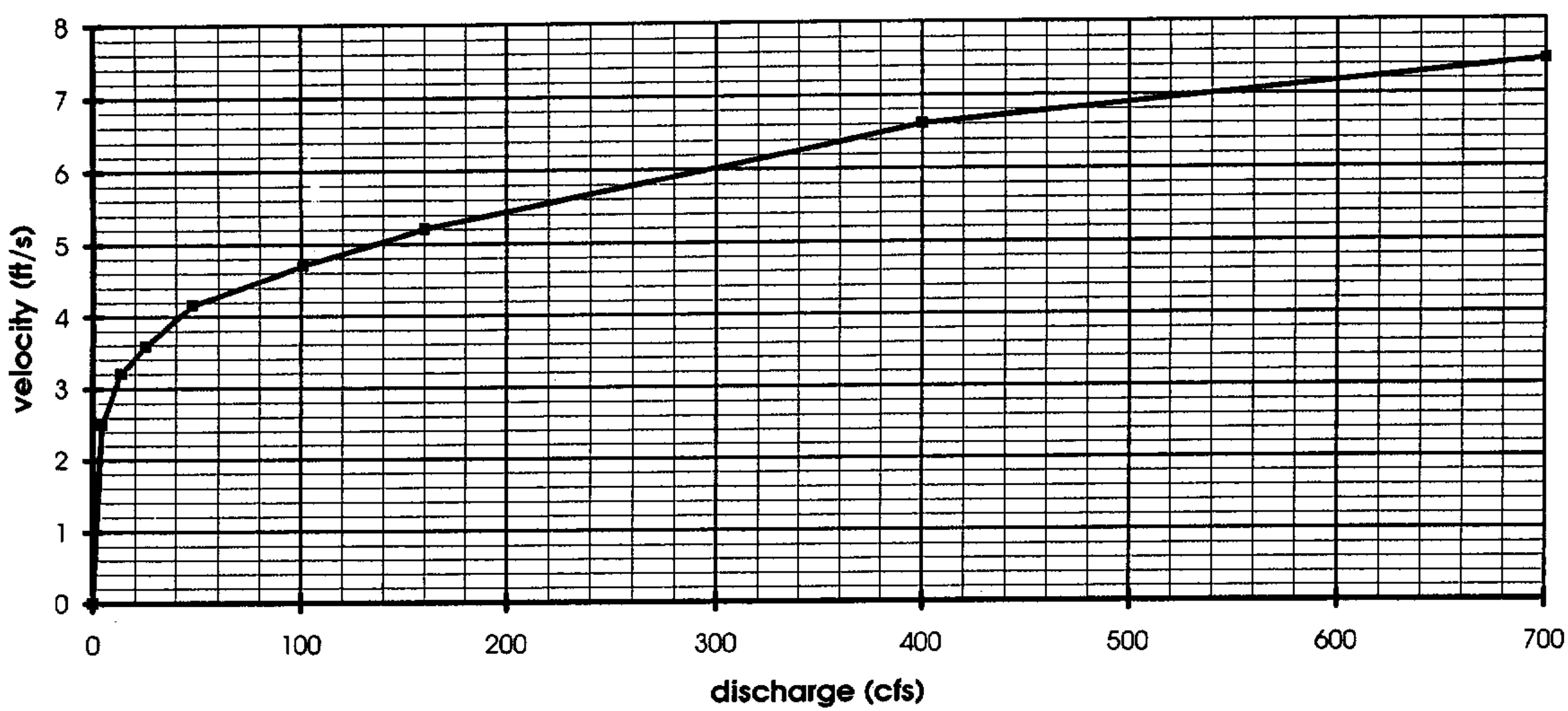


note. because of the shifting nature of a sandy gravelly channel, low flow estimations of widths may not be accurate

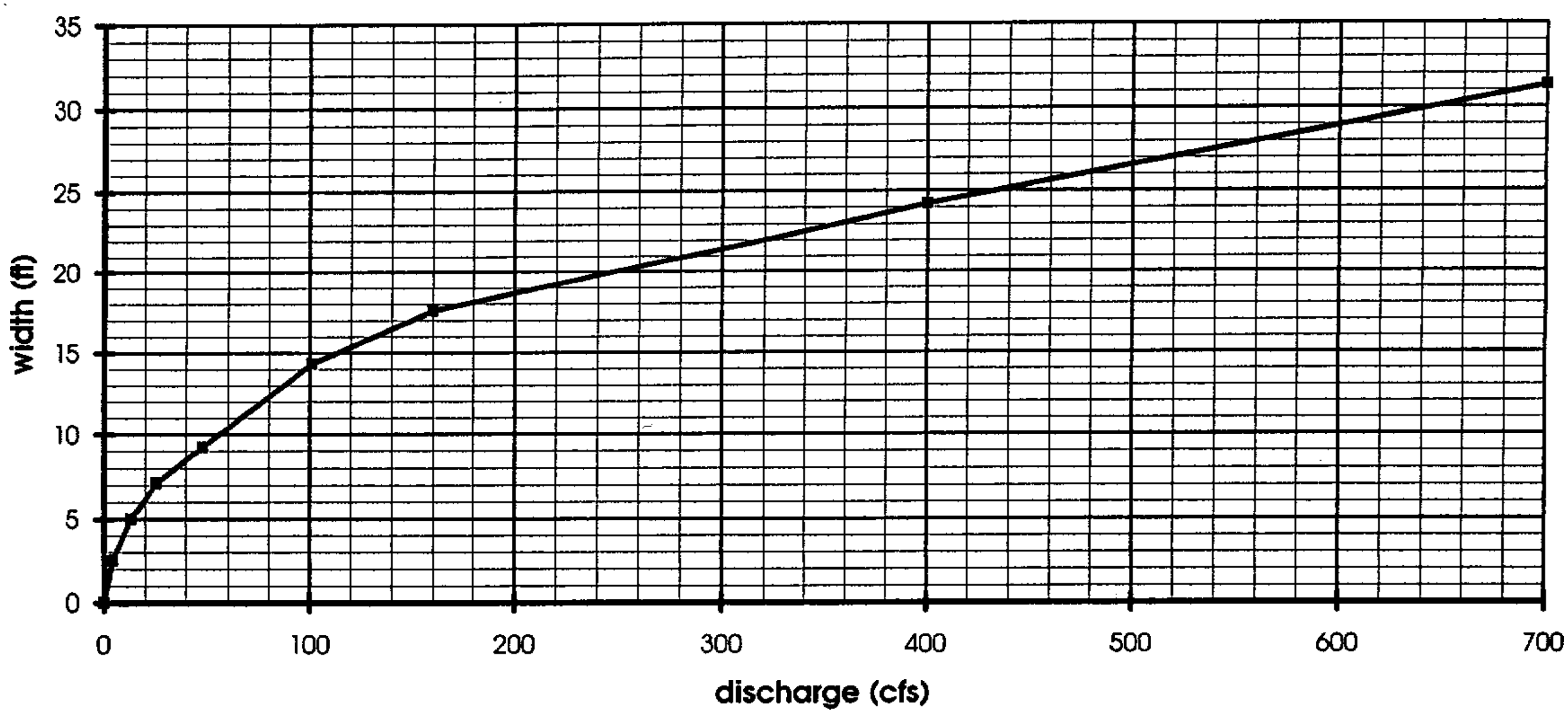
San Pedro River at Charleston (1904 to 1906)



San Pedro River at Charleston (1904 to 1906)



San Pedro River at Charleston (1904 to 1906)



within each cross section are described in the Ground Water chapter. Flood levels at each cross section are discussed in the surface water hydrology chapter.

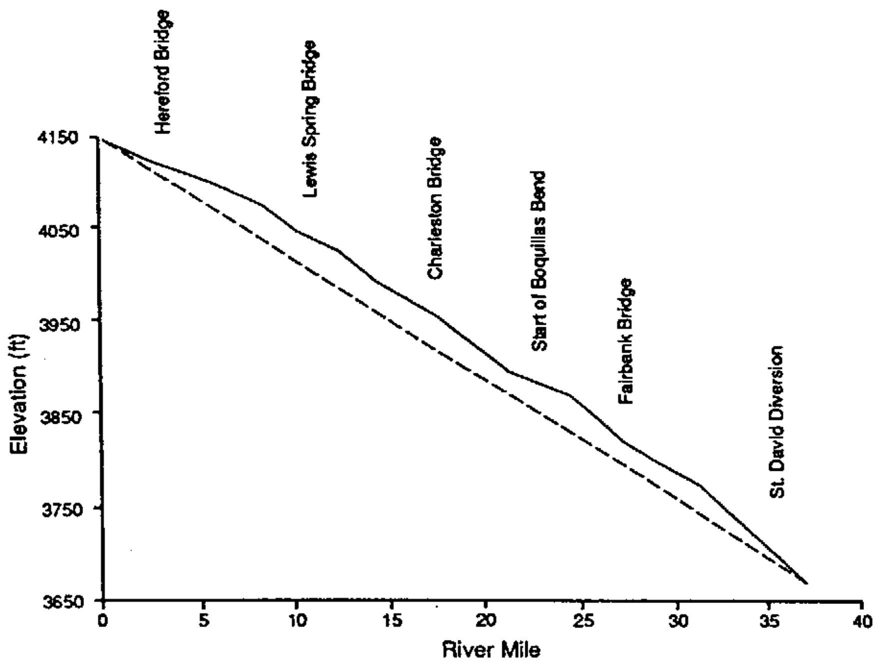


Figure 13. San Pedro River longitudinal profile.

Figure 14. (a-g) San Pedro River channel cross sections indicating the inundation extent of flood flows with 2-year, 10-year, 50-year, and 100-year return periods.

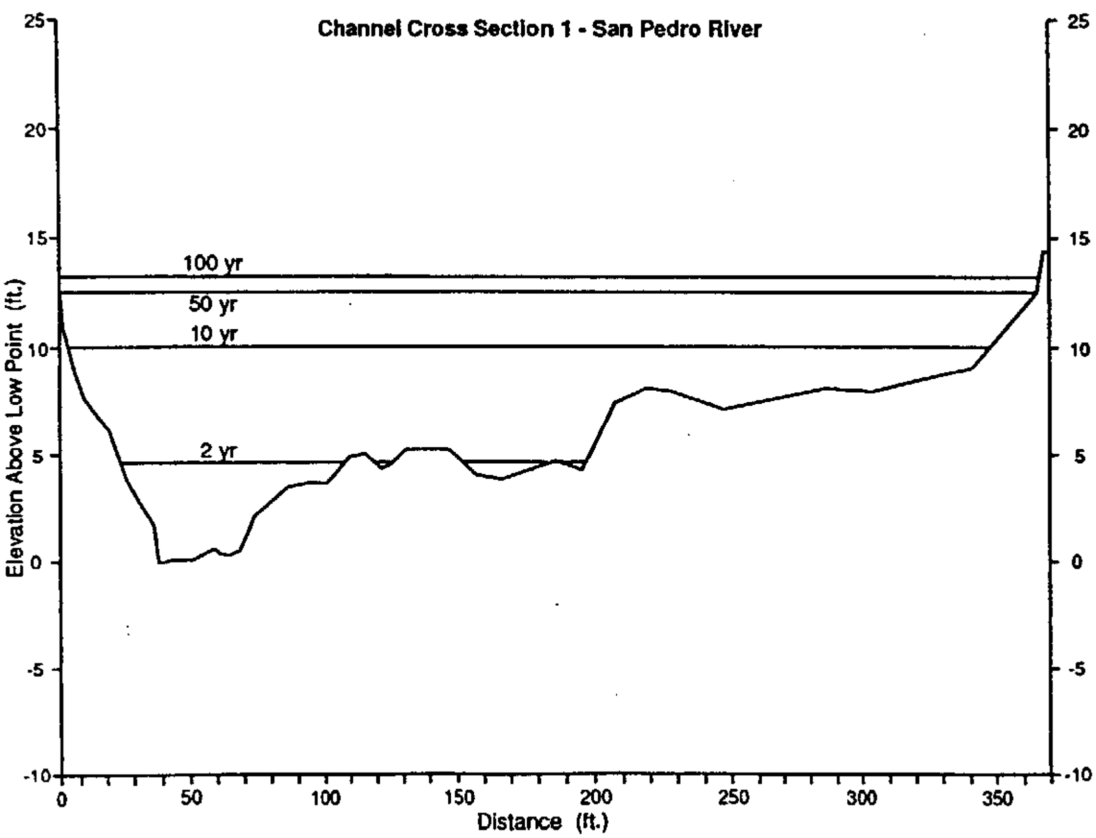


Figure 14a.

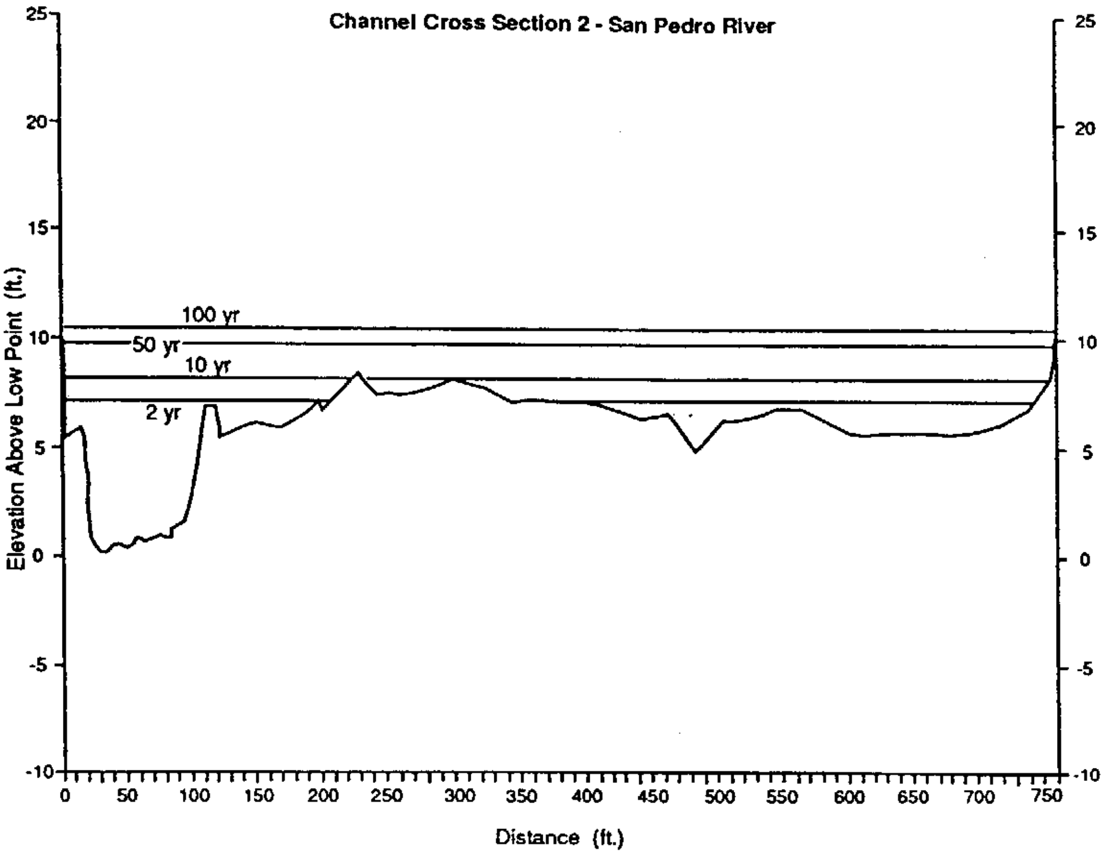


Figure 14b.

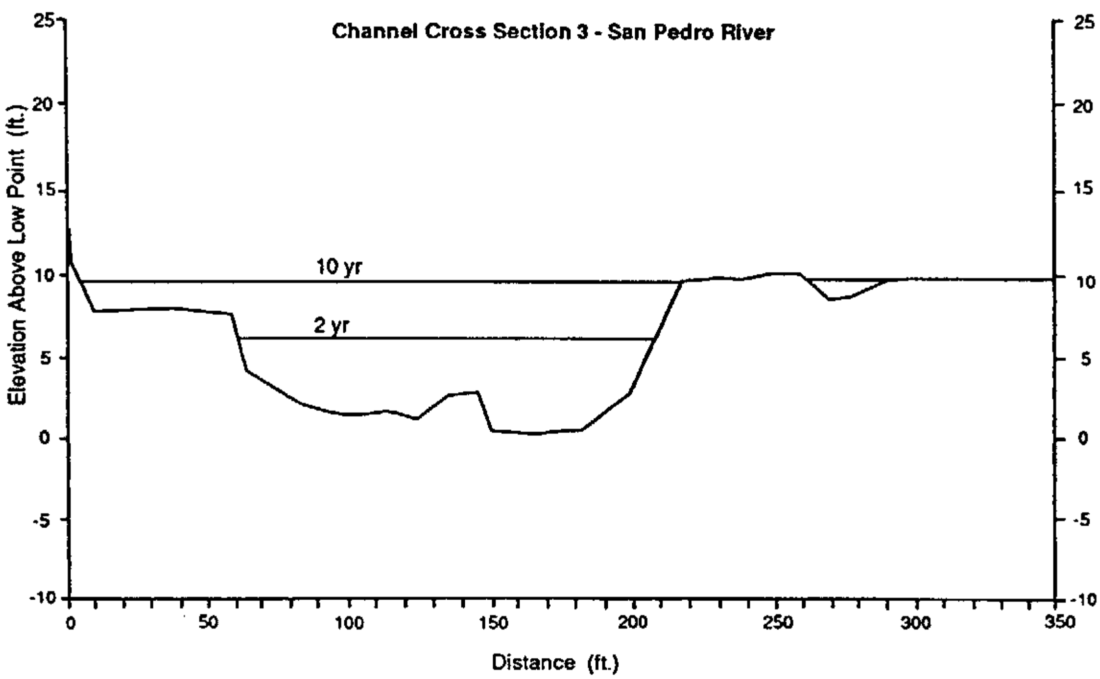


Figure 14c.

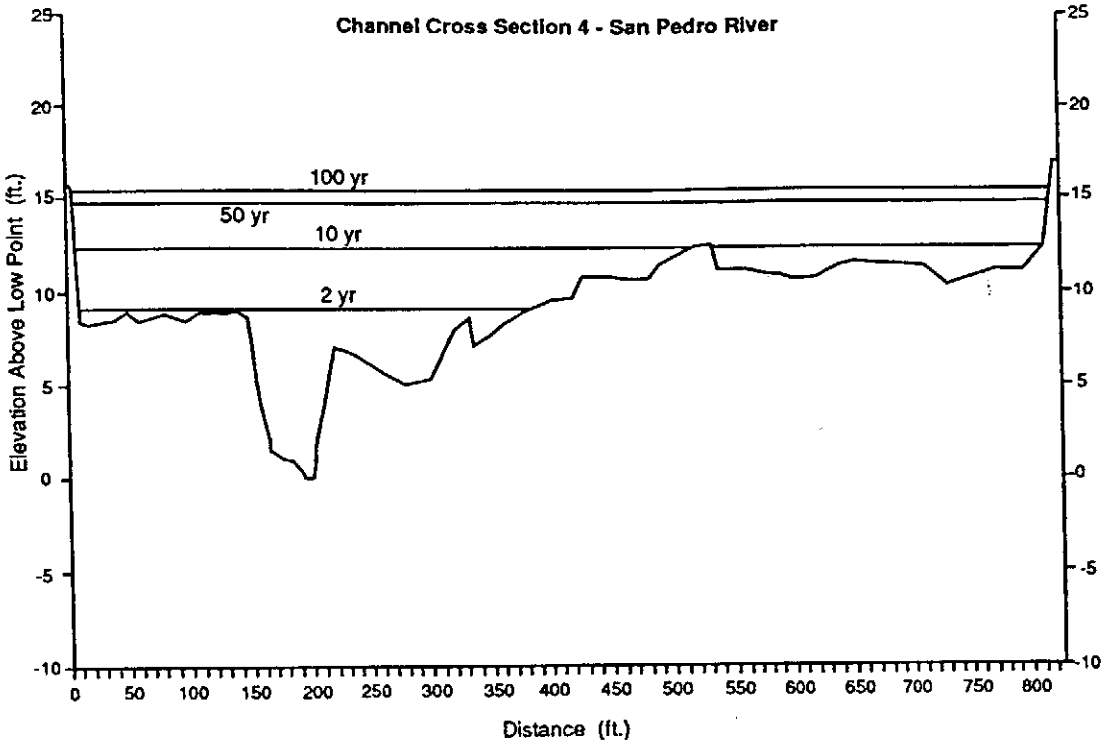


Figure 14d.

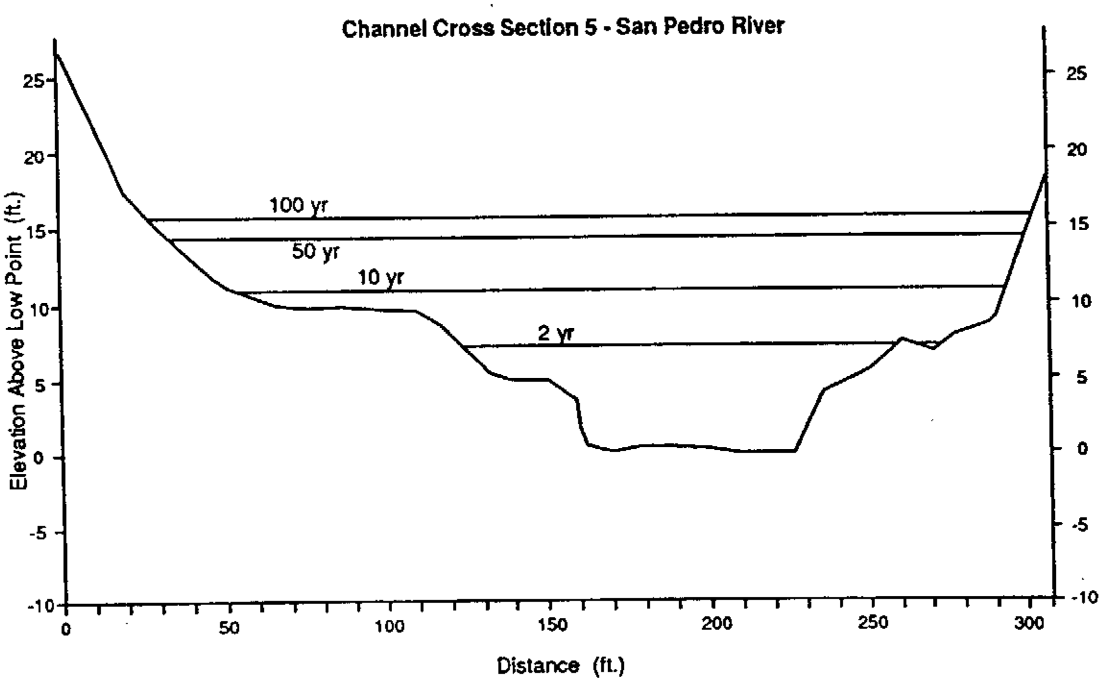


Figure 14e.

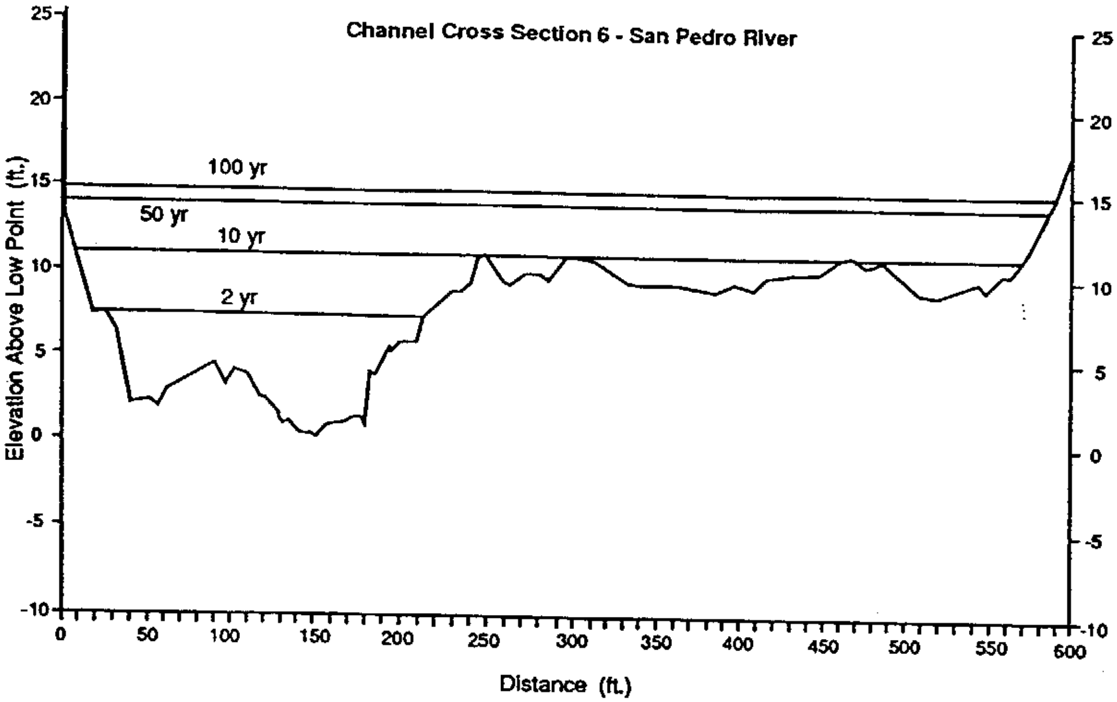


Figure 14f.

