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Arizona Stream Navigability Study

for the

Upper Gila River

Safford to the State Boundary

and

San Francisco River

Gila River Confluence to the State Boundary

Draft Final Report

Prepared for the

Arizona State Land Department

GREAT SEAL OF THE STATE OF ARIZONA
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1912

Date of Original Report: June 1997

Prepared by

SFC Engineering Company
In Association with
George V. Sabol Consulting Engineers, Inc.,
JE Fuller/ Hydrology & Geomorphology, Inc.,
and
SWCA, Inc. Environmental Consultants

Revised:

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

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UPPER GILA RIVER & SAN FRANCISCO RIVER FINAL REPORT

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PREFACE

This report was prepared under contract to the Arizona State Land Department (ASLD). This report summarizes information relating to the navigability or non-navigability of the Upper Gila and San Francisco Rivers as of the time of statehood on February 14, 1912 for two river reaches: (1) the Upper Gila River from Safford to the Arizona/New Mexico border and (2) the San Francisco River from its confluence with the Gila River to the Arizona/New Mexico border. A companion report for the Lower Gila River from Safford to the Colorado River confluence at Yuma was prepared by the ASLD. The information presented in this report is intended to provide data and evidence to the Arizona Navigable Stream Adjudication Commission (ANSAC) which will make a determination as to the navigability or non-navigability for the Gila and San Francisco Rivers. This report does not make a recommendation or conclusion regarding title navigability of the Upper Gila and San Francisco Rivers.

The report consists of several related sections. First, an archaeological overview of the Upper Gila and San Francisco Rivers relating to river uses is presented to set the long-term context of river conditions. Second, a historical study of the periods prior to and including statehood are discussed with respect to river uses, modes of transportation, and river conditions. Third, the historical geomorphology and hydrology of the Upper Gila and San Francisco Rivers are summarized to illustrate past and potential flow conditions in the river. Fourth, information on federal boating criteria and the types of boating which have occurred historically on the Upper Gila and San Francisco Rivers is provided. Finally, historical and current land use information is described and presented in a GIS format.

The Upper Gila and San Francisco Rivers Navigability Study was originally performed by a project team consisting of George V. Sabol Consulting Engineers, Inc. (GVSCE), JE Fuller/ Hydrology & Geomorphology, Inc. (JEF), and SWCA, Inc., Environmental Consultants (SWCA). This original study was completed on behalf of the ASLD (Contract #A5-0092) as directed by Arizona Revised Statutes '37-1124. Project staff included V. Ottozawa-Chatupron, ASLD, Project Manager; P. Deschamps, GVSCE, Project Co-Manager; J. Fuller, JEF, Project Co-Manager; R. Borkan, SWCA, team leader; D. Gilpin, SWCA, historian; D. Greenwald, SWCA, archaeologist; M. Cederholm, SWCA, GIS specialist. The original study was revised in 2003 by JEF under ASLD contract #AD000150-010 to reflect changes in Arizona navigability legislation.

Executive Summary

George V. Sabol Consulting Engineers (GVSCE), in cooperation with JEFuller/ Hydrology & Geomorphology, Inc. (JEF), SWCA Environmental Consultants, Inc. (SWCA), was retained in 1996 by the Arizona State Land Department (ASLD) to provide information to the Arizona Stream Navigability Adjudication Commission (ANSAC). The 1996 GVSCE report was revised in 2003 by JEF to reflect changes in Arizona navigability legislation. ANSAC will use information provided by the project team to make a determination of navigability or non-navigability for the Upper Gila and San Francisco Rivers. This report provides information on the Upper Gila River between Safford and the Arizona/New Mexico border, and the San Francisco River from its confluence with the Gila River to the Arizona/New Mexico border.

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

- Historical Uses of the River. Data describing actual uses of the river as of 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 as of 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 Gila and San Francisco Rivers. For the latter task, public officials from communities located within the study reach were contacted. The objective of the literature search was to obtain published and unpublished documentation of historical river uses and river conditions. Information collected from agency contacts was supplemented by published information from public and private collections.

The literature search focused on five subject areas: (1) Archaeology, (2) History, (3) Hydrology, (4) Hydraulics, and (5) Geomorphology. Archaeological data augment the historical record of potential river uses at statehood by providing an extended record of river conditions, use of river water, climatic variability, and cultural history along the rivers. Historical data provide information on actual river uses as of the time of statehood, but also provide anecdotal 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 records of natural stream conditions at statehood, and records of 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. Another element of the study was collection of land use information. Land use data were compiled for the Gila and San Francisco Rivers and were entered in a GIS database. Land use data included existing title records from county assessor's offices, FEMA floodplain delineations, and state and federal land leasing records from ASLD. The land use GIS was not updated in the 2003 revision of the original GVSCE report.

The data collected was organized into six main subject areas: archaeology, history, geology, hydrology, and land use. Archaeological studies of the Upper Gila and San Francisco Rivers in Arizona have been fairly limited, although it is known that the Gila River played a major role in the human settlement patterns and occupational success of prehistoric development within the study area. The rivers provided a permanent water source, fish that were used as a protein source, and a riparian corridor that was rich in building materials, wildlife and vegetation. Therefore, most prehistoric habitations in the study area were close to the rivers. Although archaeologists have documented some 11,000 years of human use in southeastern Arizona, most of the archaeological sites in the study area date to the period from about 50 BC to AD 1200 when farmers of the Mogollon archaeological culture lived in the area. The Mogollon farmers lived in farmsteads and hamlets of as many as 20 rooms scattered along the Gila River and in the vicinity of Clifton, on the San Francisco River. In addition to the riverside farming communities, campsites and specialized activity sites have been identified throughout the uplands adjacent to the rivers. In the early historic period (circa AD 1540-1870) the area was occupied by the Yavapai and Apache, who lived primarily by hunting wild animals and gathering wild plants. Their sites consist primarily of rock overhangs, agave-roasting features, and campsites.

Except for the lower portion of the Upper Gila River near Safford, there is no evidence of extensive prehistoric irrigation agriculture on the Upper Gila and San Francisco Rivers, as was documented for the Lower Gila River in a companion report, probably due to the lack of a wide floodplain and arable land area along the rivers. Given that the water supply in the Upper Gila and San Francisco River study area was sufficient to support an extensive canal system and agricultural economy near, and downstream of, Safford, lack of water probably cannot explain the lack of archaeological evidence of prehistoric irrigation agriculture. Archaeological reconstructions suggest that streamflow rates changed little from the AD 740-1370 period to the AD 1800-1979 period. Archaeological research has not documented any use of the river for commercial trade and travel or any regular flotation of logs.

Historical records of the Upper Gila and San Francisco Rivers extend back to the Spanish explorations of the Southwest during the 1500's. The Spanish are thought to have named the Gila River the "Rio de Los Balsas" (River of Rafts), either because their army was forced to cross the river in rafts, or because of the Indians' use of wicker baskets to cross the river. By the 1820's, Mexico had won its independence from Spain, and American fur trappers such as James Ohio Pattie, Ewing Young, and Kit Carson explored the Upper Gila and San Francisco Rivers, trapping beaver along the rivers, and establishing a travel route into Arizona. These early trappers traveled primarily on horseback or on foot in the study area, although their records indicate that they built and used canoes and rafts when they reached the Colorado River downstream of the study area. The American military expedition of Stephen Watts Kearny and William Emory in 1846, and Bartlett's boundary survey of 1850-1853 of the Gadsden Purchase, included explorations of the Upper Gila and San Francisco Rivers. Later expeditions through Arizona abandoned the Gila River route of the trappers and the military for Cooke's less difficult route located to the south of the study area.

Discovery of copper deposits by Cavalry troops along the San Francisco River during the Apache wars of the 1870's led to establishment of the Clifton-Morenci mining district. With the Apache threat subdued, and the economic incentive for development provided by copper mining, Euro-American settlement of the Upper Gila River occurred, and with it development of farms and ranches to supply the mines, roads and railroads, and a number of small towns. A Bureau of Census map from 1901 shows most of the Gila Valley was irrigated above the confluence with the San Francisco River, but only a small portion of the San Francisco River near Potter's Ranch above Clifton was irrigated. By 1922, there were about 54 miles of main irrigation canals watering about 4,500 acres of farmland along the Upper Gila River.

Although there is some historical evidence that small boats were used on both the Upper Gila and San Francisco Rivers, transportation in the region was typically by horse, mule, wagon, stagecoach, or rail. A railroad spur was constructed to Clifton by 1883 to transport copper ore, which had previously been shipped by oxen and mule teams. A cattle trail from New Mexico followed the channel of the San Francisco River to the Gila River, and then downstream along the Gila River to other parts of Arizona. This trail remained a popular jeep and four-wheel drive route during low flow months, until the route was recently closed by the U.S. Forest Service to protect the habitat of the endangered Loach Minnow.

During the period around statehood, river crossings near Clifton were accomplished by means of swinging bridges (foot bridges) or railroad. Horses, wagons and others had to ford the river.

Several episodes of boating the Upper Gila and San Francisco Rivers were documented during the historical period, in additional to the possible Indian boating noted by the Spanish explorers. The Chiricahua Apaches of the region were known to construct boats made of bull hides stretched over wooden frames for crossing streams, although no instances are specifically recorded for the Upper Gila and San Francisco Rivers. Several persons used canoes or unspecified small boats to float down the entire length of both rivers around the time of statehood. G.W. Evans and Amos Adams floated from Clifton to Riverside (near Florence) in January-February of 1895 in an unspecified type of small boat, and did not report any difficulties until well downstream of Safford. Stanley Sykes used a canoe to float the entire length of the Gila River in Arizona in 1909. Early residents of Clifton reported that building rafts for use on the San Francisco River was a popular pastime for children during the period immediately following Arizona statehood. During recent years, recreational boating has become a popular pastime on both the Upper Gila and San Francisco Rivers, especially during the winter and late spring. No evidence of boating in the upstream direction, sustained commercial boating operations, ferries, or use of keel boats or other powered boats was identified.

Early descriptions of the Upper Gila and San Francisco Rivers do not differ significantly from contemporary descriptions of the rivers. Bartlett (1854) believed that Gila River was not navigable, except during irregular floods. During these "floods" Bartlett felt that flat bottom boats could pass to the Salt River confluence near Phoenix. Whipple (part of the Bartlett survey) felt that the Gila River was an impracticable route for a wagon or railroad route due to its narrow canyons in some reaches. The San Francisco River was described as usually "relatively shallow" flowing over a wide expanse of white sand and reeds. It has steep-walled canyons with a relatively flat floodplain averaging 300-600 feet wide. The permanent stream width was generally less than 30 feet, which meanders across the floodplain. The low flow channel position changes during each flood, creating cut banks and leaving gravel bars. Floods fill the canyon from wall to wall. The Upper Gila was described as a perennial stream, often narrow and shallow enough to travel down the riverbed, except in the impassable (to land vehicles) canyons. The river corridor supported a variety of species including beaver, quail, geese, ducks, deer, wolves, coyotes, and fish.

The study area was sparsely populated throughout the historical period, much as it is today. Clifton, at its peak of mining activity in 1910, had a population of about 5,000 (1993 pop. = 3,000). Several small farming and ranching communities grew up along the Upper Gila River to serve the mining community at Clifton. Much of the study is now located within the Apache-Sitgreaves National Forest or is managed by the Bureau of Land Management. Historical uses of the Upper Gila and San Francisco Rivers included limited agriculture supported by irrigation diversions from the rivers, municipal and industrial consumptive uses, recreation, and hunting, gathering, and fishing by Indians prior to the Apache wars.

The geomorphology of the Upper Gila and San Francisco Rivers is substantially unchanged from its condition at or before statehood in most of the study area upstream of the Safford Valley. Most of the Upper Gila and San Francisco Rivers are formed within bedrock canyons. Bedrock along the channel margins in these canyons precludes significant movement of the river channel or other channel changes. In addition, the bedrock geology of the Upper Gila and San Francisco Rivers area made access to the river difficult during the period around statehood, prevented development of extensive irrigation systems, and prevented the development of large population centers near the river. The reach of the Gila River located downstream of the Gila Box widened significantly around the time of statehood in response to large floods, and changed from a narrower, tree-lined river to a wide braided floodplain. Ordinary high and low watermarks may be defined based on existing topographic, vegetative, and soil characteristics.

The Upper Gila and San Francisco Rivers are perennial streams which, except for numerous irrigation diversions, have remained free-flowing since they were first settled in the 1870's. Flow rates within the study reaches probably have not changed significantly since the time of statehood. River flows have been reliable enough over the past 120 years to support irrigation-based agriculture in the Duncan Valley at the upstream end of the Upper Gila River reach, as well as a more extensive irrigation-based farm economy in the Safford Valley downstream of the study area.

As early as 1899, there were 45 diversions in the Duncan and Safford Valleys. The combined capacity of the early diversion canals and ditches was enough to divert all the flow from the Gila River during the peak irrigation season in reaches with irrigated agriculture. Available diversion data for the San Francisco River are sparse; however, even small diversions from the San Francisco River could have had a measurable impact, given the typical low average flow rates during seasons when high irrigation demand coincides with seasonal low flow. Under natural conditions, the Upper Gila River would rarely have had no-flow days, but could have experienced annual periods of low flow during June and July.

Streamflow data gathered for the Upper Gila and San Francisco River study indicate the following:

- The Upper Gila River is a naturally perennial stream. The average annual discharge for the Upper Gila River varies from about 200 cfs to 430 cfs in the study reach. The minimum monthly average flow ranges from about 15 cfs to 100 cfs within the study reach, and typically occurs during the month of June.

- The San Francisco River is a naturally perennial stream. The average annual discharge for the San Francisco River varies from about 90 cfs to 215 cfs. The minimum monthly average flow ranges from about 13 cfs to 53 cfs, and typically occurs in the month of June.

- The long-term flow record demonstrates that the Upper Gila River and the San Francisco Rivers are susceptible to wide seasonal and annual variations in discharge rates.

The average annual discharge rates are only equaled or exceeded 20% of the time on the Upper Gila and the San Francisco Rivers. Therefore, the average annual discharge rate may not be as representative of "typical" flow conditions as the median (50%) flow rate or the 90% flow rate, which may give a better indication of their susceptibility to navigation. Long-term median flow rates for the Upper Gila River vary from about 66 cfs to 174 cfs between the Arizona/ New Mexico border and Safford. The long-term median flow rate for the San Francisco River varies from about 32 cfs to 76 cfs between the Arizona/ New Mexico border and the Gila River confluence. Flow depths and widths for the Upper Gila and San Francisco Rivers are shown in Table E-1.

Table E-1 Upper Gila River and San Francisco River Flow Characteristics				
Frequency	**Discharge (cfs)**	**Hydraulic Depth (ft)**	**Average Velocity (ft/sec)**	**Top Width (ft)**
Gila River Near Virden, NM - Upstream End of Study Reach (Duncan Valley)				
90 % Flow	**21**	**0.6**	**1.3**	**27**
Median (50%) Flow	**91**	**0.9**	**2.2**	**45**
Mean Annual Flow	**190**	**1.2**	**1.6**	**100**
2-Year Flood	**4,980**	**5.5**	**8.5**	**107**
5-Year Flood	**10,400**	**7.5**	**12.6**	**110**
Gila River Near Clifton/Guthrie, AZ - Midpoint of Study Reach (Gila Box)				
90 % Flow	**18**	**0.7**	**1.0**	**26**
Median (50%) Flow	**80**	**1**	**1.7**	**47**
Mean Annual Flow	**206**	**1.3**	**2.5**	**64**
2-Year Flood	**5,940**	**3.7**	**11.5**	**140**
5-Year Flood	**11,500**	**5.5**	**14**	**150**
Gila River at Safford Valley, Near Solomon, AZ - Downstream End of Study Reach (Safford Valley)				
90 % Flow	**62**	**0.8**	**0.5**	**144**
Median (50%) Flow	**174**	**1.3**	**0.9**	**146**
Mean Annual Flow	**433**	**1.9**	**1.5**	**150**
2-Year Flood	**9,400**	**6.7**	**8.8**	**160**
5-Year Flood	**22,900**	**11**	**11.6**	**180**
San Francisco River at Clifton - Entire Study Reach				
90 % Flow	**34**	**0.9**	**1.4**	**28**
Median (50%) Flow	**76**	**1.0**	**1.6**	**49**
Mean Annual Flow	**215**	**1.2**	**2.5**	**72**
2-Year Flood	**6,800**	**4.5**	**10.1**	**150**
5-Year Flood	**17,800**	**8.5**	**13.7**	**153**

According to various federal agency criteria for recreational use of water crafts, and according to long-term gauge records, which demonstrate highly variable flow rates on an annual basis, the Upper Gila River and the San Francisco River would have been susceptible to navigation by low-draft boats on an annual and seasonal basis, respectively. Nevertheless, canoes, small rafts, and kayaks could have navigated some portions of the Upper Gila River and the San Francisco River during the lowest flow months, as well as during flows up to and exceeding the 5-year recurrence interval. Neither the Upper Gila River, nor the San Francisco River would have been susceptible to reliable navigation by larger boats such as powered barges, steamboats, keel boats, etc., due to the occurrence of rapids, high velocities, low flow depths, long narrow canyons with no access to safe landings, natural and man-made obstructions such as riffles and irrigation diversion structures.

The Upper Gila and San Francisco Rivers were used for recreational boating as of the time of statehood. Historical hydrologic conditions in the Upper Gila and San Francisco Rivers probably would have met current federal criteria for some types of recreational boating, for most of the year. No evidence of boating in the upstream direction along the Upper Gila and San Francisco Rivers, or use of large machine-powered boats was found. No evidence of any commercial boating industries developed on the Upper Gila and San Francisco Rivers as of 1912 was uncovered. Both rivers are currently boated for recreational purposes, primarily during the winter and spring months, with limited commercial river running operations in the Gila Box Reach. Current river running guidebooks describe the Upper Gila and San Francisco Rivers as boatable at flow rates from 150 cfs (canoes and inflatables) to 10,000 cfs (large rafts).

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Section 1

UPPER GILA AND SAN FRANCISCO RIVERS FINAL REPORT

SECTION 1

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INTRODUCTION

George V. Sabol Consulting Engineers (GVSCE), in cooperation with JEFuller/ Hydrology & Geomorphology, Inc. (JEF), SWCA Environmental Consultants, Inc. (SWCA), was retained in 1996 by the Arizona State Land Department (ASLD) to provide information to the Arizona Stream Navigability Adjudication Commission (ANSAC). The 1996 GVSCE report was revised in 2003 by JEF to reflect changes in Arizona navigability legislation. ANSAC will use information provided by the project team to make a determination of navigability or non-navigability for the Upper Gila and San Francisco Rivers. This report provides information on the Upper Gila River between Safford and the Arizona/New Mexico border, and the San Francisco River from its confluence with the Gila River to the Arizona/New Mexico border.

This report provides information on the Upper Gila River between Safford and the Arizona/New Mexico border, and the San Francisco River from its confluence with the Gila River to the Arizona/New Mexico border. A companion report for the Lower Gila River was prepared by ASLD in 1993 and was also revised in 2003 by JEF. No recommendation or conclusion regarding title navigability of the Upper Gila or San Francisco Rivers is made in this report. The report consists of several related sections:

Section 1 - General information is provided by the study team regarding the project background, the definition of navigability, the study reach limits, the objectives of the project, and the method of approach;

Section 2 - An archaeological overview of the Upper Gila River valley prepared by SWCA relates to river uses and sets the long-term context of river conditions;

Section 3 - A historical review by SWCA addresses the periods prior to and including statehood with respect to river uses, modes of transportation, and river conditions;

Section 4 - The historical geomorphology of the Upper Gila River evaluated by JEF estimates river conditions and changes since statehood;

Section 5 - The hydrology of the Upper Gila River evaluated by JEF estimates flow rates and conditions at statehood and for existing conditions;

Section 6 - A review of information on boating criteria and use of the river for various types of boating was summarized by JEF;

Section 7 - Historical and current land use information compiled by SWCA is described and presented in a GIS format;

Section 8 - The results of the Upper Gila River study most pertinent to the legislatively mandated criteria of navigability or non-navigability are summarized.

A list of references cited, as well as an extended bibliography where appropriate, is included in each section. Appendices contain supporting documentation and the GIS work products. A glossary of terms and a list of acronyms used in the report are provided.

Project Background

Public Trust principles date back to English Common Law when the King held the beds of rivers affected by tides in Trust for the general public and for the public good. This provision was founded on the principle that there is a public need to use the waterways for commerce. When the United States gained independence from the British Crown, Public Trust principles were recognized so that the lands beneath navigable waters within the original thirteen states became the sovereign property of those states. The Equal Footing Doctrine provided that future states were entitled to sovereign ownership of riverbeds located within those new states on an 'equal footing' with the original thirteen states.