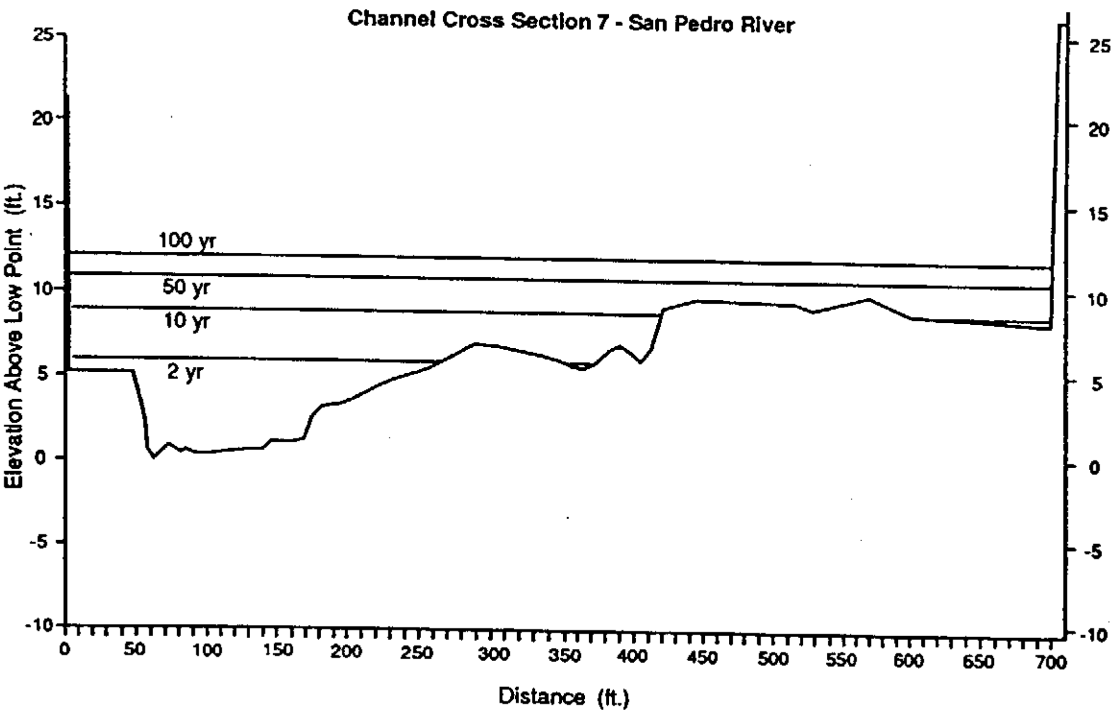


Figure 14g.

Figure 29. (a-g) Indirect discharge rating curves for San Pedro River cross sections.

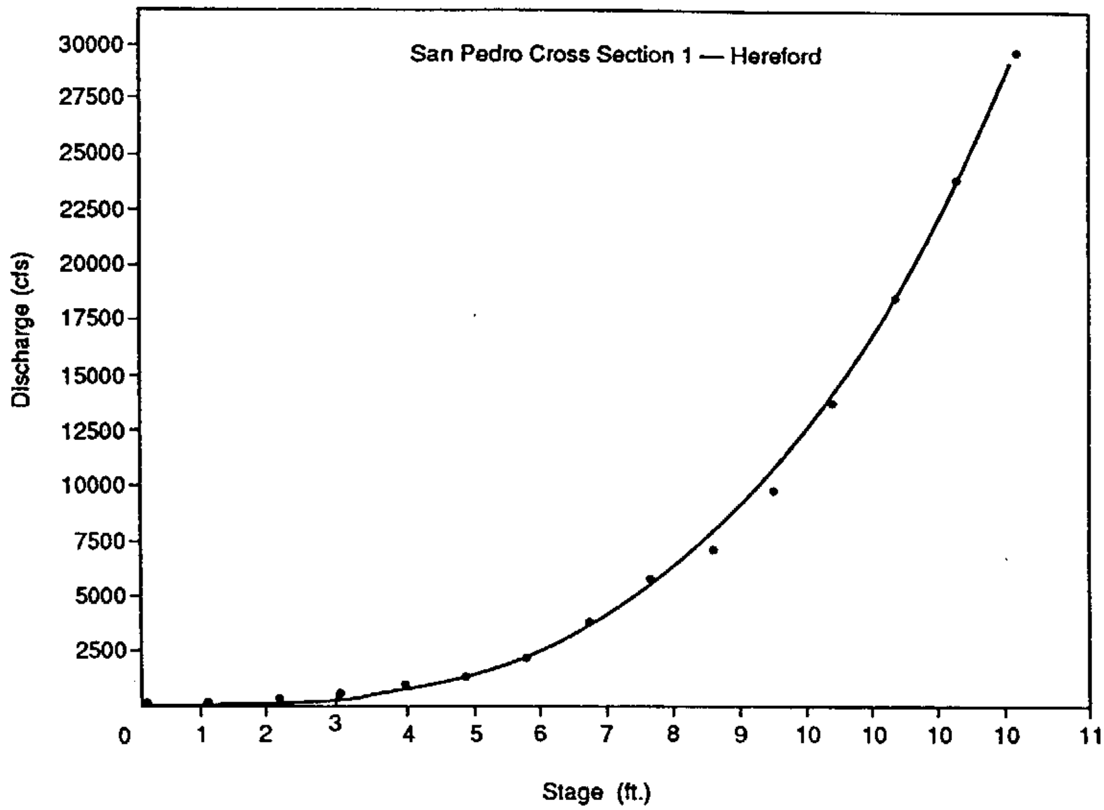


Figure 29a.

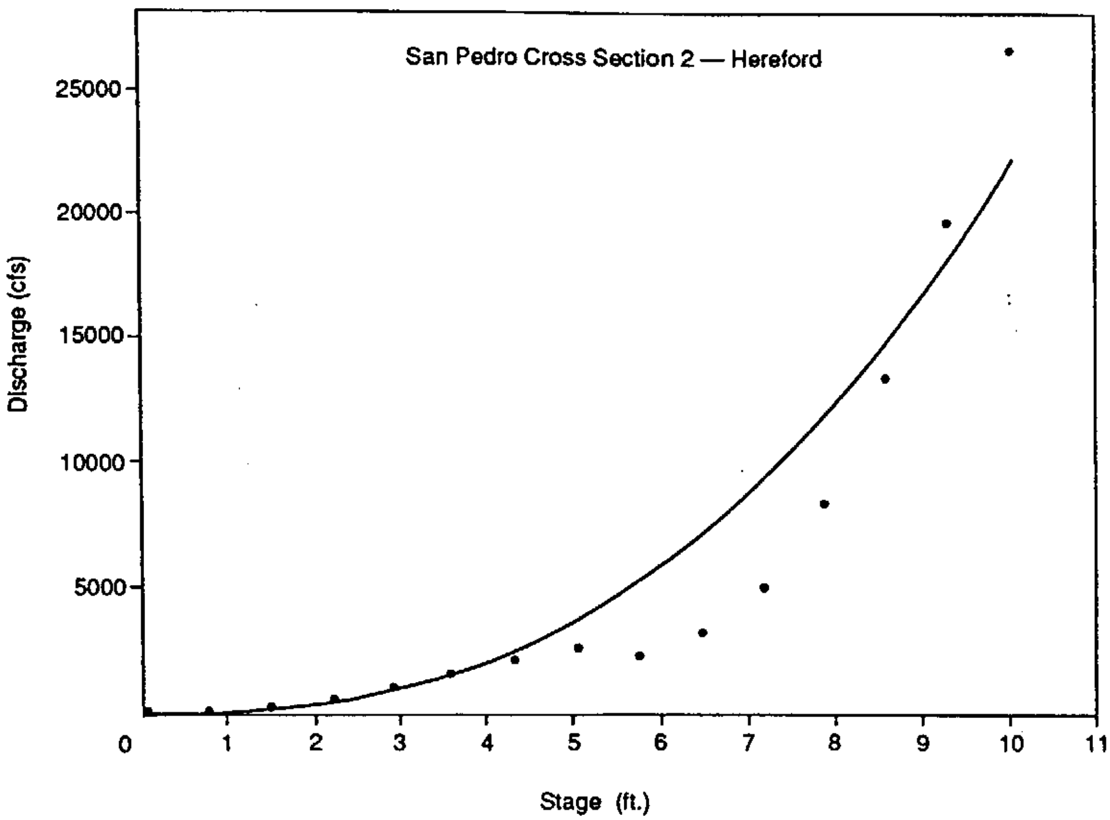


Figure 29b.

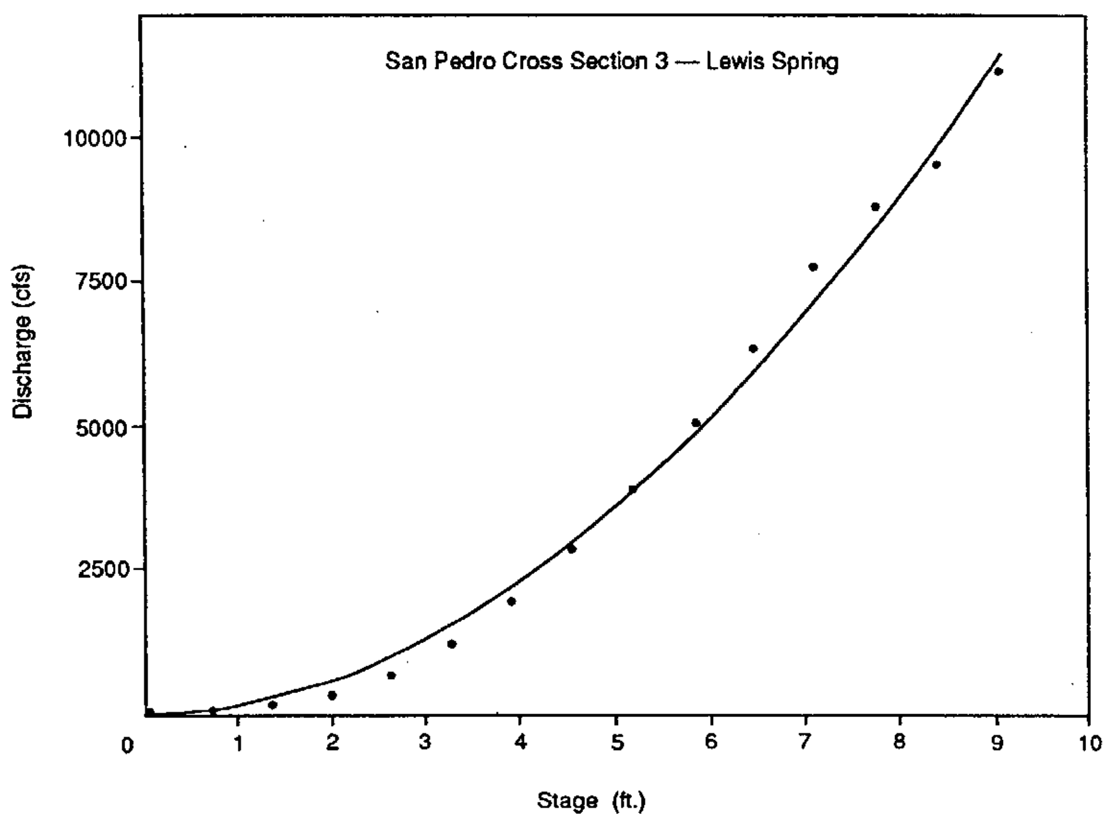


Figure 29c.

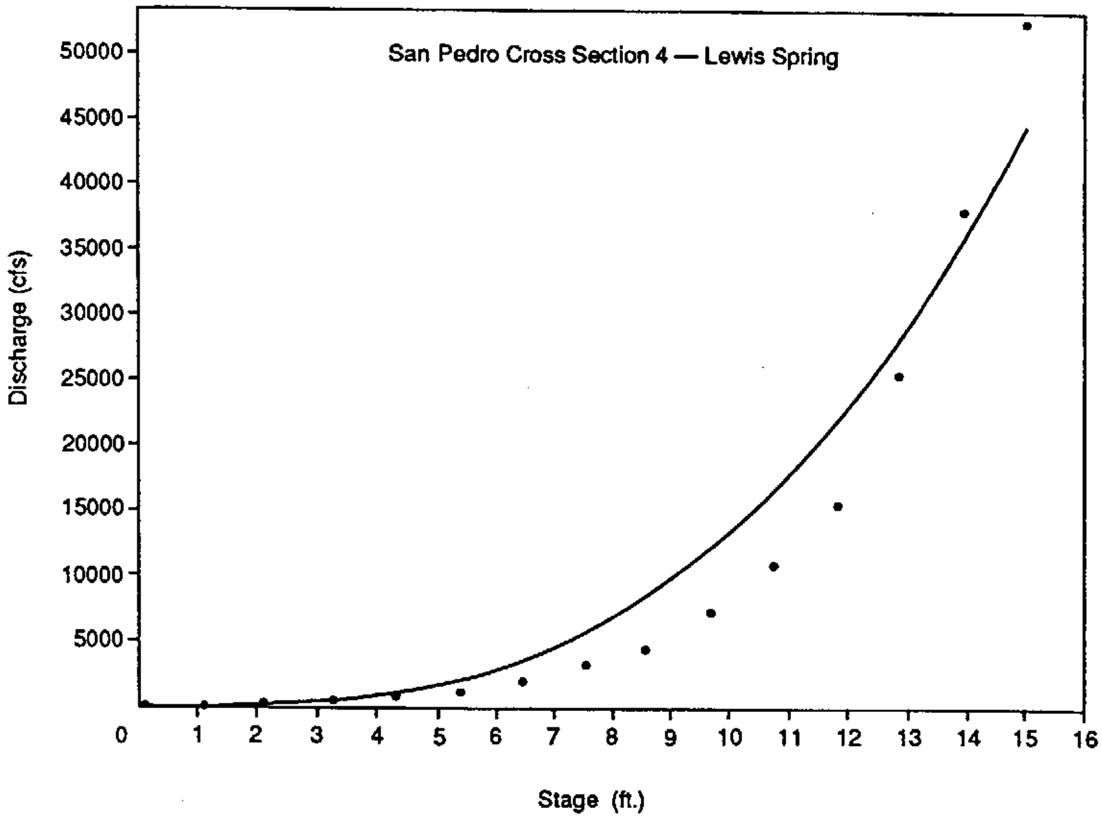


Figure 29d.

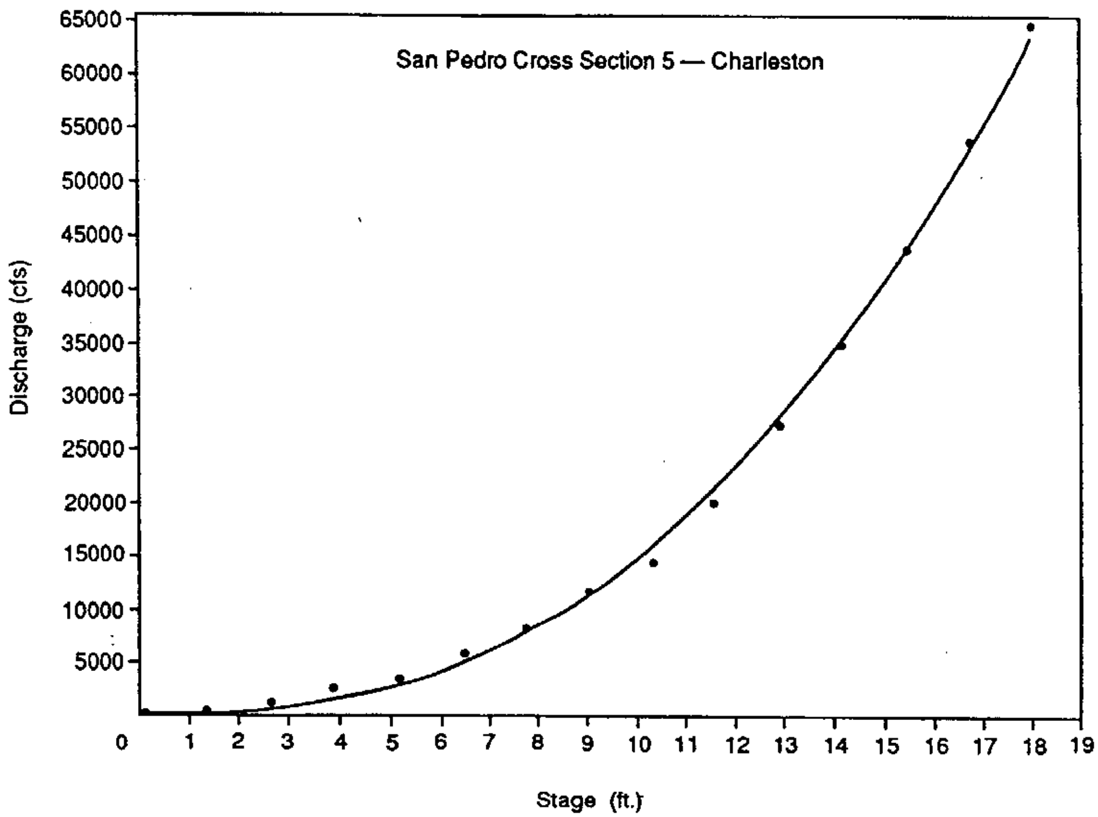


Figure 29e.

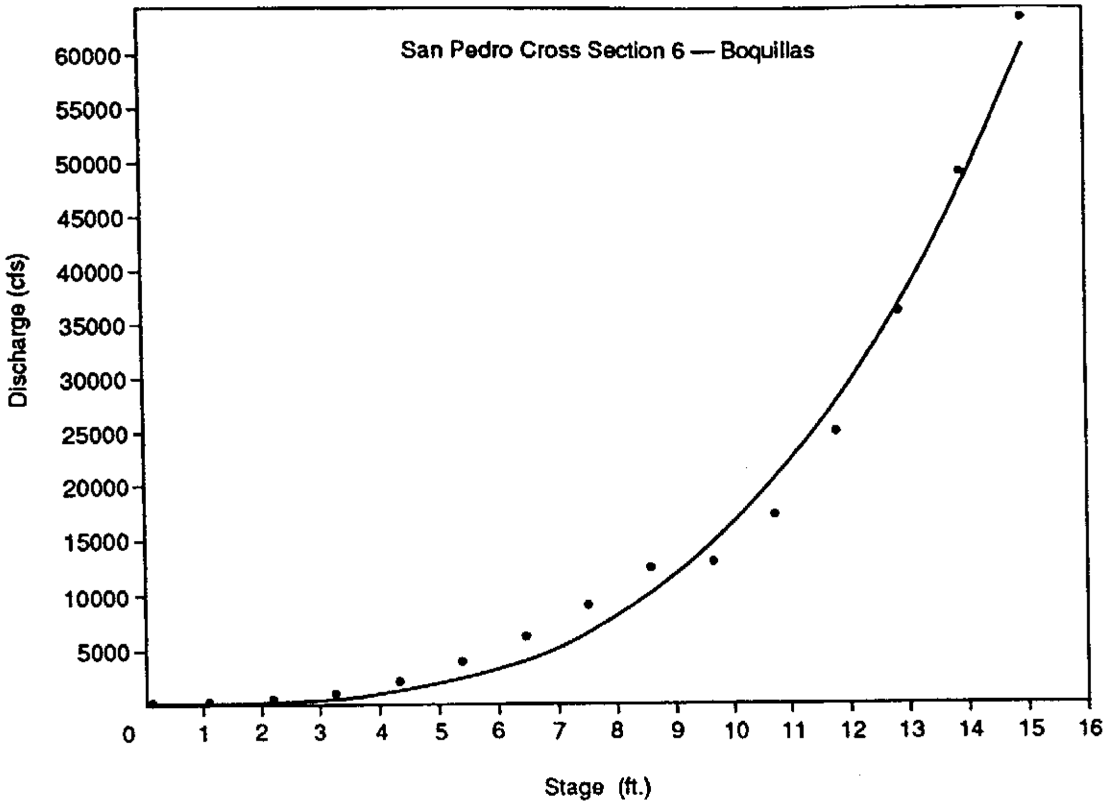


Figure 29f.

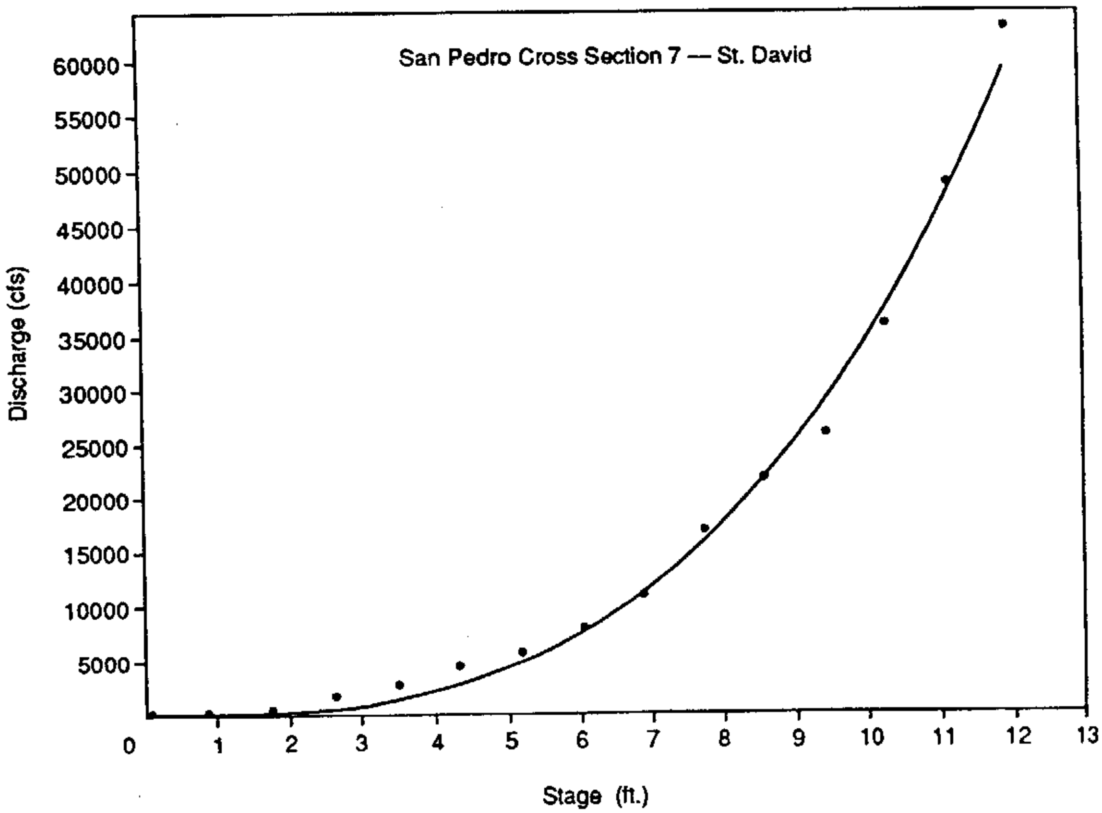


Figure 29g.

Appendix F
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 of climatic data were conducted for this report. This summary focuses on climatic effects streamflow. Data from the published studies were derived from the following: 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 F-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.

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

[1] Tree ring studies assume the thickness of the individual annual rings are related to discharge. Wet years (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.

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

- The period from 1905-1920 (Arizona statehood in 1912) 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 F-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) reached similar conclusions as Cooke and Reeves, and also noted 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) noted 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 concluded that beginning in 1900, precipitation abruptly increased until about 1910, at which time 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 effects 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 as of 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 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 as of 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 as of 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, 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 effect 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 as of statehood than during other periods of history.

[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 Hassayampa River, like the Verde River, climatic changes probably had minimal impact on whether the Hassayampa River was navigable as of 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.

- 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 boatable) 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 as of statehood. That is, runoff producing rainfall frequency has decreased. In addition, other factors have reduced average streamflow rates from statehood levels.

Summary

Some data are available from which to evaluate climatic conditions as of 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 as of 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 G
Boating on Arizona Rivers

Boating on the Arizona Rivers

Introduction

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 G-1 and G-2, were developed primarily for recreational boating (transport of people), not necessarily for commercial boating. Minimum stream conditions required are summarized in Table G-1. Minimum and maximum conditions are summarized in Table G-2.

Table G-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 G-2 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 G-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 G-2 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 make upstream segments non-navigable

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 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 G-3 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 G-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	

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 G-4.

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 Reef Dam is not mentioned in the Parks publication. The Hassayampa is mentioned only for

[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.

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 G-4
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 was 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. 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 some Arizona rivers are currently boated for recreational purposes at certain times of the year.

Appendix H
San Pedro River GIS

San Pedro River GIS Plots

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

Appendix H.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 H.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 I
Photographs of the Modern San Pedro River

Photos are on file with the Arizona State Land Department.

Appendix J
Public Comment

PUBLIC INFORMATION MEETING

ARIZONA STREAMBED NAVIGABILITY STUDIES
SAN PEDRO RIVER STUDY PUBLIC INFORMATION GATHERING

September 29, 1993

Dear Interested Party:

The Arizona State Land Department and CH_2M Hill Consulting Engineers invites you to attend a public information meeting regarding the San Pedro River navigability study at:

Thursday, October 21, 1993 7:00 p.m.
Sierra Vista Library - Art Gallary
2950 East Tacoma Street
Sierra Vista, AZ

In July, 1992, the Arizona State Land Department was charged by the Arizona Legislature under House Bill 2594 with gathering information and performing studies to assist the Arizona Navigable Stream Adjudication Commission (ANSAC) in its duties related to determining the navigability of Arizona's watercourses at the time of Statehood (1912) and thereby resolving clouded titles. The information which is gathered from the public and agencies will include the history, archaeology, hydrology, hydraulics, geomorphology, ownership and use of the underlying lands within and along the study rivers.

In order to complete the San Pedro River study currently in progress the Department needs your assistance to obtain additional existing available information from the public which will be included in the final report.

We appreciate any assistance you can provide us in these studies. If you have any questions or require additional information, you may contact:

Arizona Streambed Program
Drainage & Engineering Section
Arizona State Land Department
1616 West Adams
Phoenix, AZ 85007
(602) 542-3507
(fax) 542-4668

MEETING ATTENDANCE

Date: Oct. / 21 / 93   Subject: San Pedro River Streambed Meeting

Name	Representing/Address	Phone #
Don Henderson	ARID POBx3015, SV, AZ 85636	3783649
Jim Vlahovich	Cochise Cty Bisbee	432-9400
AL Rand	Az. Water Co. P.O. Box AW Bisbee Az. 85603	432-5321
Sherry Ruther	Az Game & Fish 555 N. Greasewood, Tucson 85745	628-537
Jim Herrewig	City of SV 2400 [illegible]	[illegible].331
Greg Yuncevich	BLM RR#1 Box 9853 Huachuca City Az	457-2265
JEFF INWOOD	ASL 2701 N. 16th St. Phoenix, AZ 85006	263-9522
Michael Lacey	ASL 2701 N 16th ST #106 Phx AZ 85006	263-952-

MEETING ATTENDANCE

Date: Oct. / 21 / 93 Subject: San Pedro River Streambed

Name	Representing/Address	Phone #
FREDERIC L. SALINGER	G.H.A. Democrats LIONS	458-4945

ARIZONA STREAMBED NAVIGABILITY STUDY - GILA RIVER

- PUBLIC INQUIRIES -

Today's Date: 10 / 21 / 93 Location: Sierra Vista

Name: Greg Yurcevich

Address: RR#1 Box 9853

Huachuca City, AZ 85616

Telephone: 457-2265 Fax No.: Same

Comment/Question:

Have Historical on San Pedro — Work for BLM Sierra Vista Office → Recommend to contact Ben Lomeli - BLM Phoenix Office.

Response: Yes ☐ No ☐ IP #69

Follow-Up:

Appendix K

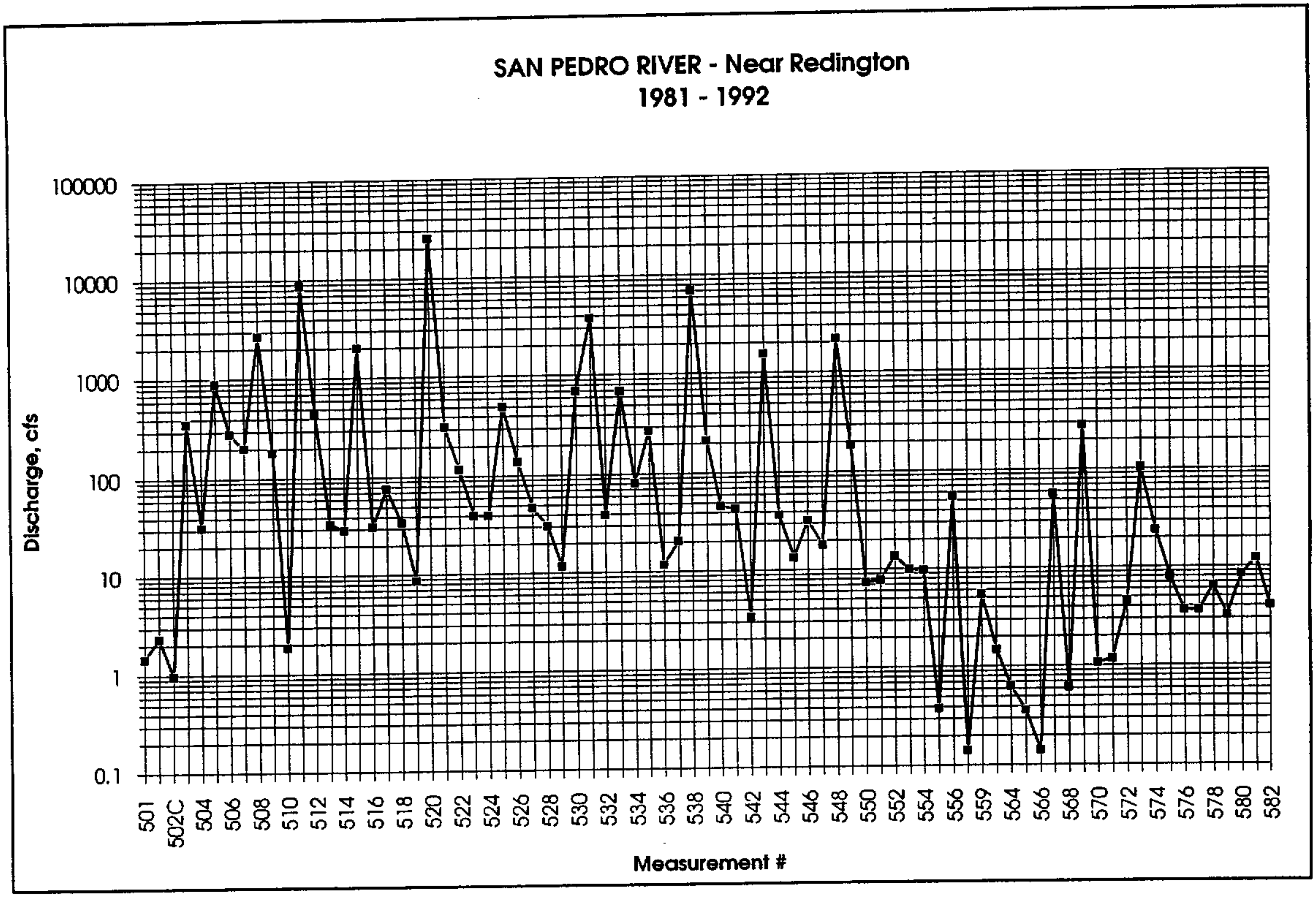
Lower San Pedro River:

Supplemental Geomorphic Analysis

544	32	18.4	2	8.94	36.9	0.6	
545	14	7.21	1.84	8.67	13.3	0.5	
546	14.5	12.4	2.57	9.04	32	0.9	
547	36	18.1	1.47	8.82	17.9	0.5	
548				12.4	2180		
549	68	51.3	3.59	10.04	184	0.8	
550	6.3	3.69	1.99	8.76	7.33	0.6	
551	10.4	4.21	10.85	8.7	7.75	0.4	
552	18	7.48	1.8	8.8	13.5	0.4	
553				8.77	9.83		
554				8.93	9.61		
555	2.9	0.72	0.53	8.54	0.38	0.2	
556	29.4	23.1	2.36	9.27	54.6	0.8	
557	11.6	6.89	0.69	8.46	0.14	0.6	
559	20.7	4.77	1.12	9	5.35	0.2	No Q for 55
560	7.8	1.6	0.92	8.14	1.47	0.2	
564	4	0.83	0.76		0.63	0.2	
565	3.8	0.93	0.39		0.36	0.2	
566	2.45	0.35	0.4	7.59	0.14	0.1	
567	28	23.2	2.44	8.42	56.6	0.8	
568	3.3	0.52	1.17	7.82	0.61	0.2	
569				9.15	281		
570	5	1.4	0.83	7.84	1.07	0.3	
571	6.8	1.9	0.62	7.86	1.17	0.3	
572	8.2	3.22	1.41	8.08	4.53	0.4	
573	60	39.5	2.59	8.6	102	0.7	
574	39.5	13	1.82	8.3	23.7	0.3	
575	14.4	5.03	1.57	8.92	7.92	0.3	
576	13.7	3.03	1.19	9	3.6	0.2	
577	20.5	5.03	0.42	9.11	3.63	0.2	
578	12	15.5	0.41		6.38	1.3	
579	8.9	7.5	0.42		3.18	0.8	
580	9	8.67	0.96		8.36	1.0	
581	25.8	8.07	2.51		12.2	0.3	
582	10.5	12.4	0.32		4	1.2	

SAN PEDRO RIVER NEAR REDINGTON						
2) Sorted w.r.t. Q						
Meas #	Discharge	Width	Area	Velocity	Gage H.	Depth
557	0.14	11.6	6.89	0.69	8.46	0.6
566	0.14	2.45	0.35	0.4	7.59	0.1
565	0.36	3.8	0.93	0.39		0.2
555	0.38	2.9	0.72	0.53	8.54	0.2
568	0.61	3.3	0.52	1.17	7.82	0.2
564	0.63	4	0.83	0.76		0.2
502C	0.97	3.9	2.52	0.38		0.6
570	1.07	5	1.4	0.83	7.84	0.3
571	1.17	6.8	1.9	0.62	7.86	0.3
501	1.45	5.7	1.8	0.81	7.15	0.3
560	1.47	7.8	1.6	0.92	8.14	0.2
510	1.86	10	2.14	0.87	7.48	0.2
502	2.33	10	1.98	1.18	7.48	0.2
579	3.18	8.9	7.5	0.42		0.8
542	3.34	14.2	3.06	1.09	8.78	0.2
576	3.6	13.7	3.03	1.19	9	0.2
577	3.63	20.5	5.03	0.42	9.11	0.2
582	4	10.5	12.4	0.32		1.2
572	4.53	8.2	3.22	1.41	8.08	0.4
559	5.35	20.7	4.77	1.12	9	0.2
578	6.38	12	15.5	0.41		1.3
550	7.33	6.3	3.69	1.99	8.76	0.6
551	7.75	10.4	4.21	10.85	8.7	0.4
575	7.92	14.4	5.03	1.57	8.92	0.3
580	8.36	9	8.67	0.96		1.0
519	8.64	12.1	4.6	1.88	8.14	0.4
554	9.61				8.93	
553	9.83				8.77	
529	11.6	17	7.96	1.46	8.12	0.5
536	11.7	23	6.53	1.79	8.79	0.3
581	12.2	25.8	8.07	2.51		0.3
545	13.3	14	7.21	1.84	8.67	0.5
552	13.5	18	7.48	1.8	8.8	0.4
547	17.9	36	18.1	1.47	8.82	0.5
537	20.4	24	9.27	2.2	8.83	0.4
574	23.7	39.5	13	1.82	8.3	0.3
514	29	33	12.6	2.3	7.76	0.4
528	30.4	24	12.7	2.39	8.5	0.5
516	31.4	27	13.4	2.34	7.84	0.5
504	31.8	50	18.3	1.74	7.76	0.4
546	32	14.5	12.4	2.57	9.04	0.9
513	33.8	42	16.2	2.09	7.82	0.4
518	34.3	46	16.1	2.13	8.13	0.4
544	36.9	32	18.4	2	8.94	0.6

	Q			V		D
532	38.8	37	15.8	2.48	9.34	0.4
523	40	28	19	2.11	8.8	0.7
524	40	26	17.4	2.3	9.15	0.7
541	43.4	30.5	21.7	2	9.2	0.7
540	46.3	38	22.1	2.1	9.1	0.6
527	47.4	23.5	17.6	3.69	8.8	0.7
556	54.6	29.4	23.1	2.36	9.27	0.8
567	56.6	28	23.2	2.44	8.42	0.8
517	76.5	53	28	2.73	8.35	0.5
534	80.2	38	27	2.97	9.32	0.7
573	102	60	39.5	2.59	8.6	0.7
522	117	64	40.9	2.86	9.84	0.6
526	137	33.5	37.1	3.69	9.23	1.1
509	180	64	62.8	2.87	8.25	1.0
549	184	68	51.3	3.59	10.04	0.8
507	201	56	51.4	3.91	8.32	0.9
539	214	84	60	3.57	9.81	0.7
535	273	116	74	3.69	9.67	0.6
569	281				9.15	
506	283	70	66.3	4.27	8.61	0.9
521	317	87	77.4	4.1	10.47	0.9
503	360				8.7	
512	434	113	110	3.95	8.88	1.0
525	500				10.65	
533	687	148	144	4.77	10.85	1.0
530	689	150	165	4.18	10.5	1.1
505	900				9.6	
543	1550				11.9	
515	2000				10.5	
548	2180				12.4	
508	2700				10.5	
531	3800					
538	7000				14.5	
511	8700				14.75	
520	25400				21.4	


SAN PEDRO RIVER - Near Redington
1981 - 1992
Discharge, cfs
100000
10000
1000
100
10
1
0.1
501
502C
504
506
508
510
512
514
516
518
520
522
524
526
528
530
532
534
536
538
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546
548
550
552
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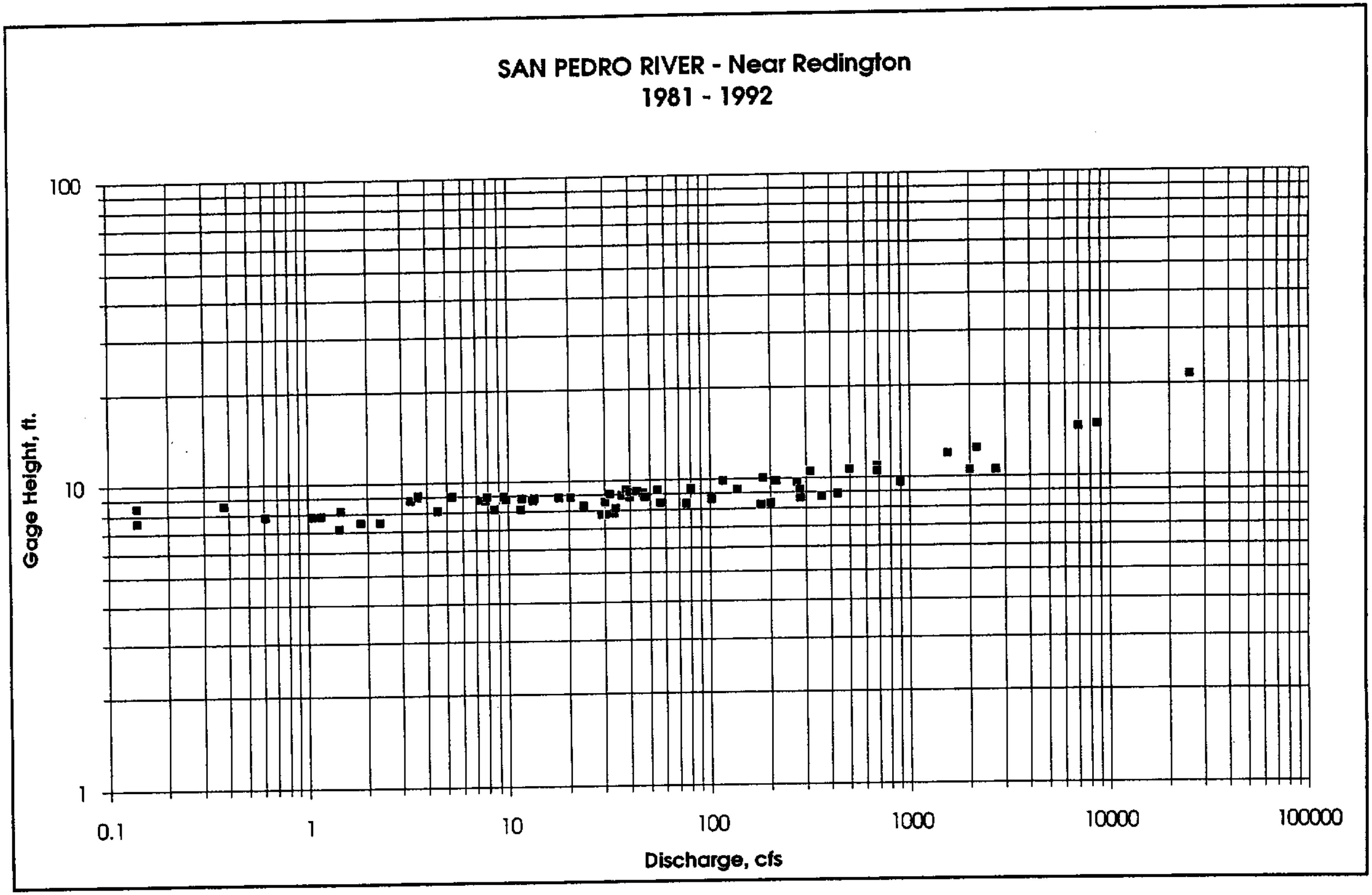
559
564
566
568
570
572
574
576
578
580
582
Measurement #

SPR-M-Q.XLC


SAN PEDRO RIVER - Near Redington
1981 - 1992
Gage Height, ft.
100
10
1
0.1
1
10
100
1000
10000
100000
Discharge, cfs

SPR-Q-GH.XLC

Appendix L

Historical Channel Changes Along the Lower San Pedro River

Original copy is on file at the Arizona State Land Department

HISTORICAL CHANNEL CHANGES ALONG THE LOWER SAN PEDRO RIVER

An Investigation Conducted for the
Arizona State Land Department

by Michelle Lee Wood
Arizona Geological Survey
August 1997

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INTRODUCTION

The San Pedro River is divided into upper and lower reaches based on environmental and geomorphic contrasts (Tuan, 1962; Heindl, 1952a,b). The upper reach extends from the headwaters to "The Narrows," a bedrock constriction near Benson. The lower reach extends from The Narrows to the San Pedro River's confluence with the Gila River (Figure 1). A previous study of the historical geomorphology of the San Pedro River conducted by the Arizona Geological Survey for the Arizona State Land Department (Huckleberry, 1996) summarized the available published information regarding the nature and timing of channel changes along the upper and lower San Pedro River. Whereas there is an abundance of published information regarding the character and timing of channel changes along the upper San Pedro River, there is very little published information available regarding channel changes along the lower San Pedro River.

Major channel changes and arroyo formation occurred on the upper San Pedro River during the late 1800's and early 1900's. Much of the published literature inferred that the upper San Pedro became entrenched as a result of the flood events that occurred during the 1890's. In addition, many inferred that the timing and general character of channel changes were similar on the upper and lower San Pedro River. The Arizona Geological Survey recently received feedback from residents of the lower San Pedro River whose family records and historical photographs suggested that the lower San Pedro River had a history of channel change significantly different from that of the upper San Pedro River. In particular, they believed that greater channel changes resulted from the 1926 flood event than from the 1890's flood events.

This report summarizes a new investigation of historical channel changes along the lower San Pedro River that supplements Huckleberry's 1996 report and explores the possible differences between the channel-change histories of the lower and upper reaches. It contributes to the baseline information that may be used by the Arizona Stream Navigability Commission in its determination of the potential navigability of the San Pedro River at the time of Statehood (1912). The primary objective of the research presented in this report is to establish a *chronology* of changes in channel characteristics along the lower San Pedro River, rather than to determine the *causes* of channel changes. For a review of the causes of channel change and arroyo formation on the San Pedro River and

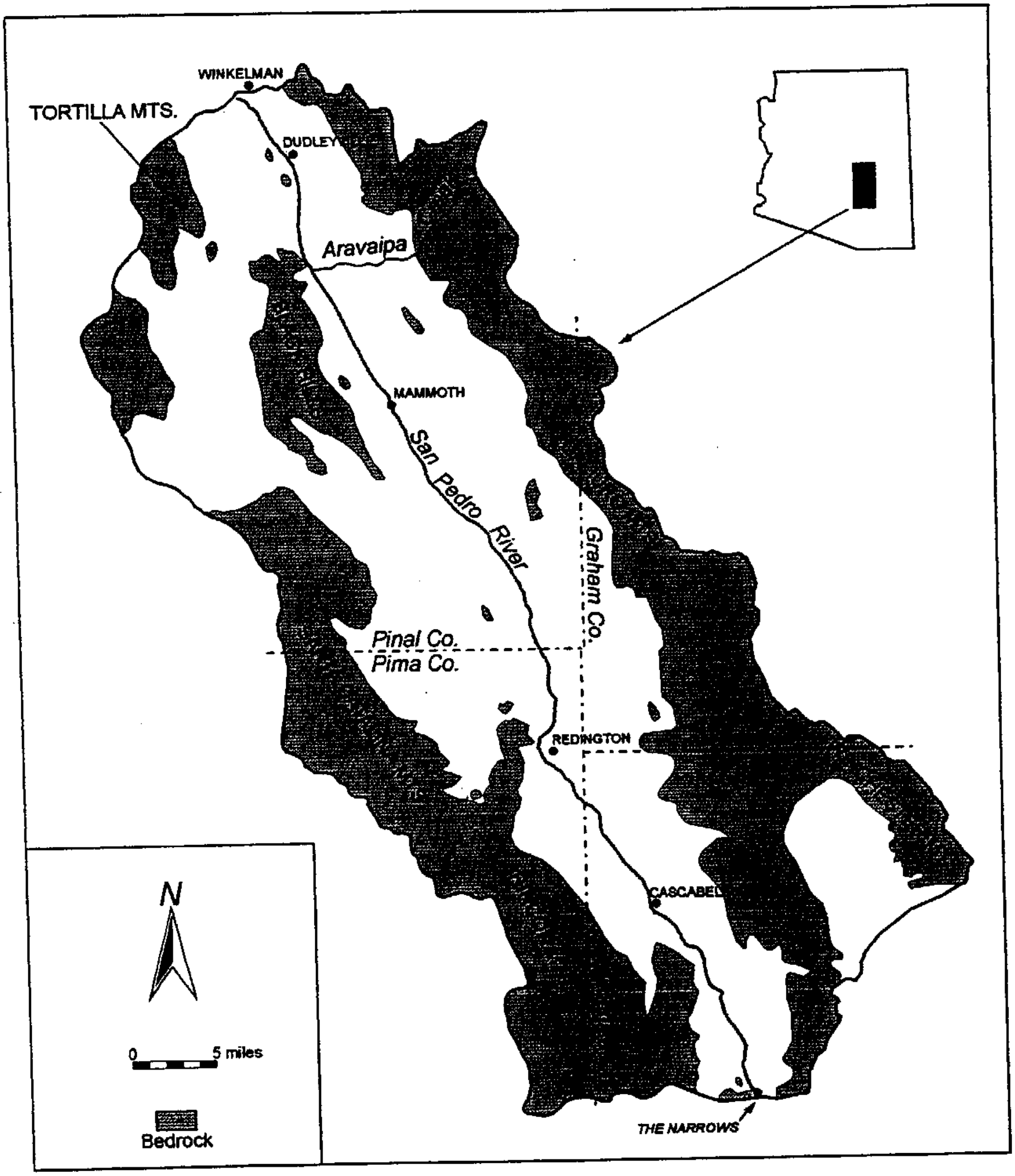

Figure 1. Lower San Pedro River Basin (adapted from Huckleberry, 1996, and Heindl, 1952.)

other rivers in southeastern Arizona, refer to such publications as Antevs (1952), Hastings and Turner (1965), Cooke and Reeves (1976), Betancourt and Turner (1990), and Hereford and Betancourt (in press).