At the time of statehood on February 14, 1912, the State of Arizona received sovereign title to the beds of navigable rivers located within state boundaries. Under the Equal Footing Doctrine, the United States government previously held these lands in Trust pending the creation and admission of the State of Arizona to the Union. Although the State owned the land, in order to perfect title to the navigable streambeds, the State was required to make its claim of ownership. From statehood until the mid-1980's, Arizona claimed only the bed of the east half of the Colorado River. The State failed to act on all other claims of streambed ownership and other parties asserted title to certain streambeds lands. In assuming ownership of lands located in or near these streambeds, many of the current record title holders constructed projects and improvements to the land, paid property taxes, and altered the stream ecosystems and riparian habitat.

During recent years, the State, as well as a number of private and public entities, asserted claims of ownership of streambeds throughout Arizona. These claims turned on whether or not the streams were navigable or susceptible to being navigable at the time of statehood. The titles held by land owners whose property includes all or a portion of the streambed of potentially navigable streams are clouded. As a result of litigation addressing in-stream sand and gravel mining activities in the Verde River, the Arizona Legislature recognized the economic hardships created by the uncertainty of the State's potential future claims on streambed lands. In 1987, House Bill (HB) 2017 was passed outlining a procedure to quit claim any interest of the State in the beds of the Salt, Gila, and Verde Rivers for a nominal fee, reaffirming the State's claim to the Colorado River, and waiving any claim to all of the other streambeds in the State. A lawsuit challenging the constitutionality of HB 2017 was successful in 1991 and the Court found that one flaw in the bill was that it did not provide for an evaluation of the validity and value of the State's Public Trust interest on the individual watercourses.

In 1992, the Governor signed HB 2594 which repealed HB 2017 and established a systematic administrative procedure for gathering information and determining the extent of the State's ownership of streambeds. The main purpose of the legislation was to confirm State ownership in Public Trust lands located in the beds of streams determined to have been navigable at statehood. 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, hold public hearings, and make determinations of navigability or non-navigability for specific watercourses. The legislation also directed the Arizona State Land Department (ASLD) to facilitate determination of navigability and to act as support staff for the ANSAC.

In early 1994, HB 2589, amending Arizona Revised Statutes (A.R.S.) '37-1101 through 37-1156, was adopted. HB 2589 set the criteria to be used for determination of navigability and non-navigability and established an ombudsman office to represent the interests of private property owners in proceedings involving governmental action. HB 2589 required ANSAC to set priorities for investigating and conducting hearings on watercourses within this state, and then to report its recommendation as to which watercourses or reaches of watercourses were navigable or non-navigable as of the time of statehood to the Legislature which would enacts legislation in response to the determination. The original GVSCE report for the Upper Gila and San Francisco Rivers was prepared under HB 2589 criteria.

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 considered, and restored the applicable burden of proof in line with the so-called federal test of navigability. The 2003 revision of the original GVSCE report was prepared to reflect changes in the navigability statutes made under SB 1275.

Definition of Navigability

A.R.S. §37-1101 (6) sets out the definition of "navigable" or "navigable watercourse" to be used to address the ownership of streambeds. That definition is:

> *"Navigable" or "navigable watercourse" means a watercourse, or a portion or reach of a watercourse, that was in existence on February 14, 1912, and at that time 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.*

The data collection effort for this study provides information that will assist ANSAC in determining if a given river meets the criteria of the statutory definition of navigability.

Project Limits

The project team collected data and information relevant to the navigability or non-navigability of the Upper Gila River from Safford to the Arizona/New Mexico border, and the San Francisco River from its confluence with the Gila River to the Arizona/New Mexico border, as shown in Figure 1.

Study Reach Lengths

The lengths of the study reaches were estimated using data reduced from the Arizona Land Information System (ALRIS) GIS database. Those data were converted to an AutoCAD drawing file and the lengths of the subreaches determined using that software program. The resulting total lengths of the study reaches are shown in Table 1.

Table 1. Study Reach Lengths

River Study Reach	Length (miles)	Length (kilometers)
Upper Gila River	**73**	**118**
San Francisco River	**45**	**72**

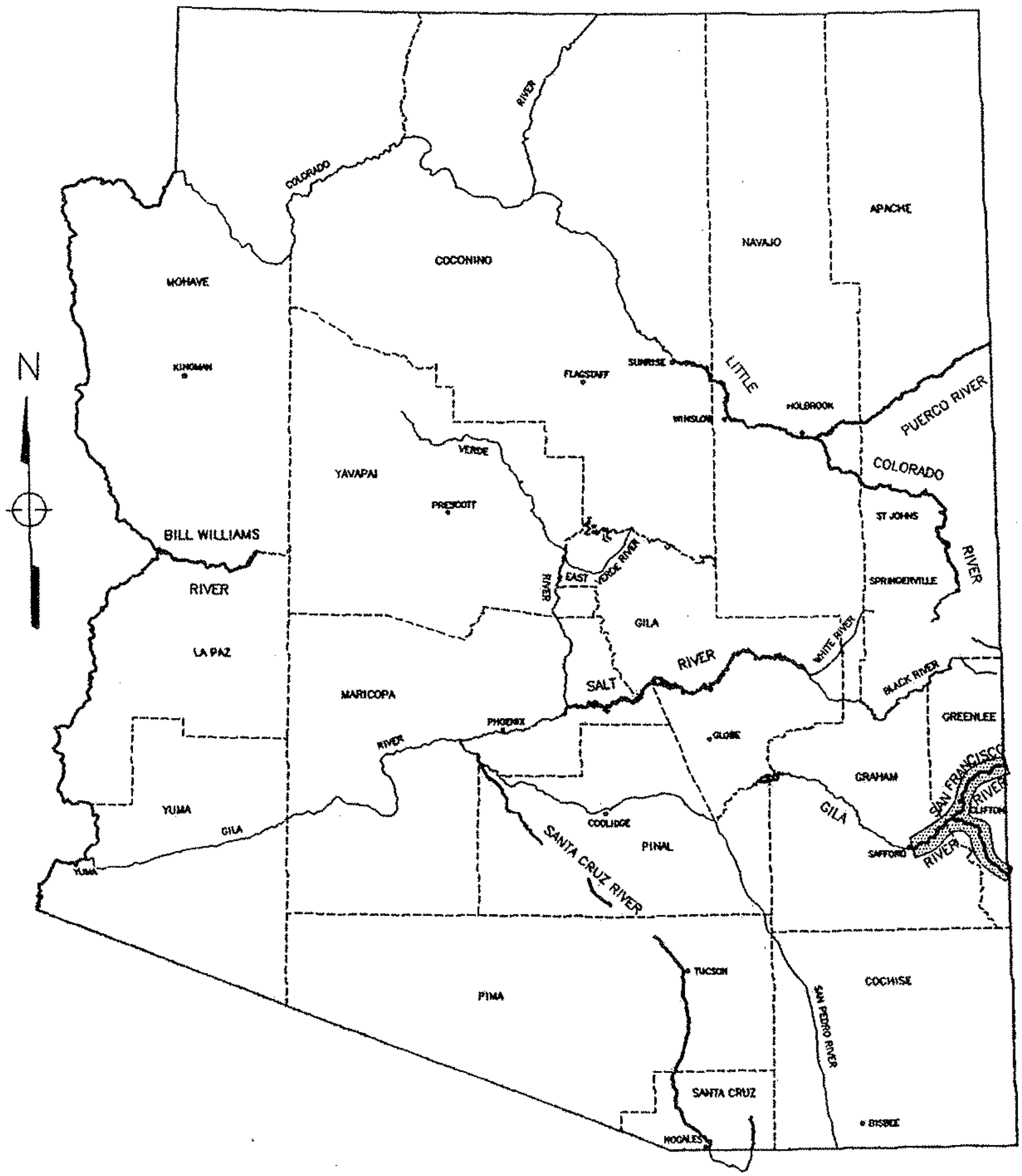

FIGURE 1

General Location Map for Arizona Stream Navigability Studies

Lateral Study Limits

The maximum lateral extent of the study limits for each study reach is the 100-year floodplain boundary. The identification of the lateral limits of the study reaches was conducted in two steps. First, a set of key maps was developed for all study reaches indicating sources of floodplain maps, topographic information, aerial coverage, and other pertinent information. The primary source of floodplain boundary delineations was the Federal Emergency Management Agency (FEMA) Flood Insurance Rate Maps (FIRM). Then, a GIS map layer was developed for each study reach showing the 100-year floodplain to establish the maximum lateral extent of the study limits for the purpose of information and data collection in subsequent work tasks. For those subreaches mapped by FEMA, the 100-year floodplain boundary was digitized in GIS format directly from the FIRM maps. No FEMA maps are available for those portions of the study reaches which are on Federally-owned or Indian reservation lands; therefore, no floodplain boundary delineations were generated or mapped for those subreaches due to budget limitations. The GIS for the Upper Gila and San Francisco Rivers was not updated as part of the 2003 revisions to this report.

Study Objectives

The primary objective of this project is to provide information concerning the factors addressing navigability set forth in A.R.S. §37-1101 *et seq.* to assist in the determination of navigability or susceptibility to being navigable as of statehood. Specific technical goals include the following:

- Perform a literature search to identify and catalog existing historical, archaeological, hydrologic, hydraulic, geomorphic, and land use information.
- Review existing historical, archaeological, and land use information to identify and evaluate evidence of navigable uses of the study areas.
- Review existing hydrologic, hydraulic, and geomorphic materials to identify and evaluate discharge characteristics of the study reaches.

- Identify title owners, lease holders, improvements, and current uses of land located in or near the study reaches using existing information.

- Prepare reports, maps, and other information describing the results of the archaeological, historical, hydrologic, hydraulic, geomorphic, and land use investigations.

- Participate at public hearings and other public forums, as required.

In addition to the goals stated above, other identified goals that are important to the success of the streambed program include the following:

- Establish a cost-effective, streamlined procedure for data collection which can be used for future analyses of other Arizona streams.

- Implement quality control procedures.

- Develop data to a level sufficient to support legal surveys of the boundaries of navigable streams.

PROJECT METHODOLOGY

The basic approach to the stream navigability studies is to develop a database of information to be used by ANSAC in making navigability determinations. To that end, the scope of services for this study includes five main tasks:

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

Because the legislative definition of a navigable watercourse includes both actual navigation and susceptibility to navigation, the data collection effort was focused on two areas:

Historical Uses of the River - Data describing actual uses of the river as of the time of statehood were collected. Specific tasks included agency contact and literature search.