The next section provides a description of the sources of information available for this report. The third and fourth sections provide discussions of the changes in channel width and location, and of the timing of entrenchment of the reaches of the lower San Pedro River near Redington and Mammoth/Dudleyville, the reaches for which there was historical information available. The fifth section of this report compiles all available archival and physical evidence that describes streamflow and channel characteristics into chronological listings for the Redington and Mammoth/Dudleyville reaches. The final section summarizes the most notable channel changes to occur along the lower San Pedro River.

SOURCES OF INFORMATION

This research focused on the collection of information relating to channel changes along the entire length of the lower San Pedro River between 1890 and 1926, a period that encompasses not only the date of Statehood, but also the time of most dramatic change along the San Pedro River. Several sources of information were investigated: published and unpublished references; historical maps; aerial and ground photographs; and, oral histories collected from people who have lived along the lower San Pedro River.

The search for historical information had four phases. The first phase was a thorough review and update of the published references compiled by Huckleberry (1996). Digital reference databases maintained by several different universities were searched using The University of Arizona's computerized card-catalog system known as "SABIO." In addition, the card catalogs compiled by The University of Arizona's Special Collections and the Arizona Historical Society's Tucson library were searched manually.

The second phase consisted of sending letters to approximately one hundred individuals and families that owned land along the lower San Pedro River. The letters inquired about knowledge of family records such as photographs, historical maps, manuscripts, diaries, or any other information or memories that related to channel characteristics between 1890 and 1926. The names and addresses for the mass mailing were retrieved from the Land Ownership Geographical Information System, which was compiled as part of the 1993 Arizona Stream Navigability Study[1] and was archived by the Arizona State Land Department.

The third phase involved contacting over forty public and private agencies. The goals of this phase were to locate unpublished reports and project work, and to identify long-time residents of the lower San Pedro River Valley who might have memories or family records that described the channel at the turn of the century. The final phase of the search for historical information was contacting, by telephone or in person, current and former residents of the lower San Pedro Valley. A list of agencies and individuals that provided information, and summaries of the oral interviews and response letters, is provided in Appendix C. Information provided by these contacts that is relevant to the thesis of this report is interwoven throughout the following sections.

The vast majority of the data gathered related to two specific reaches of the San Pedro River: a ten-mile reach near Redington, and a twenty-five-mile reach between Mammoth and the Gila-San Pedro confluence. Information that relates to the history of arroyo formation in these two reaches is presented in the next section. Information about changes in channel width and location is presented in the fourth section of this report. The fifth section of this report provides detailed chronological listings of historical channel and streamflow descriptions for the Redington and Mammoth reaches of the lower San Pedro River.

Many of the oral histories described *flow* characteristics rather than *channel* characteristics. Much of the information in general related to changes that occurred after both Statehood and the 1926 flood event. Although such information did not fall within the scope of this investigation, it was included in the chronological listings if the authors thought it could be useful in the Arizona Navigable Stream Adjudication Commission's determination of the potential navigability of the San Pedro River.

Places mentioned in the following text are shown in Figure 1 or Plates 1, 2, and 3. Because the locations of many places are described using the Bureau of Land Management's system of land division, an explanation of this system is provided in Appendix A. Appendix B contains one historical photograph and nine recent ground

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1 Arizona Stream Navigability Study for the San Pedro River: Gila River Confluence to the Mexican Border, November 1993, Draft Final Report. Prepared by CH2M Hill, SWCA Environmental Consultants, and Arizona Geological Survey for the Arizona State Land Department and the Arizona Navigable Stream Adjudication Commission.

photographs that illustrate conditions along the Redington and Mammoth reaches of the river, and Appendix C contains the list of contacts and oral history summaries.

LATERAL CHANNEL CHANGES ALONG THE LOWER SAN PEDRO RIVER

The dominant channel-change mechanism in each reach of a river depends on channel morphology, channel sediment, bank resistance, and flood magnitude. Where the channel is entrenched into an arroyo, a combination of fluvial processes and bank retreat mechanisms leads to arroyo change (Parker, 1995). The different types of lateral and vertical changes a river channel may experience are described in Table 1.

Major channel changes along the San Pedro River have occurred primarily as a result of large flood events (Hastings, 1959; Hastings and Turner, 1965; Cooke and Reeves, 1976; Hereford and Betancourt, in press). Newspaper accounts indicated that large floods occurred on the San Pedro River in 1881, 1886*[2], 1887*, 1890*, 1891*, 1893, 1894, 1896, 1900, 1901*, 1904*, 1905*, and 1926* (Hereford and Betancourt, in press). Figure 2 provides the annual peak discharge measurements recorded by the U.S. Geological Survey gages at Charleston (located at the northernmost part of the upper San Pedro River) and near Redington, that began in 1916 and 1926, respectively. The gage record at Redington indicated that large floods occurred in 1926, 1940, 1947, 1951, 1977 (Water Year[3] 1978), 1983 (Water Year 1984), and 1993. The Charleston and Redington discharge records and the newspaper accounts indicated that the largest flood of record occurred in September of 1926.

This section of the report focuses on historical changes in the channel width and location of the San Pedro River, near Redington and Mammoth/Dudleyville, that resulted from the large floods of the late 1800's and early 1900's. To ascertain such lateral channel changes, the channel location and boundaries discerned from historical survey maps, and from historical and recent aerial photographs, were compiled onto 1:24,000-scale base maps. Table 2 describes the maps and photographs that were available for this study.

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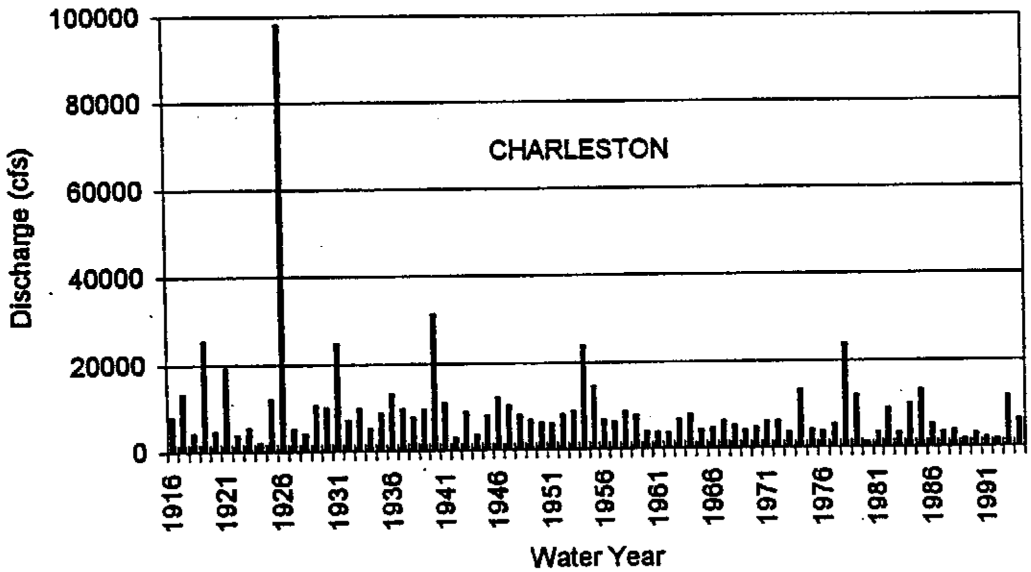
[2] Asterix (*) indicates a year in which newspaper accounts noted flood(s) specifically on the lower San Pedro River.

[3] A water year is defined as October 1st of the previous calendar year to September 30th of the current calendar year.

Table 1. Channel change mechanisms.
(Source: Wood *et al*, 1996. Adapted from Parker, 1995.)

MECHANISM	DESCRIPTION
Meander migration:	Lateral shifts of centerline position associated with the inception of meanders and their subsequent downstream translation, lateral extension, or rotation of meander axis.
Avulsion:	An abrupt shift in channel position that occurs when overbank flow incises new channels as other channels aggrade and are abandoned.
Meander cutoff:	An abrupt shift in channel position that occurs at meanders and may or may not involve concurrent aggradation of the abandoned channel segment. Meander cutoff and avulsion tend to occur where channels are shallowly incised, the floodplain is active, and aggradation rates generally are high.
Channel widening:	Results primarily from high flows that erode weakly cohesive banks. It is different from arroyo widening because arroyo boundaries may delineate not only a channel but also a floodplain at the bottom of the arroyo. It is a product of corrasion by fluvial erosion during rising flow, or mass wasting of banks following the flow peak.
Vertical change:	Results from changes in stream power, sediment comcentration, or resistance that occur as a result of variation in flood magnitude, sediment availability, channel morphology, or local channel gradient. "Degradation and aggradation occur over years to decades and may reflect climatic changes, adjustments to channel widening or narrowing, sediment storage and episodic transport, and natural or artificial changes in channel-hydraulic properties... Degradation and aggradation can alternate in time and space." [Parker, 1995, p. 24]

Figure 2. Annual peak discharges recorded at the Charleston and Redington gages.



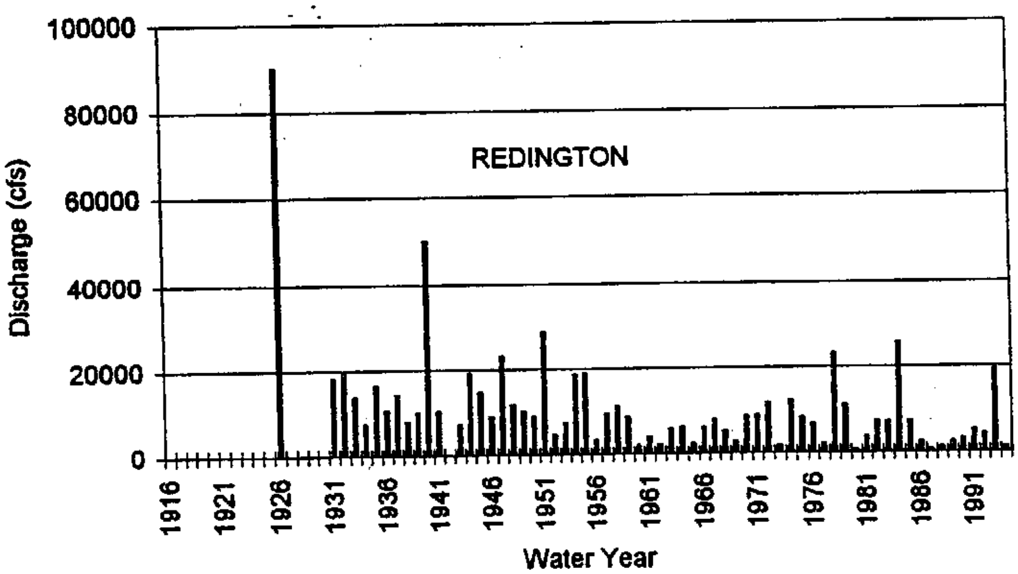


Table 2. Historical maps and aerial photographs available for this study.

DATE	TITLE	SURVEYOR	COMMENTS
1877	Survey of Gila & Salt River Meridian (Mammoth/Dudleyville reach)	John L. Harris, Government Land Office	See Plate 2 and Plate 3. Maps were available for all Townships except T.8S. R.16E.
1879	Survey of Gila & Salt River Meridian (Redington reach)	John L. Harris, Government Land Office	See Plate 1.
1899	[Map showing location of canals diverting water from the San Pedro River.]	U.S. Geological Survey	Small-scaled map published in the U.S. Geological Survey's Twenty-First Annual Report of the United States Geological Survey to the Secretary of the Interior, 1899-1900 Part IV - Hydrography.
1902	Map of the Desert Land Entry No. 3248, Embracing W1/2 SE1/4 Sec 10, and W1/2 NE1/4 Sec 15, T11S R18E, Gila and Salt River Meridian, Arizona	N/A [Filed Charles Bayless]	Scale: 1 inch = 1000 feet
1907	Property of the Bayless and Berkalew Company Situated Along the San Pedro River, Arizona.	William B. Alexander, C.E., U.S. Land Surveyor, Tucson, AZ	See Plate 1. Scale: 1 inch = 2000 feet
1913	30' Winkelman Topographical Quadrangle	U.S. Geological Survey	Surveyed in 1910-11. Scale: 1:125,000
1921	Gila River Determination, Pima and Cochise Counties, Arizona: Map of surveys showing irrigated lands under ditches taking water from Gila River or tributaries, District No. 3	State Water Commissioner	This boundaries of the river channel on this map did not compare well with maps of earlier or later surveys. For example, when the river boundaries and ditch locations from the 1921 map were overlaid onto the 1981 base map, the river and Bayless Ditch were located high on the side of a present-day hill. Scale: 1 inch = 1000 feet
1926 Feb.	Untitled.	N/A	Area of Bayless and Berkalaw Company holdings. Scale: 1 inch = 1000 feet
Pre-1926 Flood	Untitled. [RR-East]	N/A	This is a survey of the channel area conducted by a railroad company (Smallhouse, 1997, oral commun.). It is a detailed map of all drainage features along only the eastern bank of the river. The location of the channel boundaries in this map closely matches the location of the river on the maps surveyed in 1902 and 1907. Scale: ~3 inches = 1 mile

Table 2. Historical maps and aerial photographs available for this study, continued.

DATE	TITLE	SURVEYOR	COMMENTS
Post-1926 Flood	Untitled. [RR-West]	N/A	This is identical in design to the above map, except that it is a survey of the drainage features west of the San Pedro's channel, and the location of the channel boundaries in this map resemble the boundaries depicted in the 1934 aerial photographs, indicating that it was probably surveyed after the flood of 1926. Scale: ~3 inches = 1 mile
1934	Aerial photographs of the San Pedro Valley.	Soil Conservation Service	See Plate 1, Plate 2, and Plate 3. This is the first systematic aerial photography performed for the lower San Pedro River. Scale: 1:62,500.
1945	15' Redington Topographical Quadrangle	U.S. Geological Survey	The survey was conducted in 1942-43. Scale: 1:62,500
1948	7.5' Mammoth Topographical Quadrangle	U.S. Geological Survey	Scale: 1:24,000
1949	7.5' Winkelman and Saddle Mountain (now Dudleyville) Topographical Quadrangles	U.S. Geological Survey	Scale: 1:24, 000
1950	7.5' Lookout Mountain Topographical Quadrangle	U.S. Geological Survey	Scale: 1:24,000
1972	7.5' Dudleyville, Lookout Mountain, and Mammoth Topographical quadrangles	U.S. Geological Survey	See Plate 2 and Plate 3. Scale: 1:24,000
1981	7.5' Redington Topographical Quadrangle	U.S. Geological Survey	See Plate 1. Scale: 1:24,000
1994	Aerial photographs of Pinal County.	Pinal County Department of Planning	See Plate 2 and Plate 3. Scale: 1 inch = 600 feet
1995	Aerial photographs of Pima County.	Pima County Maps and Records	See Plate 1. Scale: 1 inch = 600 feet
1997	Aerial photographs of the Nature Conservancy's holdings along the San Pedro River in Pinal County.	Nature Conservancy – Dudleyville	Scale: 1 inch = 400 feet

The next two parts of this section describe the changes in channel width and location that have occurred in the past century.

The timing of arroyo formation is not discussed until the fourth section of this report. However, because it is widely accepted that the channel of the lower San Pedro River has been entrenched at least since the 1926 flood event, and because periods of channel widening were often associated with periods of vertical change, it is impossible to completely segregate the discussion of channel widening and channel entrenchment. Therefore, the term "arroyo" and other key phrases used throughout this report are defined below.

Channel: A long, narrow, troughlike depression occupied and shaped by a stream.

Active channel: The San Pedro River, like many streams in the Southwest, is intermittent; that is, it has reaches that flow only during wet weather or during part of the year, and reaches that flow year-round. In addition, the streamflow experiences great variability from one season to the next, and from one year to the next. Hence, this report uses the phrase "active channel" to describe the area of the sandy channel bottom that was cleared of vegetation by recent flows ("recent" relative to the time a map was surveyed or aerial photograph taken), rather than the area of the sandy channel bottom covered by streamflow, or the area delineated by defined channel banks or *arroyo* walls.

Floodplain: A belt of low, flat ground present on one or both sides of a stream channel, subject to inundation by floods and underlain by stream-laid sediment deposits.

Arroyo: In the convention established by Bryan (1922) and refined by Antevs (1952), the term "arroyo" is used when there is a single channel incised in unconsolidated material consisting of clay, silt, sand and some gravel, with banks more than two feet high. The boundaries of an arroyo are defined by its steep banks. Once an arroyo widens to the point that it becomes relatively stable, the former floodplain becomes a terrace, and the arroyo floor becomes a floodplain (Meyer, 1989). Hence, the steep banks of an arroyo may delineate an *active channel* and a *floodplain* at the bottom of the arroyo.

Note: Several of the historical maps and written accounts did not define their use of the word "channel." That is, their use of the word "channel" may refer to the area of the channel bottom covered by water, the area delineated by defined channel banks or arroyo banks, or the area defined by the sandy channel bottom cleared of vegetation. In such cases, this report uses "channel" in the same context as it was used in the historical reference.

Lateral Channel Changes in the Redington Area

A compilation map of channel changes created for the San Pedro River near Redington is shown in Plate 1. Channel locations from the 1879 General Land Office

(GLO) survey, the 1907 Bayless and Berkalew Company (BBC) survey, and the 1934 and 1995 aerial photographs, were transferred to the U.S. Geological Survey's 1981 Redington topographic quadrangle using a zoom-transfer projector. The 1879 GLO survey maps showed the channel location rather than the channel boundaries. In addition, the position of the channel was surveyed only where it crossed cadastral lines; channel locations between the cadastral lines were interpolated (Huckleberry, 1996).

The 1907 BBC survey mapped distinct channel boundaries; however, it is not known whether this survey defined the channel boundaries by the extent of a sandy channel bottom, by the edges of streamflow, or by the presence of defined channel banks. However, the channel boundaries drawn on the July 1902 Desert Land Entry map, the February 1926 Bayless and Berkalew map, the 1921 State Water Commission map, and the Rail Road-East Bank map, all recorded comparable channel widths. Such similarity in channel widths indicates that the channel was defined by the presence of distinct banks or by the area of the channel bottom that was cleared of vegetation.

The channel boundaries discerned from the 1934 and 1995 aerial photographs were defined by the extent of the active channel, rather than by the location of defined channel banks. The precise location of the channel banks was not visible in several of the aerial photographs, either because the photographs were shot at an angle that did not show the relief of the channel banks, or because the channel banks were obscured by vegetation. However, field observations in 1997 indicated that the extent of the sandy channel bottom typically coincided with the location of the steep channel banks that defined the width of the arroyo that had formed by this time along the Redington reach of the San Pedro River.

Although only the channel location was depicted by the 1879 maps of the lower San Pedro River, measurements of channel width were surveyed normal to cadastral lines and recorded in the notes of the surveyor, John L. Harris. Following the procedure of Burkham (1972), Huckleberry (1996) compiled and averaged the channel width measurements surveyed by Harris for each Township. The channel had a mean width of 35 feet in T.11S. R.18E., and 26 feet in T.12S. R.18E.

Between 1879 and 1907, three relatively short segments of the river experienced greater-than-1000-foot shifts in the their locations: a half-mile segment downstream of The Narrows (T.12S. R.18E. Sec.13; refer to Plate 1). Otherwise, the location of the San Pedro River channel changed very little between 1879 and 1907. However, the channel widened considerably during that period. The San Pedro River channel had a width of approximately 400 feet in T.11S. R.18E., and approximately 200 feet in T.12S. R.18E. The channel was as narrow as 150 feet at the R.18E./R.19E. Range line in T.12S., and as wide as 900 feet at the T.11S./T.12.S Township line in R.18E.

Between 1907 and 1934, a 1.5-mile segment of the river in T.12S. R.18E. had shifted to approximately 1300 feet west of its 1907 location, probably as a result of the 1926 flood event.[4] Except for the movement of channel meanders (i.e. in T.11S. R.18E. Section 15), no other changes in channel location occurred during the period from 1907 to 1934. Although the channel widened very little during this period upstream of Redington, it widened dramatically downstream of Redington. Huckleberry (1996) determined that the 1934 channel had a mean width of 236 feet in T.12S. R.18E. (upstream of Redington), and 837 feet in T.11S. R.18E. (downstream of Redington).

The 1995 aerial photographs showed that the channel location upstream of Redington (T.12S. R.18E.) had not changed since 1934, and that channel width had changed very little since 1934. However, the channel located downstream of Redington (T.11S. R.18E.) had widened dramatically since 1934. Several of the reaches had widths in excess of 1200 feet (i.e. in Sections 10, 11, 15, 26, and 34).

Lateral Channel Changes Between Mammoth and the Gila Confluence

The compilation maps of the reach between Mammoth and the San Pedro- Gila River confluence are illustrated by Plate 2 (the Mammoth area) and Plate 3 (the Dudleyville area). Channel locations from the 1877 General Land Office (GLO) survey, the U.S. Geological Survey's 1911 Winkelman topographical quadrangle, and the 1934 and 1994 aerial photographs, were transferred to the U.S. Geological Survey's 1972 topographic quadrangles of that reach using a zoom-transfer projector. The 1877 GLO survey maps showed the channel location rather than the channel boundaries, and the position of the channel was surveyed only where it crossed cadastral lines (Huckleberry, 1996). The 1911 Winkelman quadrangle appeared to depict the channel boundaries as the extent of the sandy channel bottom.

[4] Refer to the chronology of channel descriptions for the Redington reach in the fifth section of this report for more details about this segment of the river.

The channel boundaries discerned from the 1934 and 1994 aerial photographs were defined by the extent of active channel, rather than by the location of defined channel banks. The precise location of the channel banks was not visible in several of the aerial photographs, either because the photographs were shot at an angle that did not show the relief of the channel banks, or because the channel banks were obscured by vegetation. In contrast to the Redington reach, field observations in 1997 of the Mammoth-Dudleyville reach indicated that the boundaries of the active channel typically did ***not*** coincide with the location of the steep banks of the arroyo that had formed by this time. In many segments of this reach, the arroyo walls delineated both an *active channel* and a *floodplain* at the bottom of the arroyo.

Although only the channel location was depicted by the 1877 maps of the lower San Pedro River, measurements of channel width were surveyed normal to cadastral lines and recorded in the notes of the surveyor, John L. Harris. The channel had a mean width of 35 feet in T.5S. R.15E., 36 feet in T.6S. R.16E., 38 feet in T.7S. R.16E., 35 feet in T.8S. R.16E., and 40 feet in T.8S. R.17E.

The U.S. Geological Survey's 1911 survey indicated that several segments of the river experienced notable shifts in location since the 1877 survey. For example, a one-mile segment of the channel located east of and upstream from the historic location of Dudleyville (T.5S. R.15E. Sec.25, Plate 3) had shifted approximately 1000 feet east of the location of the 1877 channel. A shift of similar magnitude occurred upstream of Malpais Hill (T.6SS. R.16E. Sections 17 and 20, Plate 3) and downstream from Mammoth (T.8S. R.17E. Sec.18, and T.7S. R.16E. Sec.22 and 35, Plate 2). The 1911 survey also indicated that the San Pedro River channel had widened considerably along the Mammoth/Dudleyville reach since 1877. The 1911 channel had a width of approximately 1700 feet at its confluence with the Gila River, 700 feet in T.5S. R.15E., 850 feet in T.6S. R.16E. (with a dramatically wide reach of 2300 feet in Section 26), 800 feet in T.7S. R.16E., and 600 feet in T.8S. R.16E. and T.8S. R.17E. The channel continued to widen between 1911 and 1934. In 1934, the active channel had a mean width of 1600 feet in T.5S. R.15E., 1280 feet in T.6S. R.16E., 930 feet in T.7S. R.16E., 1120 feet in T.8S. R.16E., and 925 feet in T.8S. R.17E (Huckleberry, 1996). The active channel mapped from the 1934 photographs may indicate the location of the channel banks because of the relatively recent large flows that occurred in 1931 and 1932, may have kept vegetation from becoming re-established in the channel after the 1926 flood of record.

The comparison of the 1934 and 1995 active-channel boundaries of the Mammoth/Dudleyville reach indicated that the 1995 active channel was more narrow and sinuous than the 1934 channel. As noted above, field observations in 1997 indicated that, in many segments of this reach, the arroyo that had formed by this time had stablized to the degree that the arroyo walls delineated both an *active channel* and a densely-vegetated *floodplain* at the bottom of the arroyo. However, Plate 2 and Plate 3 also show several segments of that reach where the 1995 active channel meandered beyond the boundaries of the 1934 active channel.

ARROYO FORMATION AND CHANGE ALONG THE LOWER SAN PEDRO RIVER

Many earth scientists have observed and sought to explain the almost synchronous arroyo formation experienced by the San Pedro River and other major watercourses of southern Arizona around the turn-of-the-century (Bryan, 1925; Antevs, 1952 and 1955; Hastings and Turner, 1965; Melton, 1965; Cooke and Reeves, 1976; Betancourt and Turner, 1990; and, Hereford and Betancourt, in press). However, Hereford and Betancourt (in press) noted that neither the archival nor physical evidence of arroyo formation along the San Pedro River has received more than cursory attention. In addition, Huckleberry (1996) determined that, while there is an abundance of published information regarding the character and timing of channel changes along the upper San Pedro River, there is very little published information available regarding channel changes along the lower San Pedro River.

This section of the report describes the compilation and evaluation of archival and physical evidence, both published and unpublished, that better define the timing and character of arroyo initiation along the lower San Pedro River. The next part of this section provides a brief summary of a commonly-quoted view of historical channel entrenchhment along the San Pedro River. Then final two parts present published and unpublished information that specifically relates to the channel entrenchment histories of the Redington and Mammoth/Dudleyville reaches of the river.

General Background Information

Three often-cited statements made by Bryan (1925), Charles H. Bayless (1901), and Hastings and Turner (1965), for many years have shaped the commonly-held views on the timing and character of channel entrenchment along the San Pedro River:

> "The trench on the San Pedro River was cut progressively headward between 1883, when an arroyo formed at the mouth of the river, and 1892, when the headwater fall cut through the boundaries of the Boquillas Grant 200 km upstream." (Bryan, 1925, p. 342)

> "Where the San Pedro River of southeastern Arizona formerly wound its sluggish course northward through a marshy, largely unchanneled valley, in August, 1890, it began carving a steep-walled trench through which it thereafter emptied rapidly and torrentially into the Gila. Where it formerly ran more or less consistently throughout the year, after 1890 its flow became intermittent, leaving the new channel dry over much of its length for most of the time..." (Hastings and Turner, 1965, p.3)

> "About twelve years [1888] ago the San Pedro Valley consisted of a narrow strip of subirrigated and very fertile lands. Beaver dams checked the flow of water and prevented the cutting of a channel. Trappers exterminated the beavers, and less grass on the hillsides permitted greater erosion, so that within four or five years a channel varying in depth from 3 to 20 feet was cut almost the whole length of the river. Every year freshets are carrying away new portions of the bottom lands. At present this valley is a sandy waste from bluff to bluff, while the few fields remaining are protected from the river at large and continuous expense. Thus, in addition to curtailing the area of good land, the deep channel has drained the bottoms, leaving the native grass no chance to recover from the effects of close pasturing. It also makes it more difficult to get irrigating water onto the surface of the land." (C.H. Bayless, as cited in Griffith, 1901, p. 111[5])

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[5] In December of 1900, Charles H. Bayless received a circular from D.A. Griffiths, who was the chief botanist in charge of grass and forage plant investigations for the Arizona Experiment Station in Tucson (Griffiths, 1901; Santiago, 1994; Bahre, 1991). Griffiths had sent a circular to a select group of ranchers in southern Arizona in order to obtain accurate knowledge of range conditions before the livestock boom of the 1880's. The above quote is Charles H. Bayless' response to the questions, "Can you describe any specific instances of the destructive action of water gullying out the river valleys? Can you state how and at what time such gullying started in any particular instance, and the extent to which the washing progressed in a given time?" To better understand the intensity and thoroughness of Bayless' response, it may help to know a bit of his history. Charles H. Bayless, born on November 23, 1863, in Highland, Kansas, was a well-respected resident of southern Arizona. He first came to Arizona in 1879 when he took off a year from his studies in Kansas to travel with his father and uncle out West and to spend several months clerking at a store in Tombstone (Santiago, 1994). He returned to Kansas in 1880 and resumed his studies at Highland Unviersity, where he received a B.A. in 1884. Bayless then became a partner of the Bayless and Berkalew Company (the properties of which were located in the San Pedro River Valley near Redington) with his father, William Bayless, and Jehiel W. Berkalew, in 1884. He spent a few months over the winter of 1884-85 helping his father acquire more cattle for

Although Bryan's 1925 claim has continued to be a popular citation, more recent research has cast doubt on his assertions (Hastings, 1959; Cooke and Reeves, 1976; and, Hereford and Betancourt, in press). Cooke and Reeves (1976) claim that the assertions about the timing of arroyo cutting made in Bryan's often-quoted 1925 paper are almost wholly incorrect:

> "The dates are not substantiated, and the notion of headward erosion seems to be derived more from the contemporary geomorphological 'conventional wisdom' related to drainage rejuvenation than from historical data. All available sources point towards a more complex history....." (Cooke and Reeves, 1976, p. 42)

Hereford and Betancourt (in press) explained that Bryan's sources did not support his statement that arroyo development progressed from the mouth into the upper San Pedro in less than ten years. Hereford and Betancourt also noted that, over the short term, bedrock outcrops located at The Narrows and at Charleston[6] should have restricted propagation of headcuts or coalescence of discontinuous arroyos from one subbasin to another.

While not incorrect, the statements made by Hastings and Turner (1965) and Bayless (1901) are, perhaps, overly simplistic. Hereford and Betancourt (in press) and, in subsequent chapters of their book, Hastings and Turner (1965), provided evidence that painted a more complicated picture of the character of the San Pedro River than implied by the introductory paragraph of Hastings and Turner's 1965 publication, and Bayless' 1901 statement . Hastings and Turner's review of historical references dating to the mid-1800's found that the upper San Pedro River and parts of the lower San Pedro were characterized by a perenial stream flowing through a grass-choked valley with *cienegas*[7] and pools. However, they also found evidence that the river was intermittent in some reaches, especially in the lower San Pedro River Valley, and that some reaches were entrenched, both in the upper and lower San Pedro River Valley.

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their company, and then returned to Kansas. He received a M.A. from Highland University in 1887, taught at Highland University for several years, and then began studies for a Ph.D. at John Hopkins University in Baltimore in the fall of 1891. However, when his father fell seriously ill, Bayless left his studies in February of 1892 and returned to southern Arizona to help manage his father's properties near Redington and Oracle. By 1900, Bayless had developed the very firm opinion that the extinction of the beavers caused excessive flooding in the San Pedro Valley, and that overstocking, not drought, had turned the range into desert (Santiago, 1994).

6 Charleston is located about 35 miles upstream of The Narrows in the upper San Pedro River Valley.

7 "Cienega" is a term applied by Spanish explorers to the distinctive, treeless, riparian marshes of the Southwest.

Regarding the timing of channel entrenchment along the San Pedro River, Hastings and Turner (1965) cited two 1890 newspaper accounts that described channel-bank erosion near Dudleyville[8] and Mammoth[9] that resulted from the 1890 flood event, and one account of the flood-caused destruction that occurred between Tres Alamos (located just south of The Narrows) and the confluence with the Gila River.[10] They made no mention of channel-bank erosion due to the 1890 flood event along any other reach of the river.

Hereford and Betancourt (in press) more thoroughly compiled and evaluated archival records for all reaches of the San Pedro River, and field mapped the floodplain surfaces and cutbank stratigraphy of a reach in the upper San Pedro. Their goals were to better define general floodplain conditions before arroyo-cutting and to establish timelines for major floods and cutting episodes. They ascertained that alternating marshes, mesquite thickets, and short entrenched channels appeared to have persisted in the middle and lower San Pedro until the 1880's, and probably as late as the early 1900's in the upper reaches of the San Pedro River Valley. In addition, they noted that, although 1881, 1882, and 1883 had unusually wet summers, and large floods occurred in 1886, 1887, 1890, and 1891, arroyo initiation probably did not occur along the southern reach of the upper San Pedro River until 1896, and the northern reach of the upper San Pedro River did not become entrenched until the 1910's.

Although Hereford and Betancourt's manuscript provided the most thorough review of archival and physical evidence of any reference to date, it highlighted the sparcity of information available for the lower San Pedro River Valley. The rest of this section provides evidence that better defines the timing and character of channel entrenchment in the lower San Pedro River. There are two parts: one part that describes channel

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[8] "At Riverside, the road is fordable for the first time in two weeks, but raining again on the San Pedro. If the San Pedro continues to rise the next thing we'll see is Dudleyville floating down the Gila. Has caved within 15 ft of Cook's place. He piled brush to divert, but now it has washed out. Mr. Bates house in danger, several of his outhouses gone. The Riverside-Globe road impassable for two weeks; is being rebuilt on Kane Springs Canyon stretch." (*Arizona Daily Star*, September 6, 1890, as cited in Hereford and Betancourt, *in press*)

[9] "Recent floods at Mammoth washed the soil out in places 30 ft deep along the river bottom. Exposed area at bottom brought out in many places evidence of ancient civilizations...." (*Arizona Daily Star*, October 2, 1890, as cited in Hereford and Betancourt, *in press*)

[10] "Of the country down the San Pedro, from Tres Alamos to the Gila [Captain Van Alstine] . . .says, "all of it is gone, destroyed, torn up, 'vamosed' down with high water." He never saw such a destruction in all his life. . . The San Pedro never was as high as it was this time, and will not probably be for the next ten years. The losses sustained by the people will reach into the thousands." (*Arizona Daily Star*, August 14, 1890, as cited in Hastings and Turner, 1965, p.42)

entrenchment in the Redington reach; and, one part that describes the Mammoth/Dudleyville reach.

Channel Entrenchment in the Redington Reach of the San Pedro River

Four types of information were found that described the nature and timing of arroyo initiation along the Redington reach of the lower San Pedro River: historical maps with the location of *acequias* noted; oral histories; historical ground photographs; and, previously-published accounts of channel entrenchment. Each type of information is first described individually below, and then discussed together in the final part of this section.

Location of Acequias

The location of historical *acequias*, or gravity-flow ditches, can provide information about the local channel characteristics in two ways.[11] Gravity-flow ditches, as their name implies, rely on the slope of the land to transport water from the source (a river or spring) to the fields that need irrigation. Hence, if the intake of a given *acequia,* that has the river as its source, is located immediately upstream of the fields for which it supplies water, it can be inferred that the channel is not entrenched (Huckleberry, 1996). In addition, the upstream movement of *acequia* intakes (also called "ditch heads") over time implies that changes have occurred in the slope of the channel, probably due to arroyo initiation and deepenng.

The locations of ditch heads discerned from the historical maps and oral histories for the Redington area are listed in Table 3 and plotted on Plate 1.

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[11] Jack Smallhouse, grand-nephew of C.H. Bayless, brought it to the attention of the authors that comparing the location of *acequia* intakes over time could help to determine possible changes in the depth of the channel (Smallhouse, 1997, oral commun.). He contributed a number of historical maps to this project that were not found in any other private or public map collection. He also contributed several oral histories passed on to him by his neighbors and family members. Much of the information presented in this section would have been unknown, but for Smallhouse's generosity with his time and family records.

Table 3. Historical locations of ditch heads along the Redington reach.

NAME OF DITCH[12]	DITCH-HEAD LOCATION[13]	YEAR	SOURCE OF INFORMATION[14]
Bayless Ditch:[15]	T.12S. R.19E. Sec. 19 BBB T.12S. R.19E. Sec. 19 BAD T.12S. R.19E. Sec. 19 BAD	1879 1907 Before 1926	GLO Survey Bayless & Berk. Map RR-East Map
Los Angeles Ditch:	T.12S. R.19E. Sec. 30 ABA	1907	Bayless & Berk. Map
Markham Ditch:	T.11S. R.18E. Sec. 26 CBD T.11S. R.18E. Sec. 27 DDA	1902 1907	Desert Land Entry Map Bayless & Berk. Map
Bollen Ditch:	T.11S. R.18E. Sec. 23 BAB/BBA T.11S. R.18E. Sec. 14 CCA T.11S. R.18E. Sec. 23 BBA T.11S. R.18E. Sec. 23 CD	1879 1902 1907 After 1926[16]	GLO Survey Desert Land Entry Map Bayless & Berk. Map Smallhouse (1997, oral c.)
Unnamed Ditch - 1:	T.12S. R.18E. Sec. 11 ABA T.12S. R.18E. Sec. 2 DCC	1879 Before 1926	GLO Survey RR-East Map
Unnamed Ditch - 2:	T.12S. R.18E. Sec. 2 BBC[17]	1879	GLO Survey

[12] Several of the historical maps used different names for the same ditches. The names listed above were the most commonly used for each of the different ditches.

[13] Refer to Appendix A for a description of the system of land subdivision used to describe the location of the ditch heads.

[14] Several of the historical maps listed in Table 2 showed the location of ditches. However, only the ditch heads located on large-scale maps with reliable surveys were listed above and plotted on Plate 1.

[15] The modern intake for the Bayless Ditch is located about one mile upstream of the historic intakes, south of the reach shown on this map (Smallhouse, 1997, oral commun.).

[16] The Bollen ditch had its intake at approximately this location until it was abandoned during the 1940's, when an irrigation well was drilled.

[17] The intake for this ditch was was not located near the river. It may have had a spring as a source.

The 1879 survey map showed that the intake for the Bayless Ditch was located near the fields that it irrigated, implying that the channel was not entrenched in that segment of the Redington reach. The locations of the other *acequias* (Bollen Ditch, and two unnamed ditches) were either not as near the fields they irrigated, or were noted in areas that had no field delineated on the maps. However, Cooke and Reeves (1976) noted that it is unlikely that ditches would have been constructed where the main river was entrenched.

The records of ditch-head movement for the Bollen and Bayless ditches are the most useful for inferring channel changes because they bracket the entire period of interest: before and after the 1880-90's floods; and, before and after the 1926 flood. The intake location for the Bollen ditch remained almost unchanged between 1879 and 1907. However, it shifted almost a mile upstream after the 1926 flood event.

In contrast, the 1907 and Before-1926 intakes of the Bayless Ditch were located more than a half of a mile upstream of the 1879 intake. However, the contrast between the pre-1926 flood intake locations and post-1926 flood intake location is even more dramatic. The modern location of the Bayless Ditch intake is almost a mile upstream of the 1907 intake location.

The segments of the Bayless and Los Angeles ditches located at the Redington Narrows[18] provided another type of information about the rate of channel entrenchment in that reach. The canal for the Los Angeles Ditch, located on the western bank of the channel, was carved through the cemented conglomerate that forms the constriction known as the Redington Narrows *before* the flood of 1926, and was later reinforced with cement during the 1940's (Smallhouse, 1997, oral commun.). The U.S. Geological Survey's Twenty-First Annual Report (1901) indicated the presence of the Los Angeles Ditch as early as 1899, and the Bayless and Berkalew Company map showed the location of its intake in 1907 upstream of the Redington Narrows. Photograph #1 in Appendix B shows the canal as a horizontal line of white cement perpendicular to the gaging station. The photograph also shows a grass-covered surface to the right of the cemented conglomerate

[18] The geographical feature known as the Redington Narrows is not labelled on Plate 1. However, it can be easily identified by the constriction of the river channel approximately 1500 feet east of the Cochise-Pima County line; also, it coincides with the location of the Redington gage, labelled "Gaging Station" on the base map.

that is even with the canal, indicating that this surface existed prior to the pre-1926. The canal and pre-1926 surface are 17 feet above the surface of the modern-day channel floor.

Photograph #2 shows a tunnel that was dug in 1927 for the Bayless Ditch through the cemented conglomerate of the eastern bank of the Redington Narrows. To the left of the tunnel is the modern canal on the floor of the present-day channel, about two feet lower than the base of the 1927 tunnel. The difference in elevation between the pre-1926 Los Angeles Ditch and the 1927 Bayless Ditch indicate a vertical change in the channel bottom of about 15 feet, probably as a result of the 1926 flood event. The two-foot difference between the bases of the 1927 and 1997 canals indicate that very little net vertical change has occurred in this segment of the channel during the last seventy years.

Oral Histories

Cayetano Ronquillo told Jack Smallhouse that he and his family crossed the San Pedro River in several locations using simple foot bridges before the 1926 flood event, and that the 1926 event changed the course of the river and incised it (Smallhouse, 1997, oral commun.). He showed Jack Smallhouse where they used a cable foot bridge tied from a tree. Photograph #4 in Appendix B, taken in June of 1997, shows the remains of the cable still tied to a tree at the edge of an abandoned channel. Though the channel is barely noticeable in this photograph, it was discernable in the field as a very gentle dip in the ground to the west of the current location of the present-day channel (T.12S. R.18E. Sec.3, "Photo 4" on Plate 1). Ronquillo showed Smallhouse a second place where there had been a foot bridge across a narrow channel, in T.12S. R.18E. Sec. 27.

Barbara Clark, of the Cascabel[19] area, recounted histories of the area told to her by long-time residents such as Carey Smith and Emma Bennett. According to Smith and Bennett, the 1926 flood caused the entrenchment of the channel in the Cascabel area. Clark also was able to indicate in the field the location of an abandoned channel that she believed to be a former channel of the San Pedro River, although she did not know when it had been abandoned. The abandoned reach that she indicated closely resembled the abandoned channels present in the Redington area in width and depth.

[19] Cascabel is located upstream (south) of the Redington reach, between The Narrows and the Redington Narrows.

Conrad Gamez, who was born in 1928 in the Cascabel area, noted that there have not been any large floods in the Cascabel/Redington area for a long time, and therefore the sand was building up in the channel bed (Gamez, oral commun., 1997).

Historical Photographs

The Arizona Historical Society's archives contained several photographs taken in 1903 along the San Pedro River during one of Bayless and Berkalew Company's cattle drives. The photograph entitled, "A round-up in old Arizona, taken on the Bayless and Berkalew Ranch, San Pedro River, fall of 1903" [AHS #21329], gave the best view of the river. Refer to Photograph #5 in Appendix B to see a copy of the original 1903 photograph, and Photograph #6 to see the same view in June of 1997.

The 1903 photograph showed a very narrow, shallow channel with flow. The floodplain immediately adjacent to it was very flat with little vegetation (perhaps because of the cattle, perhaps because of recent flood events). There were no signs of steep arroyo walls in this photograph. However, steep channel banks were not discernable in the 1997 photograph, either, not because there were no steep banks, but because the photographer was standing on one bank to take the picture, and the other bank was hidden from site by the vegetation in the distance and by the angle of the view.

Previously-Published Accounts

Charles H. Bayless' account (cited in Griffiths' 1901 publication) claimed that by 1900, the valley was a "sandy waste from bluff to bluff" and a channel varying in depth from 3 to 20 feet was cut almost the whole length of the river. He also noted that it was more difficult to get irrigating water onto the surface of the land. Because he managed ranches near Redington, it probably would be sensible to infer that he had particular experience with channel change along the Redington reach of the river.

The U.S Geological Survey's Twenty-First Annual Report was the first published account to note the presence of a sandy channel bed and intermittent reaches:

> "The period of greatest precipitation is in the months of July and August, when floods of considerable size come down San Pedro River. During the rest of the year the stream is small, winding back and forth in its sandy bed... In the lower portions of its course the river is in places dry, owing to the diversions made by a large number of small canals" (USGS, 1901, p.352)

However, no mention was made in this report of the presence of entrenched reaches or of which reaches were dry.

Cooke and Reeves (1976) cited Melton (1965) and Jones (1968) when they noted that marked downcutting north of The Narrows appeared to have occurred in two periods: prior to 1895, when a continuous sand-bed was formed; and, 1926-27, when major floods resulted in notable incision. Entrenchment was reported to have happened as late as 1926-27 between The Narrows and Hot Springs Canyon near Cascabel (Melton, 1965, oral communication with a rancher, Charles Gillespie, as cited in Cooke and Reeves, 1976).

Discussion

The historical photographs and maps, and the accounts by the U.S. Geoloical Survey, Bayless, and Cooke and Reeves, all indicated that a wide channel with a sandy bed had been established along the Redington reach, and, indeed, along most - if not all - of the San Pedro River in the late 1800's to early 1900's. However, the different types of evidence imply a more complicated history of channel entrenchment along the Redington and Cascabel reaches of the San Pedro River.

Bayless' account indicated that the entire San Pedro River became entrenched prior to 1900. An alternate scenario would be one in which only particular segments of the reach became notably incised. Oral histories and previously published accounts indicated that the channel in the Cascabel area did not become entrenched until 1926. The analysis of the movement of the Bollen Ditch intakes indicated that that segment of the Redington reach did not become incised until the 1926 flood event, or, if it became incised prior to 1926, the entrenchment was not deep enough to affect the location of the intakes. The analysis of the Bayless Ditch intakes at the Redington Narrows indicated that that segment of the Redington Reach probably did become incised somewhat prior to the 1926 flood event. However, comparison of (1) the elevations of the pre-1926 Los Angeles Ditch and the 1927 Bayless Ditch, and (2) the pre- and post-1926 locations of the Bayless Ditch intakes, indicates that even more dramatic incision resulted from the 1926 flood event.

The oral histories that described the use of foot bridges over a narrow San Pedro River prior to the 1926 flood event, the abandoned channels near Redington, and the photograph of the 1903 channel provided inconclusive, or even contradictory, information about channel entrenchment. They seemed to imply that the channel prior to the 1926 flood event was still very narrow. However, the historical maps and several other accounts indicated that the channel was very wide and had a sandy base. Perhaps the accounts of the narrow channel were describing an active channel defined by the low-discharge perennial flow. Such an active channel may have been inset into a wide, sandy channel bottom that may or may not have had arroyo walls.

Channel Entrenchment in the Mammoth/Dudleyville Reach of the San Pedro River

There was much less information available for the Mammoth/Dudleyville reach of the lower San Pedro River than for the Redington reach. However, the evidence available describes a more straight-forward history of widening and entrenchment.

John L. Harris' 1877 cadastral survey of the Mammoth and Dudleyville areas indicated several *acequias* (gravity-flow ditches) along the channel, implying non-entrenchment. [Refer to Plate 2 and Plate 3 for the locations of the ditch heads.] Cooke and Reeves (1976) noted that it is unlikely that ditches would have been constructed where the main river was entrenched. Ditches located away from the main channel probably indicated other sources of water, such as springs. Unfortunately, there was no other historical information available that described the location of ditch intakes at the turn of the century.[20, 21]

Hereford and Betancourt (in press) noted that, although there were several large floods in 1886 and 1887, the first mention of extensive channel widening and channel entrenchment were described in newspaper accounts of the damage resulting from the flood events of August and September 1890:

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[20] Every attempt was made to locate State Water Commission maps for the Mammoth and Dudleyville areas, and to locate water rights information that may have described the location of ditches, but to no avail. Appendix C provides the the names of various agencies and mining companies that may have information archived, but the researcher who pursues such avenues must be willing to spend weeks or months tracking down the right contacts and exploring long-filed archives.

[21] Ralph Garcia and John Smith, long-time residents of the Dudleyville area, remembered that there had been several ditches along the river that had been in use until the 1940's, when irrigation wells with electric pumps replaced the ditches as sources of irrigation water. Huckle's 1991 publication that described the life of Jo Curtis confirmed Garcia and Smith's memories. Jo Curtis and Gussie Flieger bought the farm located at Cook's Lake in 1940. Not long after, Jo Flieger became annoyed by the amount of effort required by the ditch that brought irrigation water from the river, drilled a well, and used a pump to get water onto his fields (as told to Huckle, 1991). Unfortunately, field checks in June of 1997 indicated that most of the ditches had been eroded by bank collapse along the main channel; hence, intake locations were not discernable.

"At Riverside, the road is fordable for the first time in two weeks, but raining again on the San Pedro. If the San Pedro continues to rise the next thing we'll see is Dudleyville floating down the Gila. Has caved within 15 ft of Cook's place. He piled brush to divert, but now it has washed out. Mr. Bates house in danger, several of his outhouses gone. The Riverside-Globe road impassable for two weeks; is being rebuilt on Kane Springs Canyon stretch." (*Arizona Daily Star*, September 6, 1890, as cited in Hereford and Betancourt, *in press*)

"Recent floods at Mammoth washed the soil out in places 30 ft deep along the river bottom. Exposed area at bottom brought out in many places evidence of ancient civilizations...." (*Arizona Daily Star*, October 2, 1890, as cited in Hereford and Betancourt, *in press*).