Potential Uses of the River - Data describing river conditions as of the time of statehood were collected. Specific tasks included agency contact, literature search, and hydrologic, hydraulic and geomorphologic assessments.

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 in regard to the five study reaches. For the latter task, public officials from communities, towns, cities, and counties located along the Upper Gila and San Francisco Rivers study area 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. Community officials were 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 or telephone.

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 from clubs, professional organizations, special interest groups, and environmental groups. In most cases, contacts led to other persons thought to have information pertinent to the study.

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 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, professional 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 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 paleo-environment 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 each stream reach were also collected from city, county, state, and federal agencies. Published journal articles, books, and reports available from public library collections were also consulted. Bibliographies of documents and resources for each area of expertise are included in the corresponding report sections.

Data Summaries

Data collected from the agency contact and literature search tasks was organized and synthesized by these subject areas: archaeology, history, 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, paleo-environment, the culture history, settlement patterns, and evidence relevant to navigability of the river is presented in Section 2.

History

Historical data provide information on actual river uses as of the time of statehood, and also provide information on whether river conditions would have supported 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 historical overview is presented in Section 3.

Hydrology/Hydraulics

Hydrologic/hydraulic information is a key 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 available records. JEF evaluated information collected during the 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 conditions at statehood, as well as for existing stream conditions. Depth, velocity, and topwidth rating curves for existing and (circa) statehood channel conditions were developed from historical gauging records. Estimates of 2-year, 5-year, and average annual flow rates were obtained from gauge data or other sources. Flow duration curves and average monthly flow rates were also summarized.

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 Upper Gila and San Francisco Rivers was prepared by JEF. 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 as of the time of statehood, assess the possibility of and mechanism for historical channel movement from its current position, provide evidence of geologic control of flow rates, and to estimate the location of the ordinary high and low watermarks. The hydrologic, hydraulic, and geomorphologic summaries are presented in Section 5.

Land Use

Land use data were compiled for the Upper Gila San Francisco Rivers and entered in a GIS database. Land use data included existing title owner records from county assessor's offices, state and federal land leasing records from ASLD, the Bureau of Land Management, and the U.S. 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 Upper Gila San Francisco Rivers, such as floodplain limits, were also entered in the GIS. The land use data summary description is presented in Section 7; the GIS work product was provided separately.

SUMMARY

A comprehensive summary is presented in Section 8 of this report which itemizes the key findings of the preceding archaeological, historical, hydrologic, hydraulic, geomorphologic and land use sections. The most pertinent findings relative to evidence of navigability or non-navigability, or evidence of susceptibility to navigation, are summarized to provide information to support a determination by others of navigability or non-navigability for each study reach. This report does not make a recommendation or conclusion regarding title navigability of the Upper Gila and San Francisco Rivers.

Arizona Stream Navigability Study
for the
Upper Gila River
Safford to the State Boundary
and
San Francisco River
Gila River Confluence to the State Boundary

Draft Final Report

Prepared for the

Arizona State Land Department

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Section 2

ARCHAEOLOGICAL OVERVIEW OF THE UPPER GILA AND SAN FRANCISCO RIVER VALLEYS, ARIZONA

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INTRODUCTION

Only a limited amount of archaeology has been done on the upper Gila and San Francisco rivers in Arizona. No Paleoindian or Archaic sites have been recorded in this area, although they are known elsewhere in the general vicinity. Formative period villages along the Gila River are assigned to the Mogollon archaeological culture but are located on a boundary between several archaeologically defined subunits. Although evidence of prehistoric irrigation may be present in the Safford Valley to the west, no evidence of prehistoric agriculture has been reported on the upper Gila or the San Francisco rivers above their confluence. Archaeologists have provided only a limited amount of description of the physical environment of the study area, although environmental reconstructions of prehistoric streamflow of the Salt River using tree-ring data are apparently applicable to the Gila River as well.

ARCHAEOLOGICAL PROJECTS

The major archaeological projects that have been conducted along the upper Gila and San Francisco rivers in Arizona are summarized in Table 1. Their locations are shown in Figure 1.

Descriptions of the archaeology of the upper Gila River valley began in 1846 when General Stephen Watts Kearny and the Army of the West traveled down the river. Lieutenant William Emory of the Corps of Topographical Engineers reported seeing the first Gila River valley ruins on October 23, while still in New Mexico (Emory 1951:105). On October 24 Emory observed additional ruins, the largest of which measured 60 x 20 feet (Emory 1951:107). On October 25 Emory observed two more ruins, the largest of which measured 40 x 30 feet (Emory 1951:107). "About none did we find any vestiges of the mechanical arts, except the potter; the stone forming the supposed foundation was round and unhewn, and some cedar logs were also found about the houses, much decayed, bearing no mark of an edged tool" (Emory 1951:107). Dr. John Griffin, the expedition's surgeon, and Captain Abraham R. Johnston also kept journals and mentioned seeing the ruins (Griffin 1943:26; Johnston 1848). Johnston, especially, took great interest in the prehistoric ruins the group encountered and made sketch maps of several of them, recording dimensions of the ruins and drawing

Table 1. Major Archaeological Projects along the Upper Gila and San Francisco Rivers

Sponsor	Type of Project	Area Extent	No. of Sites	Reference
Archaeological Institute of America	Reconnaissance	Southwest U.S. and Mexico	?	Bandelier 1884, 1892
Bureau of American Ethnology	Reconnaissance	Safford Valley	15+	Fewkes 1904
Smithsonian Institution	Reconnaissance	Gila River and its tributaries	7 on S. F. River	Hough 1907
Bureau of American Ethnology	Reconnaissance	Gila River and its tributaries	?	Fewkes 1910
Gila Pueblo	Reconnaissance	?	?	Gladwin and Gladwin 1935
University of California	Reconnaissance	Southeast Arizona	?	Sauer and Brand 1930
Peabody Museum, Harvard	Reconnaissance	Western New Mexico, eastern Arizona	638	Danson 1957
National Park Service	Survey	Gila River channel between Safford and Buttes Dam Site (approximately 110 miles)	39+	Tuohy 1960
National Park Service	Excavation	San Carlos Indian Reservation	2	Johnson and Wasley 1966
National Park Service	Excavation	Buttes Dam Site	1	Wasley and Benham 1968
Tucson Gas and Electric Company	San Juan to Vail Transmission Line Survey	approximately 120 miles long	3	Doyel 1972
Tucson Gas and Electric Company	Transmission Line Survey	San Juan to Clifton	9	Kane and Fuller 1972a
Tucson Gas and Electric Company	Transmission Line Survey	3 miles along San Francisco River at Arizona-New Mexico border	3	Fuller 1972
University of Arizona	Survey and excavation	Pueblo Viejo area, Safford Valley	?	Brown 1973
Public Service Company of New Mexico	Transmission Line Survey	Deming, New Mexico, to Greenlee County, Arizona	2	Bussey and Beckett 1975
Graham-Curtis Canal Company	Survey	North side of Gila River between Bryce and Cold Springs	4	Gilman and Sherman 1975
Coronado Resource Conservation and Development Project	Survey	Foote Wash and No Name Wash	21	Kinkade 1975
Continental Oil Company	Survey	7860 acres	9	Doelle 1975
Bureau of Reclamation	Buttes Reservoir Survey	approximately 9700 acres	272	Debowski et al. 1976
Public Service Company of New Mexico	Power Transmission Line Survey	?	1	Gomolak 1977
Public Service Company of New Mexico	Excavation	Duncan area	2	Beckett 1978; Berman 1978
Arizona Electric Power Cooperative	Survey	Approximately 123 km	89	Simpson and Westfall 1978
Arizona Electric Power Cooperative	Excavation	Excavation	11	Westfall, Rozen, and Davidson 1979
Bureau of Land Management	Survey	4000 acres	25	Roberts, Ahlstrom, and Doak 1995
University of Texas, Austin	Excavation	Excavation	1	Woodson 1995

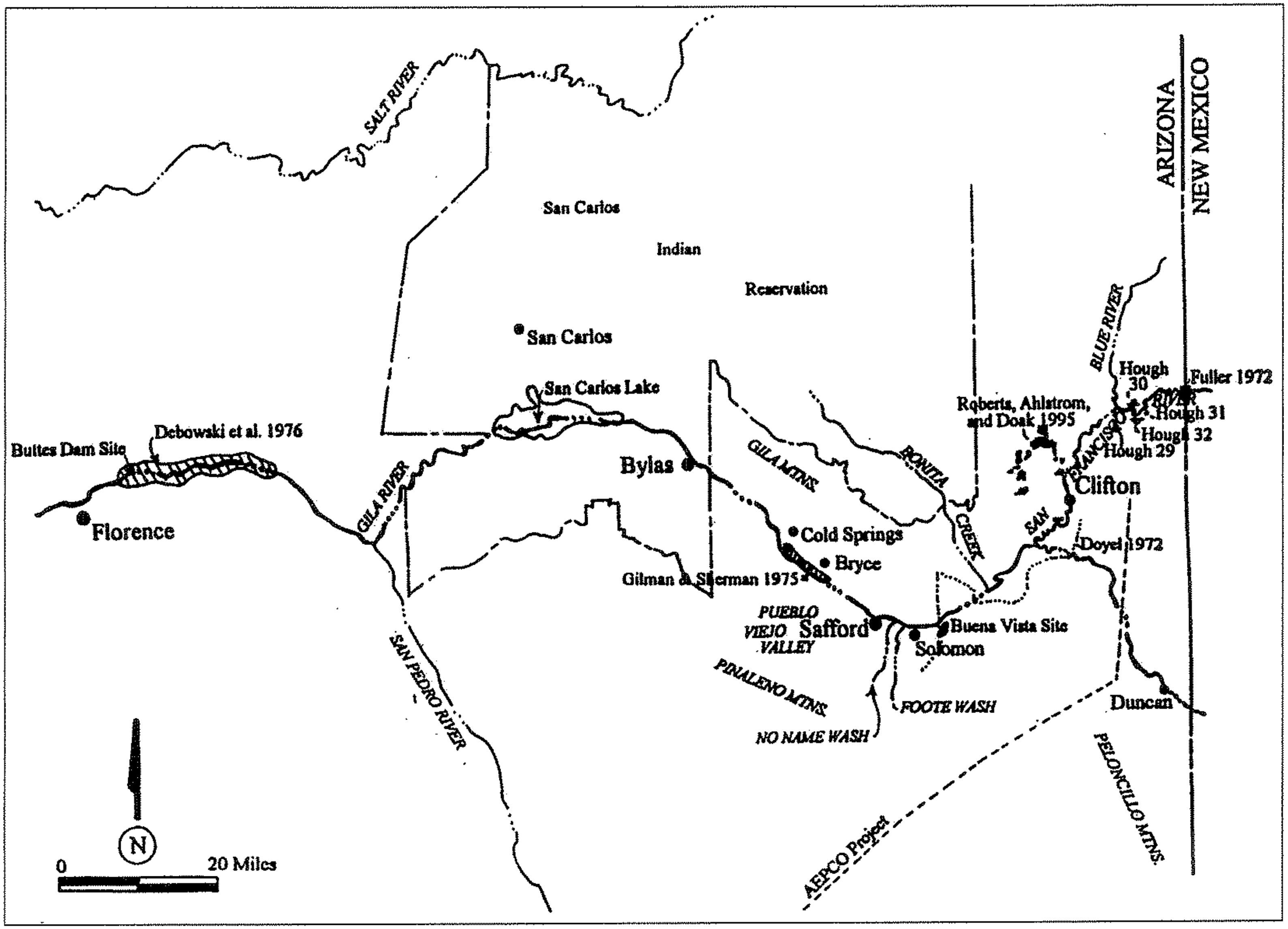

FIGURE 1
Locations of major archaeological projects and sites along Upper Gila and San Francisco Rivers in Arizona