The 1911 Winkelman Topographic Quadrangle indicated that the entire length of the Mammoth/Dudleyville reach had been widened significantly between 1877 and 1911. The widening of newly-formed arroyos and the extension of headcuts continued until 1926 in the Mammoth and Dudleyville areas as a result of subsequent flood events. (Refer to the chronological listing of newspaper accounts in the next section.) However, the 1926 flood event seemed to produce the most dramatic channel changes since the floods of 1890, as evidenced by this account:

"Every highway and railroad bridge on the San Pedro River from the International boundary line to where it flows into the Gila River below Mammoth were either destroyed or rendered useless last Monday evening and Tuesday morning when the San Pedro River, swollen by a three day rain, went on the most destructive rampage in its entire history... Mammoth highway bridge totally destroyed." (*Tombstone Weekly Epitaph*, September 30, 1926, as cited in Hereford and Betancourt, *in press*)

In addition, large parts of the Clark Ranch (~2 miles south of Mammoth) were removed by channel-bank erosion caused by the 1926 flood flow (Charles Clark Sr., 1997, oral commun. *via* Charles Clark Jr.). Landholders reported that some of their diversion canals were abandoned after the 1926 flood event because the river had incised well below the intake level (Jones, 1968).

Hereford and Betancourt (in press) and Charles Clark Jr. (1997, oral commun.) noted that the channel downtream of Mammoth has been aggrading in recent years. However, large flood events have continued to cause the widening of the steep-walled channel in many locations. For example, Ralph Garcia (1997, oral commun.) reported that the 1993 flood event resulted in dramatic undercutting of the arroyo walls in T.6S. R.16E. Sections 8 and 17, and, indeed, Plate 3 shows that the 1995 active channel extends well beyond the 1934 channel in these areas. This indicates that, although no modern flow event had exceeded the magnitude of the 1926 flood event (refer to Figure 2), and the 1995 active channel was more narrow than the 1934 channel, widening of the arroyo had occurred since 1926.

LOWER SAN PEDRO RIVER CHRONOLOGIES

The data collected from the published and unpublished references, historical maps, and oral histories were synthesized into two chronologies. The first chronology describes the historical streamflow and channel characteristics of the Redington reach, and the second chronology describes the reach between Mammoth and the Gila-San Pedro confluence. The chronologies have three components: the date of the description; the description itself; and the source of the descriptive information.

When possible, the exact year, month, and day were provided in the "Date" column of the chronology. Often an exact year was not provided in the oral histories. In such cases, the approximate date provided by the interviewee is annotated with a tilde ("~") symbol. In addition, some of the historical maps were not dated at all. However, information from undated maps was included in the chronological listing if the date of the map could be constrained to a particular range of years.

For the sake of clarity and brevity, much of the information gathered from published sources is presented in the "Description" column as direct quotes. The source of the information is provided in parentheses following the description.

Redington Reach:

Date:	Description (Source):
1879	John L. Harris performed the first cadastral survey of the Redington area in 1879. Based on Harris' survey notes, the channel had a mean width of 35 feet in T.11S. R.18E., and 26 feet in T.12S. R.18E. (Huckleberry, 1996). His survey plat maps showed *acequias*, or gravity-fed irrigation ditches, in T.11S. R.18E. and T.12S. R.18E., implying nonentrenchment of the river channel in those areas. [Refer to Plate 1 for the location of the ditch heads.] Harris' observations of flow in the channel, and the presence of cottonwoods and irrigation ditches, indicate intermittent to perennial flow in this reach (Fonseca, unpublished manuscript).
~1884-88	"About twelve years ago the San Pedro Valley consisted of a narrow strip of subirrigated and very fertile lands. Beaver dams checked the flow of

water and prevented the cutting of a channel. Trappers exterminated the beavers, and less grass on the hillsides permitted greater erosion, so that within four or five years a channel varying in depth from 3 to 20 feet was cut almost the whole length of the river. Every year freshets are carrying away new portions of the bottom lands. At present this valley is a sandy waste from bluff to bluff, while the few fields remaining are protected from the river at large and continuous expense. Thus, in addition to curtailing the area of good land, the deep channel has drained the bottoms, leaving the native grass no chance to recover from the effects of close pasturing. It also makes it more difficult to get irrigating water onto the surface of the land." (C.H. Bayless, as cited in Griffith, 1901)

~1890 "My mother told me that the river was narrow when they first came to Redington. They used just a little board to cross the river. My father had his fields there; everything was cultivated - even the sides of the hills - all the way from Benson to Winkelman. But the river got wider and wider, and it swept away my father's fields and the house we lived in. Can you imagine - they told me that Winkelman is on the banks of the river now!" (Paulina Moreno Montoya, b. 1905[22], as cited in Martin, 1992)

1883-92 "The trench on the San Pedro River was cut progressively headward between the years 1883, when the arroyo first formed at the mouth of the river, and 1892, when the head water fall cut through the boundaries of the Boquillas Grant 125 miles upstream." (Bryan, K., 1925, p. 342)[23]

1899 "The period of greatest precipitation is in the months of July and August, when floods of considerable size come down San Pedro River. During the rest of the year the stream is small, winding back and forth in its sandy bed... In the lower portions of its course the river is in places dry, owing to the diversions made by a large number of small canals" (USGS, 1901, p.352). [No mention was made in this report of the presence of entrenchment or of which reaches were dry.]

1903 A ground photograph[24] taken along the river during a Bayless and Berkalew cattle drive shows a very narrow, shallow channel with flow. The floodplain immediately adjacent to it is very flat with little vegetation. There

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[22] The date of this entry is a very uncertain estimate. Paulina Moreno Montoya was born in Redington in 1905 and was the seventh of eight children. Her mother, Vicente Soto de Moreno, came to the Tanque Verde area near Tucson from Mexico when she was nine years old because of a war (probably the war against French occupation, according to Martin (1992)). Vicente Soto de Moreno's date of birth was not mentioned in Martin (1992).

[23] Cooke and Reeves (1976) claim that the assertions about the timing of arroyo cutting made in Bryan's often-quoted 1925 paper are almost wholly incorrect. Refer to the fourth section of this report for a more detailed discussion.

[24] "A round-up in old Arizona, taken on the Bayless and Berkalew Ranch, San Pedro River, fall of 1903." Arizona Historical Society Photograph #21329; refer to Photograph #5 in Appendix B to see a copy of the original 1903 photograph, and Photograph #6 to see the same view in June of 1997.

is no sign of any steep arroyo walls in this photograph.

1907 The 1907 map of the Bayless and Berkalew property indicated that the San Pedro River channel had a mean width of approximately 400 feet in T.11S. R.18E., and 200 feet in T.12S. R.18E. However, the channel was as narrow as 150 feet at the R.18E./R.19E. range line in T.12S., and as wide as 900 feet at the T.11S./T.12.S township line in R.18E. This maps also showed *acequias* in T.11S. R.18E. and T.12S. R.18E., implying nonentrenchment of the river channel [Refer to Plate 1 and the fourth section of this report for a more detailed review of this map and the significance of the *acequias*.]

~1925 Cayetano Ronquillo showed Jack Smallhouse many years ago where he and his family crossed the San Pedro River near Redington using a cable foot bridge tied from a tree, before the river changed its course and became entrenched. In June of 1997, Smallhouse showed one of the authors of this report the remains of the cable still tied to a tree at the edge of an abandoned channel. The channel was subtle, but discernable as a very gentle dip in the ground to the west of the current location of the present-day channel (T.12S. R.18E. Sec.3, "Photo 4" on Plate 1). Refer to Photograph #4 in Appendix B. Ronquillo showed Smallhouse a second place where there had been a foot bridge across a narrow channel, located in T.12S. R.18E. Sec. 27.

1926 The September 28, 1926, flood event resulted in deep entenchment of the San Pedro River channel in the Redington and Cascabel areas (based on oral histories gathered by J. Smallhouse and B. Clark from local residents such as Cayetano Ronquillo, Carey Smith, and Emma Bennet). [Refer to the fifth section of this report for a more detailed description of the entrenchment history of the lower San Pedro River.]

~1926-27 "Entrenchment is reported to have been initiated north of Benson - between The Narrows and Hot Springs Canyon <near Cascabel, south of Redington> - as late as 1926-7 [Melton, 1965, quoting an oral communication with a rancher, Charles Gillespie]." (Cooke and Reeves, 1976, p.45)

1934 The Soil Conservation Service performed the first systematic aerial photography of the lower San Pedro River Valley in 1934. "The photography reveals a shallow, braided channel within an incised floodplain. The channel is dramatically wider than in the 19th century..., especially downstream from Redington... Because of the wider, entrenched reach below Redington, changes in channel position through time are greater along this segment than any other part of the river." (Huckleberry, 1996, p.15.) Huckleberry (1996) determined that the channel had a mean width of 837 feet in T.11S. R.18E., and 236 feet in T.12S. R.18E.

1926-1940's	Plate 1 shows how a one-and-a-half-mile reach of the river in T.12S. R.18E. had shifted to about 1300 feet west of its 1907 location. The abandoned 1907 channel was distinctly visible in the 1934 photographs but not in the 1995 photographs. According to J. Smallhouse (1997, oral commun.), this abandoned segment of the 1907 channel was in the same location as the main channel prior to the 1926 flood event. When he was a boy during the 1940's, flows came into this abandoned channel on a regular basis because the main channel had not been so deeply incised as to prevent the flow of water into it. Since the main channel has become more deeply incised, the abandoned channel has acted as a secondary flow channel during large flood events such as the floods of 1977, 1983, and 1993. At the time of the 1997 field visit, this abandoned channel was about 30 feet wide and had gentley sloping banks with a depth of about two feet. Smallhouse noted that it was deeper in 1997 than it had been in his youth because several flood flows have passed down it since then, and it has been used as an alternate farm road.
1930's	Conrad Gamez was born in 1928 and raised on a farm in Cascabel about 500 yards east of the San Pedro River. He remembered that, when he was about five or six years old, the water in the river was "about knee high, depending on the weather," and that the river flowed year-round in some reaches. In other reaches, the water went subsurface. He remembered that where the river was narrow, there were very steep banks, but where the river was wide, the channel depth was more shallow. Neighbors would work together to make dikes from sand and brush to divert river water into canals to irrigate their fields next to the river. During the monsoon rains, the river water would overflow to the adjacent fields. Gamez did not remember seeing any canoes or rafts on the river, but then, "nobody had time for much recreation – times were rough." He did not remember seeing any fish in the river.
1983	The 1983 flood event destroyed the six-inch well located in the lower part of the Redington Narrows (J. Smallhouse, 1997, oral commun.).
1935-95	Channel width, as seen in the 1995 aerial photographs, had changed very little upstream of Redington (T.12S. R.18E.) since 1934. [Refer to Plate 1.] However, the channel located downstream of Redington (T.11S. R.18E.) had widened dramatically since 1934. Several of the reaches had widths in excess of 1200 feet (i.e. in Sections 10, 11, 15, 26, and 34).

Mammoth to the Gila-San Pedro Confluence:

<u>Date</u>:	<u>Description (Source)</u>:
1870-73	John J. Bourke, who served at Camp Grant from 1870 to 1873, described Camp Grant as being located at "the junction of the sand-bed of the Aravaypa [sic] with the sand-bed of the San Pedro, which complacently figured on the topographical charts of the time as creek and river respectively, but generally were dry as a lime-burner's lot excepting during the 'rainy season.'" (Bourke, 1891, as cited in "History of the San Pedro River" chapter of the 1993 Arizona Stream Navigability Study for the San Pedro River)
1877	John L. Harris performed the first cadastral survey of the Mammoth and Dudleyville areas in 1877. His survey plat maps showed several *acequias*, or irrigation ditches, along the channel between Mammoth and Dudleyville. [Refer to Plates 2 and 3 for the location of the ditch heads.] Based on Harris' survey notes, the channel had a mean width of 35 feet in T.5S. R.15E., 36 feet in T.6S. R.16E., 38 feet in T.7S. R.16E., 35 feet in T.8S. R.16E., and 40 feet in T.8S. R.17E. (Huckleberry, 1996).
1886 Aug. 14	"Reports from Dudleyville[25] say an avalanche of water swept down the river Saturday (8/7) like a wave, 6 ft high.... People in Florence Sunday saw tailings from Mammoth mill floating in canal. Brought by freshet that passed Mammoth Friday." (*Arizona Weekly Enterprise*, as cited in Hereford and Betancourt, in press)
1886	"Inconclusive evidence suggests that channeling took place upstream at Mammoth... in 1886." (Hastings, 1959, p.64)
1887 Aug. 15	"From Mammoth dated August 15: Glorious rains last week and the San Pedro is on the rampage. The cattle are all smiles." (*Arizona Weekly Enterprise*, August 20, 1887, as cited in Hereford and Betancourt, *in press*)
1887 Sept. 14	"A letter from Mammoth dated September 14: Our San Pedro has been on the rampage, with higher water than has ever been known before. Families living near the river in Neal's corral were forced to evacuate." ." (*Arizona Weekly Enterprise*, September 17, 1887, as cited in Hereford and Betancourt, *in press*)

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[25] The book <u>Arizona Place Names</u> (Barnes, 1935), newspaper accounts, and historical survey maps indicated that Dudleyville was located about one mile south of the Gila River on the west bank of the San Pedro River in T. 5 S. R. 15 W. Sec. 25. Dudleyville was established by the family of Dudley Harrington in 1879, and a U.S. post office was established May 8, 1881 (Barnes, 1935). Between ~1949 and 1972, according to the USGS topographic maps of those dates, what is currently referred to as Dudleyville began to develop along the eastern side of the San Pedro river about five miles south of the Gila River. Field checks conducted in June of 1997 found few remains of the historic Dudleyville.

1890 Aug. 14	"Of the country down the San Pedro, from Tres Alamos to the Gila [Captain Van Alstine] . . .says, "all of it is gone, destroyed, torn up, 'vamosed' down with high water." He never saw such a destruction in all his life. . . The San Pedro never was as high as it was this time, and will not probably be for the next ten years. The losses sustained by the people will reach into the thousands." (*Arizona Daily Star*, as cited in Hastings and Turner, 1965, p.42)
1890 Aug. 15	"The river is still overflowing its banks, doing a great deal of damage. The ground about Mammoth has been flooded and many Mexicans have been compelled to vacate their houses. The river carried off a large stack of hay from Mr. John Brown's ranch, taking some fence also, and at Mr. Sellick's part of his orchard, including about 150 fruit trees, as well as part of his hay field. His house is also in danger and his family has vacated it. Mr. George Scott has had a large portion of his ranch washed away, and across the river from him the outbuildings of Theo. Gates have been taken down by the stream. The road is utterly impassable from Mammoth to Riverside, it being washed out, and in many places in holes ten ft deep." (*Arizona Daily Star*, as cited in Hereford and Betancourt, *in press*).
1890 Aug. 30	"At Dudleyville damage to the Swingle and Young Ditch is $300. George Cook has been trying to save Dudleyville by building dykes; but last flood washed away the dyke, leaving his house and store in had shape..." (*Arizona Daily Star*, as cited in Hereford and Betancourt, *in press*)
1890 Sept. 6	"At Riverside, the road is fordable for the first time in two weeks, but raining again on the San Pedro. If the San Pedro continues to rise the next thing we'll see is Dudleyville floating down the Gila. Has caved within 15 ft of Cook's place. He piled brush to divert, but now it has washed out. Mr. Bates house in danger, several of his outhouses gone. The Riverside-Globe road impassable for two weeks; is being rebuilt on Kane Springs Canyon stretch." (*Arizona Daily Star*, as cited in Hereford and Betancourt, *in press*)
1890 Oct. 2	"Recent floods at Mammoth washed the soil out in places 30 ft deep along the river bottom. Exposed area at bottom brought out in many places evidence of ancient civilizations...." (*Arizona Daily Star*, as cited in Hereford and Betancourt, *in press*)
1891 Mar. 5	"Captain Johnson, manager of the Mammoth gold mine, who is now in the city, says that the San Pedro was higher during the recent flood than the highest water mark [flood of February 23]." (*Arizona Weekly Star*, as cited in Hereford and Betancourt, *in press*)

1899 Twenty canals that diverted water from the San Pedro River in the Mammoth and Dudleyville reaches were mapped by the USGS in 1899[26] (USGS, 1901). "The period of greatest precipitation is in the months of July and August, when floods of considerable size come down San Pedro River. During the rest of the year the stream is small, winding back and forth in its sandy bed... In the lower portions of its course the river is in places dry, owing to the diversions made by a large number of small canals" (USGS, 1901, p.352). [No mention was made in this report of the presence of entrenchment or of which reaches were dry.]

1901 Aug. 10 "W.H. Clinton, who carries the mail from Riverside to Benson got through last Friday (8/2) for the first time since the floods commenced. He reports great destruction of property on the lower San Pedro between Mammoth and Riverside. He says al the ranches in the river bottoms have been injured more or less and Youtseys ranch is entirely destroyed, about half of Robles' ranch is gone and on Whetlock's ranch the river changed its channel, now being on the opposite side of the river where it used to be." (*Florence Tribune*, as cited in Hereford and Betancourt, *in press*)

1904 Feb. 27 "At Dudleyville the river bed became over a mile wide. Several times the store had to be moved to new and higher quarters because the building was removed by floods." (*Arizona Blade and Florence Tribune*, as cited in Hereford and Betancourt, *in press*)

1904 Aug. 20 "The high water in the San Pedro last week did considerable damage to the agricultural lands bordering the stream. A watermelon patch on Judge George Scott's farm at Dudleyville was entirely washed away. The river has been enroaching on his land since 1901..." (*Arizona Blade and Florence Tribune*, as cited in Hereford and Betancourt, *in press*)

1905 Jan. 21 "Greatest floods and rains since 1891 last week. P & E RR badly washed out between Florence and Winkelman. Parties coming in from the Dudleyville and Riverside country report greater damage to the farms along the Gila and lower San Pedro from the recent floods than was wrought by the great flood of 1891. The Cook, Sellick, Scott and Cunningham farms located on the east side of the San Pedro, near Dudleyville, suffered great damage, and it is reported that nearly every acre of Robert Branaman's farm on the south side of the Gila was washed away, also his dwelling house and stables." (*Arizona Blade and Florence Tribune*, as cited in Hereford and Betancourt, *in press*)

1911 Based on the U.S. Geological Survey's 1911 Winkelman Quadrangle, the San Pedro River channel had a width of ~1700 feet at its confluence with the Gila River, ~700 feet in T.5S. R.15E., ~850 feet in T.6S. R.16E. (with a dramatically wide reach of 2300 feet in Section 26), ~800 feet in T.7S. R.16E., and ~600 feet in T.8S. R.16E. and T.8S. R.17E. (Refer to Plate 2

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[26] The names, locations, and significance of the canals are provided in the fifth section of this report that describes vertical channel changes.

and Plate 3.)

1926 Sept. 30 "Every highway and railroad bridge on the San Pedro River from the International boundary line to where it flows into the Gila River below Mammoth were either destroyed or rendered useless last Monday evening and Tuesday morning when the San Pedro River, swollen by a three day rain, went on the most destructive rampage in its entire history... Mammoth highway bridge totally destroyed." (*Tombstone Weekly Epitaph*, as cited in Hereford and Betancourt, *in press*)

1926 Large parts of the Clark Ranch (~2 miles south of Mammoth) were removed by channel-bank erosion caused by the 1926 flood flow (Charles Clark Sr., 1997, oral commun. *via* Charles Clark Jr.).

Post-1926 Landholders reported that some of their diversion canals were abandoned after the 1926 flood event because the river had incised well below the intake level (Jones, 1968).

1930 Charles Clark Sr. (born in 1920) remembered that the San Pedro River ~2 miles south of Mammoth had continuous flow until he was ten years old. He also remembered seeing "sucker" fish (which he also called "trash" fish), catfish, and beaver in the river until ~1930 (Charles Clark Sr., 1997, oral commun. *via* Charles Clark Sr.).

1934 The Soil Conservation Service performed the first systematic aerial photography of the lower San Pedro River Valley in 1934. Huckleberry (1996) determined that the channel had a mean width of 1600 feet in T.5S. R.15E., 1280 feet in T.6S. R.16E., 930 feet in T.7S. R.16E., 1120 feet in T.8S. R.16E., and 925 feet in T.8S. R.17E.

~1943-45 Between about 1943 and 1945, Houston Evans and his family lived on the Teag Ranch located next to the San Pedro River near Dudleyville. He remembered that at that time the river had clear water, ~2-3 feet deep, flowing year-round. He remembered that there were fish in the river, but they were too small to eat. He also remembered that there were racoons and turtles in the river area. Evans never saw beaver along the San Pedro River, but he did find beaver ponds in the upper reaches of Aravaipa Creek. Evans and his childhood friends spent several of their weekends canoeing, fishing, and camping along the San Pedro River between Mammoth and Dudleyville. They would canoe on the San Pedro River from Mammoth to a lake[27] located in the middle of the river, downstream of the Aravaipa confluence, where they had a raft. They would then spend the rest of their weekend fishing on the lake and camping. There were water

[27] The lake that Evans described was probably Cooks Lake, and is shown in Photograph #7 (Appendix B) and on on Plate 3. The 1949 U.S. Geologcal Survey toporgraphical quadrangle showed a small, open body of water labelled Cooks Lake located on the northern edge of a marshy area in T.6S. R.16E. Sec.33. The 1972 U.S. Geological Survey topographical quadrangle indicated a large marshy area but no open water. In June of 1997, there was open water. Refer to Photograph #7 in Appendix B.

turtles, perch, small-mouth bass, and catfish in the lake and in a few of the deeper water holes along the river.

1983 The 1983 flood-flow filled the old channel in the area of the hard-rock crossing near the Araivaipa confluence (M. Spiess, 1997, oral commun.). "The 1983 flood swept the channel clean!" (J. Smith, 1997, oral commun.)

1993 The 1993 flood waters overflowed the banks of the San Pedro River and came through the main gate of Charles Clark Jr.'s house, which is located one foot above Mammoth's Main Street (Charles Clark Jr., 1997, oral commun.). The 1993 flood flows also resulted in extensive channel bank erosion, especially along the western bank, of the San Pedro River's steep cut-banks near Dudleyville (R. Garcia and J. Smith, 1997, oral commun.; refer to the next section of this report and Plate 3 for more detailed descriptions of the channel widening in this area).

1995 The San Pedro River's 1995 active channel, between Mammoth and the Gila confluence, is more narrow and sinuous than the 1934 channel. Refer to Plate 2, Plate 3, and the third and fourth sections of this report for a more detailed description of the channel characteristics.

SUMMARY

This report summarized a new investigation of historical channel changes along the lower San Pedro River. Information was gathered from published and unpublished references, historical maps, aerial and ground photographs, and oral histories collected from long-time residents of the lower San Pedro River Valley. The majority of the information related to the Redington and Mammoth/Dudleyville reaches of the river. All available descriptions of these reaches were compiled into chronologies and evaluated with the goal of better defining the timing of channel widening and arroyo initiation. The oral histories collected from long-time residents also provided information about streamflow characteristics. Although the gathering of such information was not a goal of this investigation, accounts that may be relevant to the issue of stream navigability, such as Houston Evans account of canoeing on the San Pedro River below Mammoth during the 1940's, were included in the chronologies.

The historical photographs and maps, and the accounts by the U.S. Geoloical Survey (1901), Bayless (as cited in Griffiths, 1901), and Cooke and Reeves (1976), all indicated that by 1912 a wide channel with a sandy bed had been established along the Redington and Mammoth/Dudleyville reaches of the lower San Pedro RIver, and along most - if not all - of the lower and upper San Pedro River. However, the different types of evidence described a more complicated history of channel entrenchment along the lower the San Pedro River.

The hypothesis that the down-cutting of the San Pedro River north of The Narrows occurred in two periods (Cooke and Reeves, 1976; Melton, 1965; and Jones, 1968) seems the most likely. The newspaper articles, the analysis of the historical movement of the Bayless Ditch intake, and Bayless' account indicated that, at the very least, several segments of the San Pedro River channel became entrenched as a result of the 1890's flood events (i.e. at the Redington Narrows and near Mammoth and Dudleyville). In contrast, accounts of the Cascabel area, and the analysis of the historical movement of the Bolen Ditch intake, indicated that some channel segments did not become entrenched until the 1926 flood event (i.e. in the Cascabel area and downstream of the town of Redington).

Newspaper accounts of the Mammoth/Dudleyville area, and Bayless' account, indicated that the widening of newly-formed arroyos and the extension of headcuts continued after the floods of the 1890's as a result of subsequent flood events. However, several lines of evidence indicated that incision as dramatic, if not more dramatic, resulted from the 1926 flood event. The comparison of the elevations of the pre-1926 Los Angeles Ditch and the 1927 Bayless Ditch, the comparison of the pre- and post-1926 locations of the Bayless Ditch intakes, the newspaper accounts and oral histories – all indicated that the 1926 flood event widened and/or incised any segment of the Redington and Mammoth/Dudleyville reaches that had not yet been noteably entrenched.