the potsherds. In the Safford Valley, below the mouth of the San Francisco River, Emory observed the Buena Vista site.

Professional archaeology along the upper Gila River began in the 1880s, when the Archaeological Institute of America sent Adolph Bandelier to the Southwest with specific instructions for analyzing prehistoric and historic Pueblo Indian architecture (Lange, Riley, and Lange 1984:19-32). Bandelier's instructions were formulated by Lewis Henry Morgan, author of *Houses and House Life of the American Aborigines* (Morgan 1881) and were intended to provide data demonstrating the similarity between the architecture of prehistoric ruins and that of modern pueblos. In 1883 Bandelier passed through Fort Apache, San Carlos, and Fort Thomas, traveling up the Gila River as far as Solomonville (Lange and Riley 1970:97-98). Although he heard of cliff dwellings in the vicinity of Clifton, he never visited them (Lange and Riley 1970:97-98). In 1884 Bandelier visited and recorded the Gila Cliff Dwellings in New Mexico, then went on to Tucson via Silver City and Deming, New Mexico. Thus, Bandelier only generally described the location and architecture of sites along the Gila and San Francisco rivers in the vicinity of the study area (Bandelier 1892:359-362; Kidder 1924).

In 1897 Smithsonian archaeologists Jesse Walter Fewkes and Walter Hough visited the Buena Vista and Solomonville sites in the Safford region, noting that agriculture had almost destroyed the site of Solomonville (Fewkes 1904). Fewkes was attempting to find archaeological sites that corresponded to the places mentioned in Hopi migration stories. He identified evidence of prehistoric irrigation agriculture and remarked on the environmental changes that had occurred since the Kearny expedition passed through the area in 1846. Fewkes also mentioned that cliff dwellings were present along Bonita Creek, which enters the Gila below the mouth of the San Francisco. In 1909, Fewkes (1910) surveyed the Gila River valley as far west as Florence.

Hough (1907, 1914, 1917, 1918, 1919, 1923) conducted the first archaeological research on the San Francisco River, where he recorded seven sites above Clifton. Site 26 was a ruin and rock art site on the bluff above the Clifton hospital (Hough 1907:44). Site 27 consisted of low mounds of rubble opposite the Potter Ranch, 2.5 miles north of Clifton (Hough 1907:44). Site 28 was not described. Site 29, at the mouth of the Blue River, consisted of 20 rooms in two structures with a plaza between them (Hough 1907:44). Site 30, 1.5 miles above the mouth of the Blue River, was a walled-up cave; an adjacent recess contained a milling room (Hough 1907:45). On a terrace half a mile east of Site 30, Hough found the ruins of a polygonal stone pueblo (Site 31) consisting of several room blocks fronted by a 100-foot plaza (Hough 1907:45-46). Nearby, on the south bank of the San Francisco, the uppermost of two caves (Site 32) contained bows, arrows, and other ritual paraphernalia (Hough 1907:47). Although Hough was a protégé of Fewkes, he focused less on finding archaeological evidence of Hopi migration stories, concentrating instead on recording evidence of prehistoric lifeways and technology as well as the range of variability in archaeological sites in different areas of the Southwest. Near Luna, New Mexico, in the upper San Francisco River valley, Hough discovered a village of approximately 100 pit houses, circular structures 4 m in diameter and 1.5 m deep that had originally been roofed with conical structures of logs and earth (Hough 1919). These pit houses were associated with neck-banded utility pottery and black-on-white pottery decorated with designs similar to "pre-Pueblo" (Kidder's [1924:288] term) black-on-white pottery from the San Juan River drainage in northern Arizona and New Mexico. In the Los Lentes Valley, Hough (1907:63, Figure 28; 1919:409) excavated a rectangular pueblo and found similar pit houses beneath it. Hough was thus the first researcher in the area to document how changes had occurred prehistorically in pottery and house types of the region. In so doing, Hough was reflecting new archaeological concerns with reconstructing prehistoric chronologies and classifying variability in archaeological remains such as pottery, house types, and site types.

The leader of the archaeological movement to reconstruct chronologies and classify variability was Alfred V. Kidder. In 1924 Kidder summarized the archaeology of the upper Gila, based primarily on Hough's work and on his own brief conversations with local ranchers (Kidder 1924:280-288). Kidder (1924:Figure 24) contrasted the upper Gila archaeological district—all of the San Francisco River, the upper Gila above its confluence with the San Francisco, and the Black River above its junction with Fremont Creek—with the Mimbres archaeological district, which encompassed only the Mimbres River drainage basin. The pottery of the upper Gila district (including utility ware with thinly corrugated exteriors and smoke-blackened [smudged] interiors, a black-on-white painted pottery with interlocking designs of opposed solid and hachured elements, and, rarely, redware), referred to by Kidder as the Tularosa style, was its most distinctive feature.

From the 1920s to the 1960s, archaeologists working throughout the Southwest modeled their work on Kidder's, emphasizing chronology and regional variability. In 1928 Gila Pueblo (a private archaeological research foundation in Globe, Arizona) began a survey of the range of Hohokam red-on-buff pottery (Gladwin and Gladwin 1935). In 1931 the Gila Pueblo researchers surveyed the San Francisco River, and in 1933 they excavated Site Mogollon 1:15, a pit house site on the middle San Francisco River near Alma, New Mexico (Haury 1936a, 1936b). The site consisted of 12 pit houses (eight rectangular and four circular) and numerous storage pits.

In 1 929 Sauer and Brand (1930) conducted a survey that covered the Gila River from approximately San Carlos to the Arizona/New Mexico border. Their goal was to locate the maximum number of archaeological sites in the time allotted and to collect a representative sample of artifacts. The number of sites located is not reported in the text. Tatman (Brown 1973) conducted brief excavations at the Buena Vista site, although they were never completed.

From 1939 to 1955, Paul Martin of the Field Museum of Natural History in Chicago directed a long-term archaeological research project in the Pine Lawn Valley of the San Francisco River near Reserve, New Mexico (Martin 1959). Martin excavated a series of sites ranging in date from Archaic times to about A.D. 1300. Although these sites are northeast of the Arizona reach of the San Francisco River, Martin's research confirmed Haury's belief that sites in the Mogollon highlands represented an archaeological culture distinct from the Hohokam of the Phoenix and Tucson basins and the Anasazi of the Colorado Plateau.

The Harvard Peabody Museum–Upper Gila Expedition conducted survey and excavation in the area during the late 1940s and early 1950s (Bullard 1962; Danson 1957; Danson and Brew 1948; McGimsey 1980; Smith 1973). From 1947 through 1949, the Upper Gila Expedition conducted reconnaissance of the area bounded by a line running from Springerville, Arizona, on the northwest to Magdalena, New Mexico, on the northeast to Silver City, New Mexico, on the southeast to Clifton, Arizona, on the southwest. Danson (1957:27-28, Figure 2) recorded two sites on the San Francisco River, just north of Clifton. Site 1 was a "small badly washed-out boulder pueblo" with an indeterminate number of rooms, which dated to the Mangas phase (A.D. 1000-1050). The Mangas Phase is no longer accepted by most archaeologists [LeBlanc 1986; LeBlanc and Whalen 1980], although Lekson [1990] still defends the concept.) Site 2, on a high bluff immediately above Site 1, had been previously recorded by Hough (1907:44) as Site 29. Dating to the late Mangas or early Mimbres Classic (A.D. 1050-1200) phase, it consisted of 20 rooms arranged in two blocks of rooms separated by a plaza and surrounded by a boulder wall. Danson (1957:28) also recorded a Reserve Phase (A.D. 1000-1100) masonry pueblo 25 miles northeast of Clifton on a ridge above Mule Creek, in New Mexico. This site, which contained Reserve Black-on-white and Tularosa Black-on-white ceramics, was constructed of masonry, not adobe (as was true of Mimbres pueblos).

Danson (1957:16-21) discussed the cultural history of the upper Gila and the San Francisco in terms of two regional sequences, for the Mimbres Region and the Pine Lawn Region. Danson (1957:16-18) included the Arizona portions of the San Francisco and the Gila in the Mimbres cultural province. Danson (1957:16-18) cited Haury (1936b) and Cosgrove and Cosgrove (1932) as defining five cultural-historical periods for the Mimbres Region: (1) the Georgetown phase (A.D. 500-700), (2) the San Lorenzo phase (A.D. 700-800), (3) the San Francisco phase (A.D. 800-900), (4) the Three Circle phase (A.D. 900-1000), and (5) the Mimbres phase (A.D. 1000-1250). The Pine Lawn Region included the upper San Francisco and the upper Gila in New Mexico. In this area, Danson (1957:18-21) defined four phases: (1) San Francisco (A.D. 700-900), (2) Three Circle (A.D. 900-1000), (3) Reserve (A.D. 1000-1100), and (4) Tularosa (A.D. 1100-1250).