Hereford and Betancourt (in press) noted that channel widening had probably slowed if not stopped along the lower San Pedro, and that reaches below Mammoth were presently aggrading (Hereford and Betancourt, in press). In general, their statement is true. However, the large flood events of 1977, 1979, 1983, and 1993 resulted in notable erosion of the arroyo walls in both the Redington/Cascabel and Mammoth/Dudleyville reaches of the lower San Pedro river (B. Clark, J. Smallhouse, R. Garcia, 1997, oral commun.; Plates 1, 2, and 3).

REFERENCES

Antevs, Ernest (1952). Arroyo-cutting and filling. *The Journal of Geology*, v. 60, no. 4, p. 375-385.

Antevs, Ernst (1955). Geologic-climatic dating in the west. *American Antiquity*, v. 20, p. 317-335.

Bahre, C.J. (1991). A Legacy of Change. Tucson: The University of Arizona Press, 231 p.

Barnes, W.C. (1935). Arizona Place Names. Tucson: The University of Arizona Press, 503 p.

Bryan, K. (1925). Date of channel trenching (arroyo cutting) in the arid Southwest. *Science*, v. 62, no. 1607, p. 338-44.

Burkham, D.E. (1972). Channel changes of the Gila River in afford Valley, Arizona. U.S. Geological Survey Professional Paper 655-G, 24 p.

CH2M Hill, SWCA Environmental Consultants, and Arizona Geological Survey (1993). Arizona Stream Navigability Study for the San Pedro River: Gila River Confluence to the Mexican Border. Unpublished draft final report prepared for the Arizona State Land Department and the Arizona Navigable Stream Adjudication Commission.

Cooke, R.U., and Reeves, R.W. (1976). Arroyos and Environmental Change in the American South-West. Oxford: Claredon Press, 213 p.

Fonseca, Julia (1997). Vegetation of the San Pedro River Valley, Pima County, Arizona, in 1879. Pima County Flood Control District, unpublished manuscript, 15 p.

Griffiths, David (1901). Range improvement in Arizona: Cooperative experiments with the Arizona Experiment Station. USDA Bureau of Plant Industry - Bulletin No. 4. Washington: Government Printing Office, 31 p.

Hastings, J.R. (1959). Vegetation change and arroyo cutting in southeastern Arizona. *Journal of Arizona Academy of Science*, v. 1, p. 60-67.

Hastings, J.R., and Turner, R.M. (1965). The Changing Mile: An Ecological Study of Vegetation Change With Time in the Lower Mile of an Arid and Semiarid Region. Tucson: The University of Arizona Press, 317 p.

Hereford, R., and Betancourt, J.L. (in press). Historical geomorphology of the San Pedro River: Archival and physical evidence. Haynes, C.V., and Huckell, B.M., eds., Murray Springs and Clovis Hunters of the San Pedro Valley. Tucson: University of Arizona Press.

Huckle, J.G.H. (1991). Dreams Come True for Cowboys, Too! The Remarkable Life Story of Jo Curtis Flieger. Tucson: Westernlore Press, 221 p. and plats.

Hucklebery, G. (1996). Historical geomorphology of the San Pedro River. Arizona Geological Survey Open-File Report 96-15, 35 p.

Jones, N.O. (1968). The development of piping erosion. Tucson, University of Arizona dissertation, 163 p.

Martin, P. P. (1992). Songs My Mother Sang to Me: An Oral History of Mexican American Women. Tucson: University of Arizona Press, 224 p.

Melton, M.A. (1965). The geomorphic and paleoclimatic significance of alluvial deposits in southern Arizona. *Journal of Geology*, v. 73, p. 1-38.

Meyer, D.F. (1989). The significance of sediment transport in arroyo development. U.S. Geological Survey Water-Supply Paper 2349, 61 p.

Parker, J.T.C. (1995). Channel changes along the Santa Cruz River, Pima County, Arizona, 1936-86. U.S. Geological Survey Water-Supply Paper 2429, 58 p.

Santiago, D.M. (1994). Charles H. Bayless: Educator, Cattleman, Businessman, and Banker. *The Journal of Arizona History*, v. 35, no. 3, p. 267-300.

United States Geological Survey (1901). Twenty-First Annual Report of the United States Geological Survey to the Secretary of the Interior, 1899-1900 Part IV - Hydrography. Government Printing Office, Washington D.C.

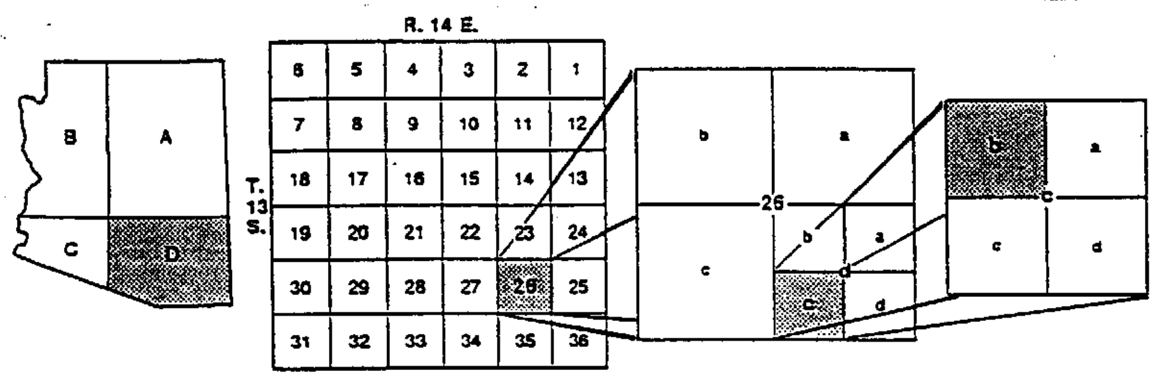
APPENDIX A

BUREAU OF LAND MANAGEMENT'S SYSTEM OF LAND SUBDIVISION

Many of the location descriptions provided in this report are based on the U.S. Bureau of Land Management's system of land subdivision. Under this system, the State is divided into four quadrants by the Gila and Salt River meridian and base line. The quadrants are designated by capital letters A, B, C, and D in a clockwise direction beginning in the northeast quarter. Because the entire San Pedro River falls within the "D" quadrant, the quadrant designation will not be included in location descriptions. The first number indicates the township, the second the range, and the third the section in which the place of interest is located. The letters A, B, C, and D after the section number indicate the location within the section. The first letter denotes a particular 160-acre tract, the second the 40-acre tract, and the third the 10-acre tract. The letters are assigned in a counterclockwise direction beginning in the northeast quarter. If the location of a place is known within the 10-acre tract, three capital letters are provided in the location description.

T.13S. R.14E. Sec.26 DCB

Quadrant D, Township 13 South, section 26, quarter section d, quarter section c, quarter section b.



(Adapted from Tadayon (1995). U.S. Geological Survey Water-Resources Investigations Report 95-4062.)

APPENDIX B

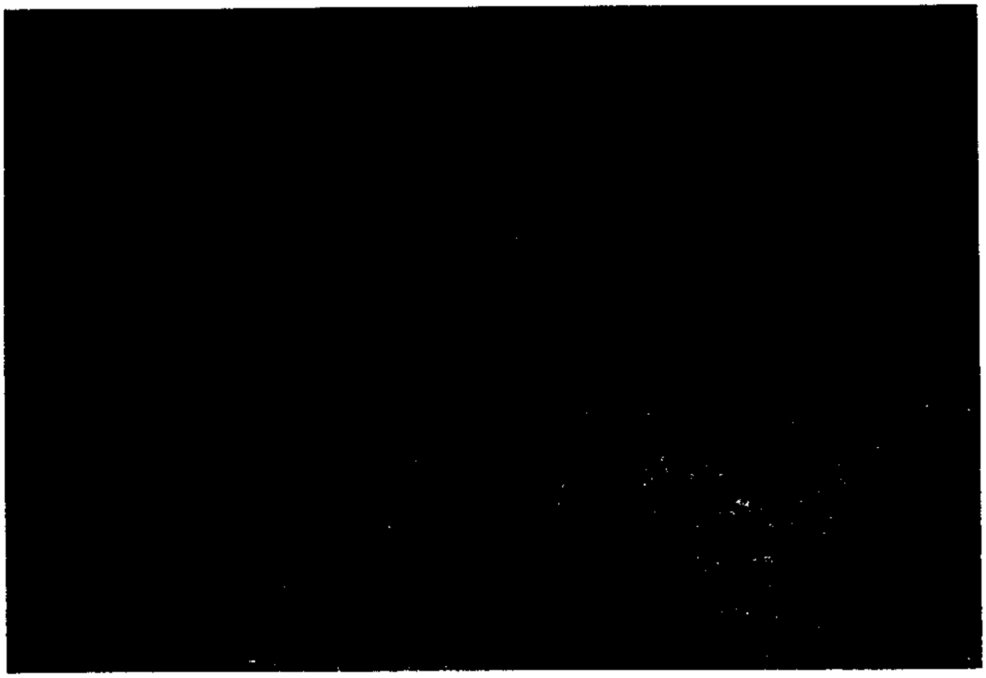
GROUND PHOTOGRAPHS

Refer to Plate 1 and Plate 3 for the photograph locations.

Photograph 1. View of the west bank of the Redington Narrows (June 1997). The Redington Gaging Station is located in the middle of the photograph. The Los Angeles Ditch is the white line of concrete perpendicular to the gage, and is 17 feet above the bottom of the channel.

Photograph 2. View of the east bank of the Redinton Narrows (June 1997). The tunnel was carved through cemented conglomerate for the Bayless Ditch in 1927. The modern Bayless ditch is located to the left of the tunnel. The bottom of the modern channel is about two feet lower than the base of the tunnel.

Photograph 3. Upstream view of the channel north of the Redington Narrows.



Photograph 4. View of an abandoned channel of the San Pedro River near Redington. It discernable as a slight dip. In the center of the photograph, barely visible in the shadows, is the remains of a cable foot bridge still tied to the tree to the left.

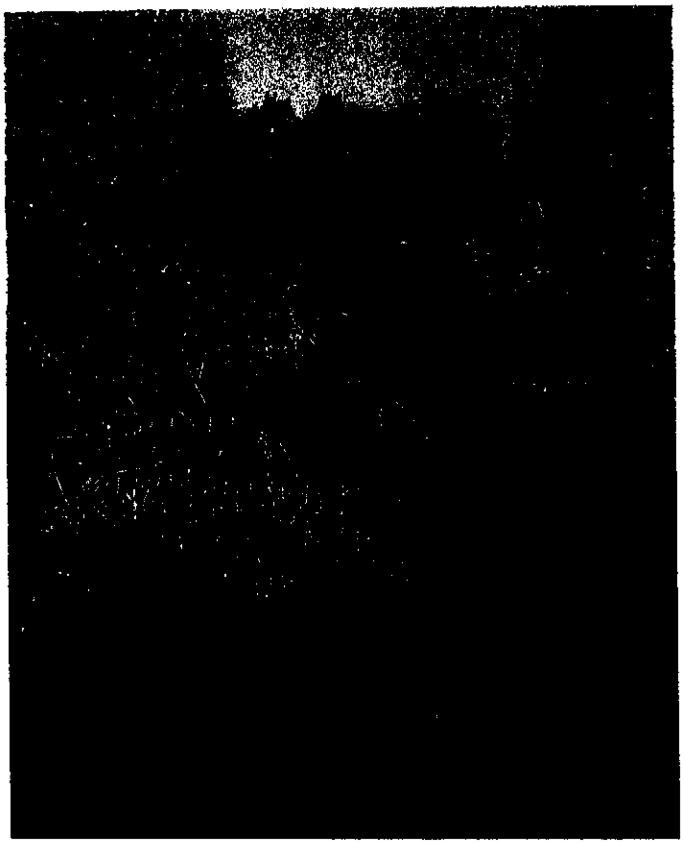
Photograph 5. "A round-up in old Arizona, taken on the Bayless and Berkalew Ranch, San Pedro River, fall of 1903." [AHS #21329]

Photograph 6. Same view as the historical photograph, taken in June 1997.

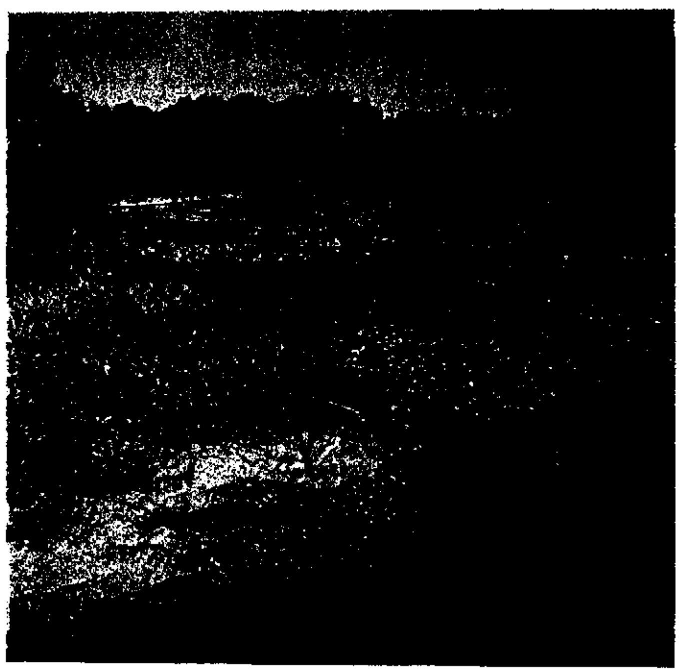
Photograph 7. View looking north at Cooks Lake.

Photograph 8. Downstream (northern) view of a perennial reach located near the PZ Ranch, about two miles downstream from the Aravaipa-San Pedro confluence.

Photograph 9. Close-up view of a more-densely-vegetated perennial reach located near Dudleyville.



Photograph 10. View of the perennial reach's end of flow, located about one mile downstream from the location of Photograph #9.



APPENDIX C

ORAL HISTORIES

Index of Contacts

Page:

Contacts

Archaeological Research Services,
Lyle Stone
520-721-4309

Archaeological Survey,
Brad Smith
520-384-0129

Arizona Department of Water Resources,
Tom Elder & Michael Winn
Information Technology Division
602-417-2400 ext. 7178

They were unable to find Arizona Water Commission maps for the lower San Pedro River.

Arizona Historical Society Museum
949 E. Second St.
Tucson, AZ 85719
520-628-5774 or 298-1705 (h)

Arizona State Land Department,
Catherine Belzano
602-542-2671

They were unable to locate Arizona Water Commission maps for the lower San Pedro River.

Arizona State University,
Dr. Will Graf
Department of Geography
602-965-7533

Because Dr. Graf tends to study the fluvial geomorphology of rivers in northern Arizona, he had no historical information for the San Pedro River. He recommended that we research the collections at the Arizona Historical Society office in Tempe. He also recommended that we contact the Mormon Church because individual churches, or "stakes," often recorded notable environmental changes that occurred in their region, sent the information to the main church, or "temple," in Salt Lake City. In addition, he noted that the EROS

Data Center in Sioux Falls, South Dakota, is the repository for all aerial photographs collected by federal agencies associated with the Department of the Interior. [Write or fax: USGS EROS Data Center, Customer Services, Sioux Falls, S.D., 57198, fax: 605-594-6589.]

Arizona State University,
Dr. Robert Ohmart
Center for Environmental Studies
602-965-4632

Dr. Ohmart recommended that we contact Will Graf (ASU Department of Geography) and Luna Leopold (UC-Berkely).

Arizona State University,
Jan Walter
Government Documents
602-965-3387

Arizona State University,
Lynda Zelmer
Head Librarian
602-965-3582

ASARCO,
Kip Gambee & Ed John
520-356-7811 ext.3383

Bateman, Jay,
Florence, AZ
520-868-6442

He did not have any relevant information. He recommended that we contact the Soil Conservation Service (Natural Resource Conservation District, NRCD) in Casa Grande.

Bennett, Elena and Emma
Benson, AZ
520-586-2679

Bingham, Faron,
Bingham-Browning Ranch,
Redington, AZ
529-212-3855

Bisbee Mining and Historical Museum,
Judy R. Reis
P.O. Box 14
Bisbee, AZ 85603
520-432-7071

The museum docents were able to find photographs for the upper San Pedro River, but not for the lower San Pedro River.

Bundy, Ted,
Tucson
520-571-8132

Mr. Bundy not only owns property along the San Pedro River, but also he was once a photo analyst for the Arizona State Historical Society Museum. He made the observation that the strip of the San Pedro River that runs through his property is shallow and unincised, like how the river was in the 1800's.

Because he is writing a book about the Tres Alamos area, which is upstream of The Narrows, Mr. Bundy has a collection of historical information about that region. While he does not have any photographs for the lower San Pedro River, he does have several historical maps that show the reach of the river upstream of The Narrows. For example, he has a pre-1877 map surveyed by the U.S. Army that shows the San Pedro River from the U.S. border to approximately the Pima/Pinal County border. He also has a GLO plat that shows the location of homesteaders in the area between Tres Alamos and The Narrows.

Mr. Bundy recommended that we contact "Henry," who works for Desert Archaeology, regarding archaeological surveys conducted in the Benson area and downstream from Mammoth. He also recommended that we review the manuscripts and maps collected by the Arizona Historical Society Museum, the University of Arizona's Map Collections and Special Collections, and the Arizona State University Library. In addition, Mr. Bundy thought that the Conklins had taken photographs of the Butterfield Stage Station downstream of Benson during the 1930's, and that we may be able to find information in the special issue of the journal, *Desert* Plants (volume 6, number 3, 1984), that focused on the location and history of cienegas.

Bundy, Winn,
Singing Winds Book Shop,
Benson, AZ
520-586-2425

Ms. Bundy recommended the book, Where the Waters Meet, published by the Central Arizona College - Aravaipa Campus. She also recommended that we contact the *Friends of the San Pedro* organization, and her son, Ted Bundy, who once was a photo analyst for the Arizona State Historical Society Museum.

Bureau of Land Management - Phoenix,
Tim Goodman
Biologist
602-780-8090

Mr. Goodman had no relevant information. However, he was able to provide Diane Lausch's current telephone number.

Bureau of Land Management - Safford,
Ben Robles
Hydrologist
520-428-4040

The only historical records that the Safford office had were the 1984 aerial photographs of the San Pedro River valley region. Mr. Robles recommended that we contact Jessie Juen at the Tucson office.

Bureau of Land Management - Sierra Vista,
Dave Krueper

He recommended that I speak to Ben Robles (BLM, Safford), Dr. Robert Ohmart (Center for Environmental Studies, Arizona State University), Russell Scott (USDA Agriculatural Research Service hydrologist), and Diane Lausch (Bureau of Reclamation biologist).

Bureau of Land Management - Tucson,
Jessie Juen
Field Office Manager
520-722-4289

Bureau of Reclamation - Phoenix,
Diane Lausch
Biologist
P.O. Box 9980
Phoenix, AZ 85068
602-395-5694

During her research of a mitigation site at the Aravaipa-San Pedro confluence, Ms. Lausch surveyed the records at the Arizona Historical Society Museum and the ASU library; however, she did not find any information relevant to our study in her search. She recommended that we contact John Smith, a rancher who owns property north of the mitigation site in the area of Cooks Lake.

Clark, Charles, Jr.,
Mammoth, AZ
520-487-2232 or 487-2335

Mr. Clark explained that his family came from England by way of New Zealand, and became established in Mammoth in 1873. His great-grandfather came west with eight children and bought a lot of land along the river. This land was split into parcels and distributed amongst the children. Little by little, the land (including the land owned by Charlie Clark, Sr., Mr. Clark's father) was sold to Magma Copper. Mr. Clark stated that his family had photographs of freight wagons, but none of the San Pedro River itself.

Mr. Clark has lived in the area since 1984. He has observed the deposition of sediments in the San Pedro River in the Mammoth area. During the 1993 flood event, water had overflowed the banks of the river and come through the main gate of his house, which is one foot above Main Street. From talking to other people who lived along the river, Mr. Clark determined that if the Aravaipa Creek and Gila River were experiencing a high flow, the San Pedro River would "back up," causing sediments to build up.

Mr. Clark recommended a book published in 1988 by the Central Arizona College - Aravaipa Campus under the direction of Dean Prichard, called The Heritage Writing Project. He said that this book contains photographs and stories written by people who had lived in the Aravaipa area for a long time. Mr. Clark also recommended that we contact Wilma Huggett of the 3C Ranch near Oracle because she has several photographs and experience with the area.

Clark, Charles, Sr.,
Mammoth, AZ

Because Mr. Clark Jr.'s father, Charlie Clark, Sr., was born in 1919, Mr. Clark thought that he may be able to provide some information. However, because Mr. Clark, Sr., had just undergone triple-by-pass surgery, he was unable to meet with AZGS personnel. Mr. Clark, Jr., relayed the questionnaire to him and then contacted AZGS with Mr. Clark, Sr.'s response.

Mr. Clark, Sr., recalled the flood of 1926. His farm was down on the river, near the tailings pond about two miles south of Mammoth. The 1926 flood flow gouged a large chunk of the farmland. He remembered that, in general, if the river were not experiencing a heavy flood flow, the river would carry a lot of sediment and deposit it. As the river deposited sediment, it would move side to side. Mr. Clark, Sr., also remembered that he caught trash/sucker fish and catfish on from the river during his childhood. In addition, he did see beaver on the river. He said that the river had perennial flow until he was 10 years old (~1930).

Cochise County Floodplain Division,
Barry
520-432-9420

Cochise County Historical and Archaeological Society
P.O. Box 818
Douglas, AZ 85607
520-364-5226

Dawson, Mary Beth & Roy,
Redington, AZ
520-212-7667

Mrs. Dawson said that her family had no manuscripts or photographs that would describe the lower San Pedro River area. (She and her husband are primarily archaeologists.) She recommended the books Where the Waters Meet (Central Arizona College - Aravaipa Campus) and Songs My Mother Sang to Me (by Patricia Presiado, UA Press, 1992). She also recommended that we research the Soza family history because they lived on the river a long time.

Desert Archaeology,
Bill Doelle & Henry Wallace
520-881-2244

Evans, Houston,
Winkelman, AZ
520-487-2263

Mr. Evans responded to the mass-mailing letter. When he was in the third grade (~1944), he lived on Teag Ranch, which was located along the river about two miles north of the old school house near Dudleyville. Because his father was a miner, Mr. Evans moved several times to-and-from the river area during the 1940's. He joined the service at age 17 and did not return to the San Pedro River area until ten years ago. He did not have any historical photographs, but he was able to remember the conditions of the river during the 1940's.

Mr. Evans said that the river had clear water, about two-to-three feet deep, year-round during the 1943-45 period. He also remembered that the Aravaipa Creek flowed year-round so that there was always a lot of water in the Aravaipa-San Pedro confluence area. He said that there was a large lake in the middle of the river between the Aravaipa-San Pedro confluence and Dudleyville that is no longer there. He, along with other young family members and friends, would canoe on the San Pedro River from the Mammoth area down to the lake, where they had a raft. He and his companions would then spend the weekend on the lake fishing and camping until his father would come pick them on Sunday so that they could go to school on Monday.

In the lake and other water holes on the river, Mr. Evans found water turtles, perch, small-mouth bass, and catfish. He said that he did fish some, but that the fish were too small to eat; the fish were about the size of a "good-sized goldfish."

During the 1943-45 period, Mr. Evans had trap lines which he ran all winter. He remembered catching bobcats, squirrels, coyotes, raccoons, and skunks, and even one black bear and one ring tail. He said that he no longer sees raccoons in that area, and that he never did see any beaver along the San Pedro River, although there were once beaver ponds in upstream reaches of Aravaipa Creek. He has noted that there is more dead vegetation now than when he was a child.

Mr. Evans recommended the book, Men and Animals in Arizona: 1824-1864, published by the University of Arizona. He said that this book contains a description of the San Pedro River. For example, the book states that a group "caught 39 beaver in one night" and saw "millions of birds" along a reach of the San Pedro River downstream of where Mr. Evans now lives. Mr. Evans also recommended that contact the Forest Service for historical maps, and Red Walkner, who was born and raised on the river.

Mr. Evans said that he would contact the Teag family and other people who had lived along the river for a long time and then call me.

Farrington, Dennis
Redington, AZ
520-212-2529

Mr. Farrington noted that one could see that the original river channel meanders of the San Pedro River cut by the new channel were much higher up. He recommended that we talk to: Mary Taylor; and, to his wife, Barbara Clark, about the watershed restoration project in the Cascabel area.

Forest Service,
Bill Gillispie
520-378-0311

He recommended that AZGS contact Archaeological Survey (Brad Smith), Old Pueblo Archaeology (Al Dart), and Desert Archaeology.