From 1946 to 1960, Emil Haury directed the archaeological field school of the University of Arizona at Point of Pines, 35 miles northwest of the confluence of the San Francisco and the Gila (Haury 1989). Although Point of Pines is outside the area covered by this overview, the field school there influenced the interpretation of the archaeological record along the Gila River. For example, Haury (1958, 1989:58-60, 116-117) and Lindsay (1987) found evidence, in the form of ceramics and architecture, that around A.D. 1270, people from the Kayenta, Arizona, area migrated to southeastern Arizona and brought with them ceramics (notably Kiet Siel Polychrome), construction styles (particularly D-shaped kivas), and cultigens (in particular a type of squash). After living in pit houses outside the pueblo for a time, the immigrants built a room block within the pueblo. Over time, these northern immigrants (whom Haury called the Maverick Mountain people) began to produce pottery (Maverick Mountain Polychrome) similar to that of their homeland, but using local materials. Around A.D. 1300, however, the Maverick Mountain people were attacked by the other residents of Point of Pines Pueblo, and the Maverick Mountain residences within the pueblo were burned. Elsewhere along the Gila and San Pedro rivers, however, the Maverick Mountain immigrants established their own pueblos (Brown 1973; DiPeso 1958; Duffen 1937; Gerald 1975; Lindsay 1969, 1987; Wasley 1962; Woodson 1995).

From the 1960s to the present, most archaeological research along the upper Gila and San Francisco rivers in Arizona has been salvage work conducted prior to construction projects. In 1963 Vivian surveyed the proposed Buttes Reservoir area for the National Park Service (NPS), locating five sites. In 1966 the Arizona State Museum excavated one of the sites, the Buttes Dam site, a large Hohokam village on a terrace on the north side of the river (Wasley and Benham 1968). Two other sites were excavated for the NPS on the San Carlos Indian Reservation in 1963 (Johnson and Wasley 1966), but they represented a local variation of a mixture of cultural manifestations (Bronitsky and Merritt 1986). The original survey for the project (Gila River Channel Rectification Project) recorded 18 sites (Tuohy 1960) in 1959, 10 on the north bank and 8 on the south bank of the Gila River, near Bylas.

In the 1970s a number of surveys and other archaeological work were undertaken in conjunction with utility and water control projects. In 1972 Doyel conducted an archaeological survey from Clifton to Tucson for Tucson Gas and Electric (Doyel 1972). The right-of-way ran south from the Greenlee Country Club and crossed the Gila River near Apache Grove. Doyel found three sites along the right-of-way, none of them in the area between Clifton and the Gila River. That same year, the Museum of Northern Arizona conducted an archaeological survey for the portion of the project between San Juan and Clifton (Fuller 1972; Kane and Fuller 1972a, 1972b). Fuller (1972) reported three sites (all prehistoric) on the San Francisco River straddling the Arizona-New Mexico border. Two of the sites were in New Mexico; Site NA11,536 (a walled-up cave containing pottery, flaked stone, and corncobs and dating from about A.D. 600 to 800) was in Arizona. Kane and Fuller (1972a) reported nine sites (seven prehistoric and two historic), one of which (NA11,585, a prehistoric camp) was on the San Francisco River. In 1974 a survey was done for the Graham-Curtis Canal Company for the proposed construction of five flood control dams and their associated features (Gilman and Sherman 1975). This survey area was approximately 10 miles northwest of Safford, with four prehistoric sites recorded between the floodplain and the second terrace of the river. Dam site areas near Safford also were surveyed for the Coronado Resource Conservation and Development Project in 1975 (Kinkade 1975). Twenty-one sites were found along Foote Wash and No Name Wash, which empty into the Gila River Valley. Most of the sites represented small temporary camps, and some of these were excavated (Fitting 1977). A series of surveys were conducted for Arizona Electric Power Cooperative (AEPCO) in 1977 from their Greenlee Substation to their Cochise Power Plant south of Willcox. The surveys recorded 103 sites (Simpson and Westfall 1978), and 11 sites subsequently were excavated (Westfall, Rozen, and Davidson 1979). Survey of the proposed Buttes Reservoir area in the 1970s located 250 prehistoric sites or site components, most of which were associated with Hohokam occupation (Debowski et al. 1976).

Other, smaller projects also took place during this time period. In 1973 survey and limited excavations in the Pueblo Viejo area, near Safford, examined the origins of Salado cultural influence seen there (Brown 1973). New Mexico State University conducted surveys in the vicinity of the Buena Vista Site near Safford (Buttigieg-Berman 1977), and Mills and Mills (1978) published a report on their excavations at this site. Two Salado sites were excavated by students from Eastern Arizona College in 1975 and 1976 (Bronitsky and Merritt 1986:65). New Mexico State University conducted archaeological surveys in the vicinity of Clifton and Duncan (Bussey and Beckett 1975; Gomolak 1977) and excavated two Mogollon sites: the Mesa Top site (Berman 1978) and the Cerro de Las Piedras site (Beckett 1978).

In 1979 Paul Martin wrote an overview of the Mogollon Culture (Martin 1979), in which he mapped the Mimbres Branch as extending just west of the Arizona-New Mexico state line, the Black River Branch (defined by the sites excavated by Haury and the Point of Pines archaeological field school) as including most of the study area, and the Cibola Branch as including the Blue River and the San Francisco River in New Mexico (Martin 1979:Figure 1). The conjunction of these three branches was just southeast of the confluence of the Blue River and the San Francisco River. Martin also described the Saladoan intrusion into the area.

In the early 1990s an archaeological survey by SWCA of approximately 4000 acres north, south, and west of Clifton resulted in discovery of 25 archaeological sites with 9 prehistoric components, 1 Apachean component, and 19 historic components (Roberts, Ahlstrom, and Doak 1995). The prehistoric components included two rock overhangs, four roasting features, one rock pile, and two artifact scatters. The Apachean component was an artifact scatter. The historic components included two mining camps, six mines, three structures, three sets of stone walls, one railroad grade, one trail, one rock overhang (also used prehistorically), one rock enclosure, and one artifact scatter. The 4,000 acres were distributed among 12 parcels, most of which were well away from the San Francisco River. Two parcels, though, were adjacent to the river. Parcel E, on the west side of the San Francisco River approximately 3 miles north of Clifton, contained only two isolated fragments of bottle glass. Parcel F, on the north side of the San Francisco River approximately 3 miles south of Clifton, contained two sites (one historic trail with associated rock alignments and artifacts and one prehistoric rock pile), six isolated flaked stone artifacts, one isolated ground stone artifact, two isolated glass fragments, one horseshoe, and one set of mining test pits.

Kyle Woodson of the University of Texas, Austin, has been conducting research on the Maverick Mountain Phase, originally defined by Haury. Woodson (1995) identifies at least eight Maverick Mountain Phase sites: Point of Pines, 76 Ranch, three sites along the Gila River (Spear Ranch, Goat Hill, and Bonita Creek), and three sites along the San Pedro River (Davis, Reeve, and Second Canyon). Woodson (1995) has excavated Goat Hill, a Maverick Mountain Phase pueblo of 35 rooms and a D-shaped kiva, in the Safford Valley.

Overviews for the area around the upper Gila River have been produced to date for the Bureau of Land Management. Separate overviews were compiled for the Middle Gila Planning Unit (Debowski and Fritz 1974), the Winkelman and Black Hills planning units (Teague 1974), the Geronimo Planning Unit (Doelle 1975), and for Southeast Arizona in general (Bronitsky and Merritt 1986). The earlier overviews do not always include maps, providing only descriptions of the planning units in the text.

CULTURE HISTORY

Archaeological chronologies of North America generally divide the prehistory and history of areas within the United States into four periods. These periods and their dates, as currently reconstructed for southeastern Arizona, are: (1) the Paleoindian Period (9500-6000 B.C.); (2) the Archaic Period (6000 B.C.-A.D. 1); (3) the Formative Period (A.D. 1-1540); and (4) the Historic Period (A.D. 1540-present). Local chronologies, such as the one developed by Roberts, Ahlstrom, and Doak (1995:Figure 1.8), modify this general chronology to reflect cultural changes specific to particular areas (Table 2).

Table 2. Cultural Chronology of the Upper Gila and San Francisco Rivers, Arizona

LIFEWAY	PERIOD	PHASE	DATE
Industrial	Late Historical		A.D. 1870-1940
Frontier/Apache	Early Historical		A.D. 1540-1870
Formative	Pueblo	Cliff	A.D. 1375-1450
		Black Mountain	A.D. 1180-1300
		Mimbres	A.D. 1000-1150
	Late Pit House	Three Circle	A.D. 750-1000
		San Francisco	A.D. 650-750
		Georgetown	A.D. 550-650
	Early Pit House	Cumbre	A.D. 200-550
Early Agricultural/Archaic	Late Archaic		2000/1000 B.C. - A.D. 200
Archaic	Middle Archaic		5000-2000/1000 B.C.
	Early Archaic		7500-5000 B.C.
Paleoindian	Paleoindian	Clovis	9500-9000 B.C.

From Roberts, Ahlstrom, and Doak 1995:Figure 1.8

Paleoindian Period

The Paleoindian adaptation to the Southwest is generally considered to have been oriented around hunting of large game using spears with distinctive lanceolate projectile points. The Paleoindian period is divided into the Clovis (Llano) (9500-9000 B.C.), Folsom (8800-8000 B.C.), and Cody (Plano) (8000-6500 B.C.) complexes. The Clovis complex was characterized by mammoth hunting using Clovis projectile points. Folsom-complex hunting focused on long-horned bison (*Bison antiquus*) using Folsom points. Cody-complex hunting focused on both long-horned bison and modern bison (*Bison bison*) using Midland, Plainview, Scottsbluff, Eden, Angostura, and Belen projectile points and Cody knives.

The Clovis Complex is well known in southeastern Arizona, where excavations at five sites (Double Adobe [Haury 1960], Naco [Haury 1953], Lehner [Haury, Sayles, and Wasley 1959; Haynes 1964; Mehringer and Haynes 1965], Murray Springs [Haynes and Hemmings 1968], and Escapule [Hemmings 1970; Hemmings and Haynes 1969] have documented the Clovis Complex as fully as anywhere in the United States. Folsom and Cody (Plano) Complex sites have not been identified in southeastern Arizona, but late Paleoindian sites have been found in southwestern New Mexico (Fitting and Price 1968). No Paleoindian materials have been found in Arizona along the San Francisco River or the upper Gila River (above the confluence with the San Francisco River).

Archaic Period

The Archaic Period in the Southwest and Great Basin has been referred to as the Desert Culture (Jennings 1968) and was based on hunting of wild animals and gathering of wild plants. The variant of the Desert Culture originally identified for southeastern Arizona was called the Cochise Culture (Sayles and Antevs 1941; Sayles 1983), which was divided into three stages: (1) Sulphur Springs, (2) Chiricahua, and (3) San Pedro. Dates assigned to each stage vary slightly with each researcher. Doyel (1972:22) dates the Cochise Culture between about 8,000 and 300 B.C. Wasley also proposed (in an unpublished paper) a Cazador Phase (7000-6000 B.P.), which has not generally been accepted.

The Sulphur Springs Stage is characterized by grinding stones in an occupation level below and earlier than a stratum containing mammoth bones. This stage was defined at the Double Adobe Site.

The Chiricahua Stage is characterized by shallow-basin milling stones and percussion-flaked stone artifacts (including biface blades, knives, scrapers, hammerstones, spokeshaves, and projectile points). Projectile points have concave bases and are side-notched, much like the San Jose projectile points of the Oshara Tradition (Irwin-Williams 1973) or the Pinto Points of the Great Basin Tradition (Jennings 1986:Figure 3, Figure 4), or are diamond shaped, much like the Gypsum Points of the Great Basin Tradition (Jennings 1986:Figure 3, Figure 4). At the Cienega Creek Site (W:10:112) on the San Carlos Apache Indian Reservation, maize pollen was found in a level dated 4200 years B.P., and 47 cremations were found dating 3135 ± 75 B.P. (Haury 1957).

During the San Pedro Phase, people began growing beans and constructing food-storage pits and pit houses. Doyel (1972:22) dates the San Pedro Stage from about 2000 to 300 B.C. (or perhaps to as late as A.D. 1).

More recent researchers (Huckell 1984; Wills 1988) have suggested alternative chronologies for the Southwestern Archaic, dividing the period into early, middle, and late periods. Huckell dates the Early Archaic from 8000-5000 B.C., the Middle Archaic from 5000-2000/1000 B.C., and the Late Archaic from 2000/1000 B.C. - A.D. 300). Wills dates the Early Archaic from 8000-5000 B.C., the Middle Archaic from 5000-2000/1000 B.C., and the Late Archaic from 2000/1000 B.C. - A.D. 300).

Late Archaic peoples in southeastern Arizona began growing corn at least as early as 850 B.C. (Huckell 1990:310-313) and at roughly the same time started building pit structures and using storage pits (Huckell 1990). These changes were part of a shift to the more sedentary life style of the Formative period.

Possible Archaic (8000 B.C. - 1 A.D.) sites have been found (Kinkade 1975) south of the river east of Safford. Securely dated Archaic sites are not known, but the Gila Valley is thought to be the northern boundary of the local Archaic occupation, the Cochise culture, in southeastern Arizona (Sayles 1945).

Formative Period

Following the Archaic period, the Gila River Valley was settled and influenced by different culture groups. The prehistoric culture that occupied the area around Safford and Clifton is called Mogollon by archaeologists, but, as can be seen from the history of archaeological research, the study area falls along archaeologically defined prehistoric cultural boundaries and has been variously classified as upper Gila (Kidder 1924), Mimbres (Danson 1957), or a combination of Mimbres, Pine Lawn, and Black River (Martin 1979). Moreover, prehistoric people in the area traded with and were influenced by the Hohokam, who lived primarily in the Phoenix and Tucson basins. Finally, the Salado Culture, a prehistoric culture unique to the transition zone between the Mogollon Highlands and the Sonoran Desert, appeared in the area about A.D. 1200, and groups from the Kayenta region of northern Arizona apparently migrated into the area and established their own pueblos about A.D. 1275.

The Mogollon Culture was originally defined as a population inhabiting mountain and mountain-lowland transition zones of east-central Arizona and western New Mexico (Wheat 1955). The Mogollon Culture originated by about 300 B.C. when pottery, maize, and other domesticated plants were introduced into the area (Doyel 1972:23). Mogollon Culture is generally defined on the basis of pit house architecture, brownware pottery, and flexed burials. Brownware pottery is made of high-iron clays derived from volcanic sources and usually containing fragments of volcanic material that act as a temper.

Anyon, Gilman, and LeBlanc (1981) and Lekson (1990) discuss the development and history of Mogollon Culture in terms of three broad periods (the early pit house period, the late pit house period, and the pueblo period) that they further subdivide into seven phases: (1) Cumbre (A.D. 200-550), (2) Georgetown (A.D. 550-650), (3) San Francisco (A.D. 650-750), (4) Three Circle (A.D. 750-1000), (5) Mimbres (A.D. 1000-1150), (6) Black Mountain (A.D. 1180-1300), and (7) Cliff (A.D. 1375-1400).

Until approximately A.D. 1000, Mogollon populations lived in pit house villages built in a dispersed pattern in easily defensible positions (Teague 1974:8). Early pit houses were oval or circular, and later (A.D. 950-1200) pit houses were rectangular. Rock-lined and masonry-lined rooms occur after the transition to surface structures. The AEPCO project (Simpson and Westfall 1978) found three Mogollon pit house villages on terraces north and south of the river. Ranging between 22.2 and 49.4 acres in area, these sites contained numerous features, including rock alignments, possible terraces, and other possible agricultural remains. Occupations dated from pre-A.D. 900 to approximately A.D. 1000. One of the sites contained rectangular cobble-lined pit houses, possibly indicative of the transition to above-ground masonry rooms (Simpson and Westfall 1978:95). After about A.D. 1000, the Mogollon peoples typically constructed above-ground pueblos and manufactured a distinctive pottery called Mimbres Black-on-white, which was commonly decorated with pictures of life forms in addition to geometric designs. Excavations near Bylas (Johnson and Wasley 1966) on the San Carlos Indian Reservation examined two sites with occupations dating from A.D. 1100 to 1200. They contained 88 surface rooms of rock-reinforced adobe construction, 2 pit houses, 4 cremations, and 5 trash mounds.

The Salado occupation, first identified by a series of pottery types such as Pinto, Gila, and Tonto Polychrome, is represented by a complex of characteristics that was centered around the Tonto-Globe area beginning about A.D. 1100-1500. Saladoan Culture is characterized by polychrome pottery, compound walls around villages, and extended burials. Gladwin et al. (1937) and McGregor (1965) thought that the Saladoan peoples originated in the Tonto Basin.

Brown's research focused on five sites, including Buena Vista, in the Safford area. He found comparisons of Salado traits among these sites and other sites from both the Point of Pines-Reserve and Tonto Basin areas. He called the Salado manifestations in the Safford area the Pueblo Viejo Salado. Sites investigated by Brown (1974) were pueblos with multiple (4 to 170), contiguous rooms and plazas, some of which were partially or fully enclosed by walls. He determined that they were occupied anywhere from post-A.D. 1250 to the early fourteenth century. The Gila River Valley was abandoned by A.D. 1400 (Doyel 1972:23).

From about A.D. 1275 to 1325, it appears that a group of people from the Kayenta region of northern Arizona migrated to the southern Mogollon Highlands and the upper Gila and San Pedro river valleys. Among the sites occupied by this group were Point of Pines Pueblo (Haury 1958, 1989:58-60, 116-117; Lindsay 1987), the 76 Ranch Site near Bonita, Arizona (Duffen 1937), the

Davis, Reeve, and Second Canyon sites on the San Pedro River (DiPeso 1958; Gerald 1975; Lindsay 1969, 1987), the Spear Ranch and Bonita Creek sites (on the upper Gila River) (Brown 1973; Wasley 1962), and Goat Hill Pueblo near Safford (Woodson 1995). These people built pueblos with kivas (subterranean ceremonial rooms) and manufactured Maverick Mountain Polychrome, which looks like Kiet Siel Polychrome (manufactured in the Kayenta region) but is made of materials found in southeastern Arizona. The immigrants are known archaeologically as the Maverick Mountain Phase.

From approximately A.D. 100 on, contact with other cultural groups increased, and by A.D. 950-1200 many Hohokam traits were present (Simpson and Westfall 1978:24). In the Safford Valley, prior to the introduction of Salado polychromes, culture contact was north-south, from the White Mountains in the north to Casas Grandes, across the modern international border, in the south. With the introduction of Salado traits, interaction expanded to include contact west of the Safford Valley. The appearance of the Salado complex added traits such as polychrome and other ceramic types, puebloan architecture of coursed masonry or solid adobe, cliff dwellings, compounds or defense walls, and inhumation burials. According to Brown,

> *Salado polychromes have been found on terraces above the Gila River, mainly on sites downstream from Safford. Salado in the Safford area differs from Tonto Basin Salado by the presence of Point of Pines-Reserve ceramic types, the absence of compound architecture, and the absence of late northern tradewares [Brown 1974, cited in Simpson and Westfall 1978:26].*

Mogollon sites adjacent to the upper Gila and San Francisco rivers in Arizona range in date from about 50 B.C. to about A.D. 1200 and include farmsteads and hamlets as well as campsites and other more specialized sites. The earliest excavated Mogollon site in the area is the Mesa Top Site near Duncan, which was occupied from about 50 B.C. to A.D. 925 (Berman 1978). Other sites in the Duncan area, including Sites AZ CC:8:3(ASM) (A.D. 400-1000) and AZ CC:8:4(ASM) (A.D. 100-400), are roughly contemporaneous, dating to the pit house period (pre-A.D. 1000). Site NA11,536, on the San Francisco River, also dates to the pit house period (A.D. 600 to 800), but consists of a walled-up cave containing pottery, flaked stone, and corncobs. Pueblo sites dating from about A.D. 1000 to 1200 have been reported on both the Gila and San Francisco rivers. The largest pueblo site reported to date is Hough's Site 29 (Danson's Site 1), which is on the San Francisco River above Clifton and consists of 20 rooms in two structures separated by a plaza and surrounded by a boulder wall. This site dates from about A.D. 1050 to 1200 (Danson 1957:27-28, Figure 2). A nearby site dating from about A.D. 1000 to 1050 contains an indeterminate number of rooms. Furthermore, Hough recorded at least three other pueblo sites and two cave sites along the Arizona reach of the San Francisco River above Clifton, and although he did not provide room counts for these sites, at least two of the pueblos consisted of multiple room blocks, and one had a plaza 100 feet long (Hough 1907:42-47). Sites along the Gila River reported by Emory (1848a, 1848b), which were as much as 40-50 feet long and 20-30 feet wide, probably date to the same period and probably contain no more than 20 rooms. Some of the rock overhangs, roasting features, and artifact scatters reported by Roberts, Ahlstrom, and Doak (1995) in the Clifton area may be contemporaneous with these habitation sites.