Gamez, Conrad
Phoenix (formerly of the San Pedro River Valley)
520-276-5452
5618 S. 9th Ave.
Phoenix, AZ 85041

Gila County Historical Museum,
Jean Stiles & Bill Haak
P.O. Box 2891
Globe, AZ 85501
520-425-7385

The Museum has information for Winkelman and Hayden, but no information regarding the water conditions on the San Pedro River.

Hugget, Wilma
Oracle

She recommended that AZGS contact a man named Acton, and research an article published by the Aravaipa Arrow in 1988. Because she had recently had a stroke, she had trouble remembering many things.

Holy Trinity Monastery,
Father Louis
1605 S. Saint Mary's Way
Saint David, AZ 85630
520-720-4642

The monastery had no relevant historical information for the lower San Pedro River. Fr. Louis recommended that I speak with Patricia Don, the curator of the Benson Historical Museum (also known as the San Pedro River Valley Arts and Historical Society Museum).

McFarland State Historic Park,
Katie
P.O. Box 109
Florence, AZ 85232
520-868-5216

Katie recommended that I contact the Pinal County Historical Museum.

Natural Resource and Conservation District - Casa Grande,
Sarah Beloshapka
Casa Grande, AZ
520-836-2048

She recommended that I contact the *Friends of the San Pedro* organization, located in Benson, and Jack Smallhouse, who lives in Redington.

Natural Resource and Conservation District - Douglas Field Office,
Geoff Parker
Route 1, Box 226
520-364-2001

Mr. Parker recommended that we contact the San Pedro NRCD field office.

Natural Resource and Conservation District - Mammoth,
Virgil Mercer
520-487-2431

Mr. Mercer said that his family had no photographs of the San Pedro River area. He observed that by 1953 almost all the families that had farmed in the Mammoth area had sold their land to the mines. He recommended that we contact the Clark family (especially Charlie Clark, Sr.) in Mammoth because they had been living along the San Pedro River since 1873. He also recommended that we research the archives held by the military, the mines, and the Department of Agriculture.

Natural Resource and Conservation District - Redington office,
Barbara Clark
520-212-2529

Ms. Clark moved to the Cascabel area in 1970. She had anecdotel information about the San Pedro River from talking to such people as the Smallhouse, Soza and Gamez families who have lived along the river for generations, and to Carrie Smith, who once taught at the school in Redington. She said that Mr. Smith learned from other residents that the channel in the Cascabel area became incised as a result of the 1926 flood event.

Ms. Clark also could show previous locations of the river channel on her property. In addition, she was able to direct AZGS to a series of historical maps on file at the Cochise County Assessor's Office. While she did not know the exact date of the maps, she speculated that they were surveyed about the time the USGS conducted the brass-cap survey in 1923.

Ms. Clark thought that Catherine Balzano, the Arizona State Land Department, might be able to help find the historical Arizona Water Commission maps that surveyed the location of all the active irrigation maps at the time of Statehood.

Natural Resource and Conservation District, San Pedro Office,
& Conservation Resource Center,
Diane Escobido
520-586-3467
880 W. 4th Street, #2
Benson, AZ, 85602

Ms. Escobido recommended that we contact Jack Smallhouse (Redington) and Barbara Clark (Natural Resources Conservation District - Redington office).

Nature Conservancy - Dudleyville,
Steve Huckett & Ralph Garcia
520-357-6076

Ralph Garcia (born ~1930) described the history since the 1940's of the Sales Ranch area, now owned by the Nature Conservancy. He said that during the 1960's the Sales family bought the ranch from Buster Noggley, who died about two years ago. He described the location of two irrigation ditches used during the 1940's, one near the mustang corrals and one that led from Leroy Springs (on "Indian territory"). Mr. Garcia remembered that flood events during the 1940's eroded a lot of land along the property.

Mr. Garcia and Mr. Huckett took Michelle Wood on a survey of the property and showed her the approximate locations of the ditches used during the 1940's, the location of modern-day springs, and flow extent within the channel. Observations made during this survey are described in the main text.

Nature Conservancy - Upper San Pedro Ecosystem Program,
Rena Anne Abolt
520-378-2640

Ms. Abolt had no historical information for the lower San Pedro River. She recommended that we contact Dave Harris at the Tucson office.

Nature Conservancy - Tucson Office,
Dave Harris & Diane Imig

Mr. Harris knew of no historical information for the lower San Pedro River. He recommended that we contact: Jack Smallhouse (Redington), the Bingham-Browning Ranch family, i.e. Jack and Louis Kelly (Louis Kelly is a descendant of the Bingham family), and Faron Bingham; and, Virgil Mercer (chair of the Winkelman NRCD and owner of a ranch in the Mammoth area).

Ms. Imig recommended that we research the photographic work of Buehman, who extensively traveled and photographed southern Arizona. She also recommended that we research the collections of Pima County Maps and Records, and of the mines in San Manuel (BHP and Asarco).

Ohnesorgen, Dora,
Benson
204 E. Walker
Benson, AZ 85602
520-586-2873

Old Pueblo Archaeology,
Al Dart & John Murray
520-798-1201

Owens, Edward
BHP - San Manual
520-385-3100

Pima County Flood Control District,
Julia Fonseca

Ms. Fonseca made available her unpublished study of historic vegetative and hydrological conditions at the Bingham Cienega Natural Preserve. The study is summarized in the main text of this report. In addition, Ms. Fonseca recommended that AZGS refer to the Arizona Department of Water Resources' Hydrographic Survey and other references related to water rights in the San Pedro River basin, as well as the U.S. Army Corp. of Engineers flood control report related to the hearing held in Benson in ~1935, and the National Archives. She also thought that the photograph collections at the UA Special Collections and the Arizona Historical Society might be useful, although she reviewed the written documents at both institutions for Bingham Cienega and the San Pedro River near Redington, and did not discover much.

Pinal County Historical Society,
Della Meadows
P.O. Box 851
Florence, AZ 85232
520-868-4382

Pratt, Jerry,
Sierra Vista
3000 Meadowlark Drive
Sierra Vista, AZ
520-458-0971

Retired wildlife biologist

San Pedro Valley Arts & Historical Society Museum,
Nedra Suderland
P.O. Drawer 1090
Benson, AZ 85602
520-586-3473

Ms. Suderland had recorded extensive oral histories from residents of the Benson area. The tapes and transcripts are archived and are open to the public at museum. She located a transcript that mentioned the 1926 flood on the San Pedro River; however, it contained no information pertinent to the study of channel characteristics of the lower San Pedro River at the turn of the century. In addition, Ms. Suderland searched the Museum's holdings for newspaper accounts describing large historical floods on the San Pedro River and made those available for this study. She suggested several people who may have more information: Dora Ohnesorgen of Benson; Kathleen Shull, a reported for the *San Pedro Valley News Sun* newspaper; Win Bundy, historian and owner of the Singing Winds Book Shop located north of Benson; and, Jack Smallhouse.

San Pedro Valley News Sun,
Kathleen Shull
Reporter
520-586-2873

Ms. Shull wrote the story, "Beavers may return to the San Pedro River," for the "Seasons" quarterly edition of the *San Pedro Valley News Sun* [Seasons, May 14, 1997]. In this article she described the history of beaver trapping on the San Pedro River in the 1800's, and the Bureau of Land Management's plan to reintroduce beaver into the San Pedro Riparian National Conservation Area, located in the upper San Pedro River basin. She provided several potential contact, reference, and research ideas: the Pacheco sisters who live on Ocotillo Road in Benson (however, she noted that they did not want to be interviewed for her report); Lt. Emory's Journal (~1860's manuscript that contained surveys and pictures]; and, irrigation projects related to the Pomerane Dam.

Smallhouse, Jack,
Bayless Ranch
Redington, AZ
520-212-5225

Mr. Smallhouse had a variety of historical maps and photographs that showed the San Pedro River in the vicinity of the Bayless Ranch south of Redington. He made these maps and photographs available to the AZGS, and helped Michelle Wood field verify the current conditions of the San Pedro River in the areas shown on the maps and photographs. Refer to the main text for a more detailed description of the maps and photographs.

Mr. Smallhouse recommended that we contact Dr. Meyers of Oracle because Dr. Meyers had a photograph hanging on his wall that showed the confluence of the San Pedro and Gila rivers at ~1900. He believed that this photograph indicated that the San Pedro River was not channelized at that time.

Smith, John,
Marana, AZ
Smith Farms
520-568-2261

Mr. Smith is a rancher and amateur historian of the lower San Pedro River area with a life-time's experience in water issues along the San Pedro (i.e. he was on the board of the Central Arizona Project and the Maricopa Irrigation District). He bought his property along the San Pedro River during the 1960's. He described channel changes of the lower San Pedro River that occurred during the last three decades. He observed that the 1983 flood event "swept the channel clean." He also said that the San Manuel mine uses some of the river water; otherwise, there were few other water uses that would affect the river's flow.

Mr. Smith took Michelle Wood on a survey of the river channel, historical structures, and the approximate location of former irrigation ditches constructed in the 1870's and 1880's on his property, his son's property, and their leased property along the lower San Pedro River. In addition, Mr. Smith showed her the historical maps that he had collected. Relevant information gathered from the maps and field visit is described in the main text. He said that he would make available the interviews he collected when he was resolving water rights for his property, and that he would provide a good contact at the mining company, American Smelting, to research the information the company contains in its water rights research files. He recommended that AZGS contact Kip Gambee at ASARCO.

Spiess, Michael E.,
Tucson
7732 North Red Wing Place
Tucson, AZ 85741
520-889-8989

Mr. Spiess responded to our mass-mailing letter. He bought property, located five miles below the hard-rock crossing near the Aravaipa-San Pedro confluence, from the Ragsdale family. He thought that the children of the previous owner had grown up on that property and that they might have the type of information needed for this project. He could not remember phone numbers of the children; however, Mr. Spiess remembered that the son of the original owner had moved to Mesa, and that one of the daughters, Ethel Stalnaker, had moved tot he Phoenix area. We were unable to locate the original owners' location based on Mr. Spiess' information. Mr. Spiess said he would research his files and get back to us.

Mr. Spiess described the more recent channel changes of the San Pedro River in the area of the Aravaipa-San Pedro confluence. He had observed that the river has been consistently moving westward and straightening out its curve. He said that the 1983 flood flow filled the old channel.

Statistical Research,
Jeff Altschul
520-721-4309

Taylor, Mary,
Redington, AZ
520-212-1314

Ms. Taylor wrote *A Bare Bones Account of Significant Happenings Along the San Pedro River,* based on oral histories she gathered from people who lived in her region. She found that people were too old to remember details about the river, were too poor to own camaras, or the pictures they took were not of the washes and river.

Ms. Taylor recommended that we research the history of the Soza Family and the C-Spear Ranch. She also recommended that we contact: the Bidegain family of Elgin; Ernest Sherman in Pomerane; the Ohnesorgen family of Benson/Tres Alamos; Johnnie Levine, the current manager of the C-Spear Ranch; and, Mary Beth and Ray Dawson, who are amatuer archaeologists and residents of the area.

Tombstone Courthouse State Historic Park,
Hollis N. Cook
Park Manager
P.O. Box 216
Tombstone, AZ 85638
520-457-3311

USDA Agricultural Research Service,
Russell Scott
Hyrologist
520-670-6380

University of Arizona,
Dr. Vance Haynes
Deparment of Anthropology
520-621-6307

University of California - Davis,
Conrad Bahre
916-752-0798

Dr. Bahre, who wrote the book Legacy of Change, was contacted in an attempt to locate the original 1901 survey conducted by D.A. Griffiths (Agricultural Experimental Research Station, Tucson) that interviewed C.H. Bayless. Dr. Bahre said that if they still existed, the notes would be archived in disorganized boxes at the University of Arizona Agricultural

Experiment Station, or perhaps in Washinton D.C. He recommended that AZGS contact Diane Hadley.

Walkner, Red,
long-time resident of the San Pedro River valley
520-473-2143 (SAS Industrial Maintainance, field office)

While Mr. Walkner was not old enough to remember the San Pedro River as it was in the earlier part of the century, he was able to recommend a few people that AZGS could contact. He refered us to: Edward Owens of BHP Copper in San Manuel, who grew up on the river near Mammoth; Jim Ragsdale, Jr., son of Mr. Ragsdale Sr. who once owned land along the river; and, his own sister, Nancy McKlinnen (520-357-6832), who would know the current location of the Ragsdale family as well as other people we could contact.

Mr. Walkner also suggested that AZGS research the history of Barkersville, the community that once existed on the western side of the San Pedro River across from Dudleyville (i.e. the location of the old school house, cemetary, and stage stop for the stage route to Florence).

Water Resources Research Center,
Barbara Tellman
University of Arizona

Dr. Tellman referred me to Julia Fonseca (Pima County Flood Control District), Mary Taylor, (author of *A Bare Bones Account of Significant Happenings Along the San Pedro River*, and Francaviglia's article in the *Cochise Quarterly* entitled, "The Upper San Pedro River Valley: A Century of Environmental Change."

Zarbin, Earl,
Phoenix
3803 E. St. Catherine Ave.
Phoenix, AZ 85040
602-437-2665

GLOSSARY

Acequia - An irrigation ditch or canal.

Aggradation - Progressive deposition of sediment, raising the elevation of the streambed. See Degradation.

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

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

Anecdotal - Undocumented evidence or accounting of an event.

Aquifer - A water-bearing bedrock or alluvium layer.

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

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

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.

Bajada - A piedmont comprised of coalescing alluvial fans.

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.

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

Cadastral Survey - A land (legal) survey.

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.

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.

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."

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. See Continuous Gage.

Degradation - Channel bed erosion resulting in a topographically lower streambed.

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

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

Entrenchment (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.

Ephemeral Stream - A stream which flows only in direct response to rainfall. It receives little or no water from springs and no long continued supply from snow or other sources. Its channel is at all times above the water table.

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

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

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.

Flow Duration Curve - A cumulative frequency curve depicting the percent of time a given discharge on a stream is equaled or exceeded in a specific period. For instance, a 10 percent flow of 20 cfs means that the stream discharge only exceeds 20 cfs, 10 percent of the time; a 90 percent flow of 1 cfs means that the stream flows at discharges greater than 1 cfs, 90 percent of the time; the 50 percent 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.

Geomorphic - Parameters or variables relating to geomorphology.

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

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

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.

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.

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

Infiltration - The process whereby water passes through an interface, such as from air into soil.

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

Intermittant Stream - A stream which flows only for portions of the year, but has sustained flow for a period after rainfall. See Perennial Stream and Ephemeral Stream.

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 percent of the time).

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

Navigable (Navigable Watercourse) - 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.

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.

Phreatophytes - Deep-rooted plants that obtain water from the water table or the layer of soil just above it.

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.

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

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

Quit claim - A transfer of one's interest in a property, especially without a warranty of title to give up claim to property by means of a quit claim deed.

Quit claim deed - A deed that conveys to the grantee only such interests in property as the grantor may have, the grantee assuming responsibility for any claims brought against the property.

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

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

Riparian - Refers to that which is related to, or located near, or living along a watercourse whether natural, man-made, ephemeral, intermittent, or perennial.

Salt Cedar - A non-native, undomesticated tamarisk tree.

Scour - Removal of streambed material by flowing water.

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

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.

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

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 analogous to stream depth.

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.

Subflow - See Underflow.

Tamarisk (salt cedar) - Non-native riparian plants. Presently the dominant vegetation on the floodplain of many streams due to opportunistic growth in channel systems in the southwestern United States.

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.

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.

Transition Zone - See Central Mountain Province.

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

Underflow - A term used interchangeably with subflow to describe the ground water underlying the surface of a stream's channel.

Unentrenched - See Entrenchment.

Wash - A river or stream with low banks and numerous channels.

Water Table - The upper surface of the underground zone of saturation; the plane which represents the elevation of ground water.
Watershed - The land area draining into a stream, or other body of water.

Xerophytes - Plants that are structurally adapted for life and growth with a limited water supply.

LIST OF ACRONYMS

Arizona Geological Survey	AZGS
Arizona Land Resource Information System	ALRIS
Arizona Navigable Stream Adjudication Commission	ANSAC
Arizona Revised Statutes	A.R.S.
Arizona State Land Department	ASLD
Arizona Upland	AU
Bureau of Land Management	BLM
Cubic feet per second	cfs
Federal Emergency Management Agency	FEMA
Flood Insurance Rate Map	FIRM
General Land Office	GLO
Geographic Information System	GIS
House Bill	HB
Lower Colorado River Valley	LCRV
Right of Way	ROW
Santa Cruz River	SCR
US Geological Survey	USGS

SUMMARY

A.R.S. §37-1101 through §37-1156 specify the procedures and criteria for determining the navigability or non-navigability of watercourses in Arizona. The key findings of the research into the archaeology, history, hydrology, hydraulics, geomorphology, and land use of the Santa Cruz River are presented below in a sequence compatible with the criteria itemized in A.R.S. §371128. This information is summarized to support a decision by others regarding the navigability, susceptability to navigation, or non-navigability at the time of statehood of the Santa Cruz River from the confluence with the Gila River to the headwaters.

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A.R.S. §37-1128, C. stipulates that the Arizona Navigable Streams Adjudication Commission (ANSAC) shall find and recommend that a watercourse was nonnavigable if, as of 14 February 1912, the watercourse either: 1) was not used or susceptible of being used for both commercial trade and travel; or 2) flowed only in direct response to precipitation and was dry at all other times.

Commercial Trade and Travel

In the case of the Santa Cruz River, archaeological research indicates that the river valley functioned as a communication, transportation, and trade corridor in prehistoric times. The Tucson Basin served as a local node in the Hohokam regional system. Interregional exchange is evident by the presence of Mogollon ceramics from the mountainous regions to the east and by shell artifacts from the Sea of Cortez. Further, the Santa CruzRiver was the line of communication for the dissemination of new types of pottery throughout the northern and southern extremities of the river. No evidence was found to suggest that the early inhabitants of the valley used boats on the river.

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food for the traveler. Although the river was an important transportation route, it was not normally used for navigation except for isolated accounts found in the literature. A few instances of boating on the river are reported, but the perennial flow that existed on the river historically was such that it was never regularly navigated.

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The middle Santa Cruz River historically had several springs and cienegas within its channel from Tubac to Tucson. A review of the daily discharge record indicates that there was some semblance of baseflow with an average of about 12 cfs during the fall and winter of 1912-1913 at the Tucson gage. An average daily discharge of 12 cfs corresponds to a water depth of approximately 0.2 feet (2.4 inches) based on interpolation of the stage-discharge curve developed from USGS data measured in 1955. Such continuous flow for months at a time was not seen again in the years that followed, though there were periods of several weeks that experienced continuous or nearly continuous flow during very wet winter seasons.

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1. no sustained trade and travel occurred both upstream and downstreamin the watercourse;

   Although the Santa Cruz River was an important transportation and trade route in both upstream and downstream directions, it was not normally used for navigation except for a few isolated accounts found in the literature.

2. no profitable commercial enterprise was conducted by using the watercourse for trade or travel;

   No evidence of navigation of the river for the purpose of commercial trade and travel was found.

3. vessels customarily used for commerce on navigable watercourses in1912, such as keelboats, steamboats or powered barges, were not used on the watercourse;

A land speculator portrayed the river at Calabasas (west of Nogales) as capable of floating steamboats in the 1880's. This, however, was pure fiction but gave rise to the belief that surfaces, occasionally even today, that the river was navigated by large ships.

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   The U.S. Geological Survey Streamgage Summaries report that essentially the entire flow of surface waters from the river were diverted both at the Nogales and Tucson gaging stations by irrigation ditches (USGS 1907,1912). Agricultural water use in the Tubac, Tucson, and San Xavier areas used most of the available surface water and also intercepted groundwater and subsurface flow.

5. any boating or fishing was for recreational and not commercial purposes;

   The Santa Cruz River provided water, wood, food, and shelter for the people who lived near it. Early inhabitants supplemented their diet with the fish caught from the river. The perennial waters near San Xavier persisted until 1949, and supported native fish until at least 1937.

   During the 1880's, Silver Lake (a manmade lake just south of downtown Tucson on the Santa Cruz River) was a popular recreation area, featuring boating, fishing, and swimming. A paddle boat on the lake was a major attraction. Boating both by rowing and sail was popular in the lake and upstream. Silver Lake

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6. any flotation of logs or other material that occurred or was possible on the watercourse was not and could not have been regularly conducted for commercial purposes;

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9. the United States did not regulate the watercourse under the Rivers and Harbors Act of 1899 (33 United States Code Sections 401 through 467e).

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SUMMARY

A.R.S. §37-1101 through §37-1156 specify the procedures and criteria for determining the navigability or non-navigability of watercourses in Arizona. The key findings of the research into the archaeology, history, hydrology, hydraulics, geomorphology, and land use of the Santa Cruz River are presented below in a sequence compatible with the criteria itemized in A.R.S. §371128. This information is summarized to support a decision by others regarding the navigability, susceptability to navigation, or non-navigability at the time of statehood of the Santa Cruz River from the confluence with the Gila River to the headwaters.

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Commercial Trade and Travel

In the case of the Santa Cruz River, archaeological research indicates that the river valley functioned as a communication, transportation, and trade corridor in prehistoric times. The Tucson Basin served as a local node in the Hohokam regional system. Interregional exchange is evident by the presence of Mogollon ceramics from the mountainous regions to the east and by shell artifacts from the Sea of Cortez. Further, the Santa CruzRiver was the line of communication for the dissemination of new types of pottery throughout the northern and southern extremities of the river. No evidence was found to suggest that the early inhabitants of the valley used boats on the river.

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Hydrologic Characteristics

Historically (circa the 1890's), the upper Santa Cruz River was perennial from its source to Tubac. Climate change since the turn of the century, combined with the extensive groundwater pumping for irrigation and the flow diversion for municipal use that began near the international border during the 1930 to 1950 drought period, resulted in no flow in the channel in Sonora, Mexico, and discontinuous flow in the channel near Nogales, Arizona. The 1913 gage record at Nogales (the earliest in that region), indicates that by the time of statehood, the Santa Cruz River near Nogales was no longer perennial, but instead had continuous flow during the winter and occasional flow during the spring, summer, and fall. The 1913 winter discharge averaged about 15 cubic feet per second (cfs), except for an increase caused by a rainfall event that ranged from 35 to 174 cfs. Based on interpolation of the stage-discharge curve for the Nogales gage plotted from the USGS data measured in 1959, an average winter discharge of 15 cfs in 1913 corresponds to a water depth of approximately 0.3 feet (3.6 inches). A survey of the daily data for the rest of the Nogales record indicates that, during wet years, there were only a few days of no flow recorded in the channel.

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1. no sustained trade and travel occurred both upstream and downstreamin the watercourse;

    Although the Santa Cruz River was an important transportation and trade route in both upstream and downstream directions, it was not normally used for navigation except for a few isolated accounts found in the literature.

2. no profitable commercial enterprise was conducted by using the watercourse for trade or travel;

    No evidence of navigation of the river for the purpose of commercial trade and travel was found.

3. vessels customarily used for commerce on navigable watercourses in1912, such as keelboats, steamboats or powered barges, were not used on the watercourse;

A land speculator portrayed the river at Calabasas (west of Nogales) as capable of floating steamboats in the 1880's. This, however, was pure fiction but gave rise to the belief that surfaces, occasionally even today, that the river was navigated by large ships.

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9. the United States did not regulate the watercourse under the Rivers and Harbors Act of 1899 (33 United States Code Sections 401 through 467e).

The Santa Cruz River was not regulated under this Act.

Specific Criteria of Navigablity

A.R.S. §37-1128, E. states that in finding whether a watercourse was navigable, the ANSAC shall not consider:

1. waters that had been appropriated for beneficial uses on or before 14 February 1912 as being within the ordinary and natural condition ofthe watercourse;

    By 1910, it was reported that the entire base flow of the Santa Cruz River at both the Mexican border and near the Congress Street bridge in Tucson was diverted for agriculture.

2. the use of ferries to cross a watercourse;

    There are no records of ferry service anywhere on the river. Fords and crossable washes are marked on numerous maps. When the bridges went out during floods, people were stranded and had to wait until the river could be crossed by horse. No evidence of boats being used to cross the river at flood time were found.

3. fishing from the banks of a watercourse;

    Although research indicates that native fish were caught for recreation and for human consumption, no documentation was found as to the manner in which the fishwere caught.

4. uses of the watercourse under flood conditions.

    Most accounts of boating on the river occurred during flood events.

A.R.S. §37-1128, F. states that in finding whether a watercourse was navigable, the Commission shall consider the existence of dams and diversions of water and the impact of other human uses that existed or occurred at the time of statehood as part of the ordinary and natural condition of the watercourse.