Historic Period

Spanish accounts of the Coronado Expedition in 1540 suggest that the upper Gila and San Francisco rivers were sparsely populated by Yavapais. Apaches displaced the Yavapais around A.D. 1700. Both the Yavapai and Apache were relatively nomadic, living by hunting and gathering and occupying the shelters of overhanging rocks and constructing brush wickiups. Both groups also harvested agave roots, which they roasted in pits lined with heated stones. The two groups manufactured plainware pottery that is so similar that archaeologists cannot reliably distinguish the ceramics of from one group from the other, making the archaeological identification of Yavapai and Apache sites highly problematic. Few Native American sites of the historic period have been identified in the study area, although the SWCA survey of 4000 acres around Clifton identified one Apachean artifact scatter and two rock overhangs, four roasting features, one rock pile, and two artifact scatters that could be Yavapai or Apache (Roberts, Ahlstrom, and Doak 1995).

After the Coronado Expedition of 1540, Euroamericans do not seem to have explored the upper Gila and San Francisco rivers until about the 1820s, when trappers from Taos, New Mexico, began to trap along the rivers. In 1846 General Steven Watts Kearny and the Army of the West traveled down the Gila River, and throughout the 1860s, 1870s, and 1880s, the U.S. Army fought with the Apaches throughout the region. Permanent settlement of the area by Euroamerican miners and farmers began in the 1870s. Despite this history of Euroamerican presence, few historic Euroamerican sites in the area have been recorded, and none have been excavated. During SWCA's survey of 4000 acres around Clifton, two mining camps, six mines, three structures, three sets of stone walls, one railroad grade, one trail, one rock overhang (also used prehistorically), one rock enclosure, and one artifact scatter used by Euroamericans in the historic period were recorded (Roberts, Ahlstrom, and Doak 1995). In a number of historic sites in the area—including Apache Grove (near York), the Gila River concrete arch bridge (near Clifton), the Clifton–Casa Grande Building, the Chase Creek District (Clifton), the Clifton Jail, the Eastside District (Clifton), the North Clifton District, the Phelps-Dodge Guest House, the Shannon Hill Distrist (Clifton), the South Clifton District, the Patterson Wagon Road Truss Bridge (Clifton), the Park Avenue Highway Truss Bridge (Clifton), Dell Potter's ranch (on the San Francisco River above Clifton), Oroville (on the San Francisco River above Clifton), the Metcalf locomotives, and the Billingsley Home (Duncan)—are on the State Register of Historic Places, the National Register of Historic Places, or both (Bronitsky and Merritt 1986:413-416).

PREHISTORIC USE OF THE GILA RIVER

During the period of prehistoric occupation, the entire length of the Gila River played a major role in human settlement patterns and occupational success. As discussed above, most prehistoric habitations in the area were close to the river. Along the lower Gila, where Patayan populations settled, occupation was confined to the river valley (Breternitz 1957:1). Along the middle Gila, communities were able to settle about 2 km from the river floodplain because of the extensive canal systems that furnished irrigation water. In all segments of the river, site density dramatically decreased with distance from the river.

Most archaeological investigations along the upper Gila River have been surveys; thus, little detail is available. Also, most have taken place around the Safford Valley, where many prehistoric remains have been lost because of historic and modern farming. However, based on survey for the Graham-Curtis Project, Gilman and Sherman (1975) concluded that there had been villages of 50-200 rooms along the entire length of the Safford Valley and along the Pinaleño Mountain foothills (Gilman and Sherman 1975:5-6). Sites with agricultural features, such as gridded gardens, terraces, and canals, are found along the river floodplain and terraces and the Pinaleño Mountain foothills. Sites in the Gila Mountains were much smaller and included both open sites and rockshelters.

Kinkade's (1975) survey southwest of Safford along two washes found numerous limited-activity sites that represented temporary camps associated with lithic manufacture and exploitation and possible check dams associated with water control.

Prehistorically, the Gila River provided a wide variety of dietary and other subsistence resources. The river itself provided a permanent water source and fish as a source of protein (Miller 1955). On the middle and lower Gila River, cobbles along the river bed were used extensively as raw material for tools and for Classic period Hohokam structures. In addition, the river promoted great diversity in floral and faunal resources along its banks. Riparian vegetation was more lush than it is today. Excavations at Escalante Ruin determined that a saltbush-mesquite community was prevalent around Casa Grande and Escalante during the prehistoric occupation (Doyel 1974:16). Today only dead mesquite trees and creosotebush are visible. In the past, mesquite bosques were common along the river, and the water table was relatively high. In fact, Haury (1978:9) describes a prehistoric well at the site of Snaketown no more than 3 m deep "that tapped a reservoir fed by Queen Creek" (Berry and Marmaduke 1982:20). There was a significant riparian community historically as well.

> *Along the formerly great Gila River (the now dry bed of which stretches across the Sonoran Desert of western Arizona) there were extensive marshes, swamps, and flood plains with cattail (Typha domingensis), bullrush (Scirpus olneyi), giant reed (Arundo donax), common reed (Phragmites communis), arrowweed (Pluchea sericea), and many trees. The dense vegetation of these well-developed riparian communities often stood 10 to 15 feet high and supported a tremendous quantity of wildlife. [Lowe 1964:30]*

The riverine environment supported a wide variety of animal species, particularly rodents, small mammals, birds, and fish. When Father Kino visited the Pima of the Gila Valley, he noted that "all its inhabitants are fishermen, and have many nets and other tackle with which they fish all year" (cited in Berry and Marmaduke 1982:27). Fish remains (*Acipenser*) were also identified from prehistoric contexts at the site of Snaketown (Miller 1955:132).

Agriculture was a primary use of the river. Irrigation, dry farming, and floodwater farming were evident along most of its length, from the Gila Bend area to beyond the Safford Valley, from the pre-Classic to the Classic period. Arable land and water availability were primary factors in settlement location, and the type of agriculture that was practiced was based on the character of the river at any given point, as well as the character of the landscape and distance from the river. According to Debowski et al. (1976:90), the area around the proposed Buttes Reservoir did not have canals because the velocity of the river was not suited to canal irrigation; instead, water control features such as diversion dams, contoured terraces, rock alignments, and rock piles were used to capture rainfall or runoff for agricultural fields. These techniques maximized potentially arable land and expanded possibilities of procuring water for fields beyond the available irrigation canal zone. The inhabitants thus decreased the likelihood of failure by not relying on one system alone. This would have been important for an expanding Hohokam population that probably needed surplus to feed political and economic specialists. Moreover, river flooding would have washed out intakes and damaged canals, necessitating a backup system for crop production. Floodwater farming was practiced by Patayan inhabitants along the lower Gila (Schroeder 1957:177) and by Hohokam farmers. Canal irrigation was practiced by the Hohokam from the area around Gila Bend (Woodbury 1961) to the Pinaleño Mountain foothills (Doelle 1975:12). Canals are known archaeologically from the Gatlin site (Wasley and Johnson 1965:24), Casa Grande (Cummings 1927:9-10) and the surrounding area (Brooks and Vivian 1976:29-33; Midvale 1965), Snaketown (Haury 1978; Woodbury 1961) and other sites along the middle Gila (Berry and Marmaduke 1982:50; Fewkes 1910; Wilcox 1979:115), the Fortified Hill Site (McGuire and Schiffer 1982:106), the Gila Butte site (Greenleaf and Vivian 1971), the eastern Buckeye Valley (Midvale 1974), and near Gila Bend (McGuire and Schiffer 1982:133; Woodbury 1961).

ENVIRONMENTAL RECONSTRUCTIONS

Within recent years, enormous strides have been taken in understanding the prehistoric natural environment. Reconstructions have included paleoclimatic and hydrological conditions in the lower Colorado Plateau that are applicable to southern Arizona in general (Dean et al. 1985; Euler et al. 1979) and paleobotanical and paleofaunal types native to the Gila River Valley.

Euler et al. (1979) produced a paleoenvironmental record for the American Southwest by plotting geoclimatic and bioclimatic indicators for the Colorado Plateau. Indicators consisted of data from tree-rings, pollen records, and alluvial sediments. These data were analyzed within a temporal framework, and fluctuations through time were noted (Table 3). Dean et al. (1985) used similar data to produce a model of interaction between the cultural system (prehistoric populations) and the natural system (environment) and to identify periods of stress. In general, low water tables and channel entrenchment, or degradation, would have an adverse effect on agriculture; on the other hand, high effective moisture and aggradation, or surface stability, would be favorable to the development of irrigation systems, as well as other agricultural technologies. Variability in the dendroclimatic record might have produced some short-term responses prehistorically to accommodate unusually high or low precipitation, such as relocation of agricultural fields or the expansion of irrigation systems (Dean et al. 1985:542-543).

Prehistorically, the floodplain and terraces of the Gila River contained a wide variety of plant and animal species. Desertification and reduction in this habitat in recent times (Crosswhite 1981:67; Hastings and Turner 1965; Rea 1983) have decreased species diversity and changed some of the flora and fauna that characterize the Sonoran Desert landscape. Human influence over only the past 100 years has created changes along the river in the amount of groundwater, erosion, and depletion of native vegetation. The riparian forest is mostly gone or replaced by feral salt cedar, and weedy species proliferate. The water table, previously a few feet below the surface, now averages hundreds of feet underground (Rea 1983:3). The archaeological and historic records document the change in riparian and desertscrub communities from historic to modern times, yet the natural resources used by prehistoric peoples remained relatively constant. Archaeological data, such as pollen, macrobotanical, and faunal remains, indicate that there were no radical changes in the natural environment, and thus the climate, prehistorically.

Historically, Fewkes (1904:174-175) contrasted the Gila River in the Safford area as it was described by Emory (1848a, 1848b, 1951) and Johnston (1848) with what he observed in 1897. Fewkes quoted Emory:

> *Everywhere there were marks of flowing water, yet vegetation was so scarce and crisp that it would be difficult to imagine a drop of water had fallen since last winter....The dust was knee-deep in the rear of our trail; the soil appears good, but for whole acres not a sign of vegetation was to be seen. Grass was at long intervals, and, when found, burnt to a cinder [Emory 1848a:68, cited by Fewkes 1904:174].*

Table 3. Environmental Reconstructions Applicable to the Gila River Valley

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

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

In 1897 Fewkes found that

> *white settlers have worked marvels in other parts of the valley, which may now be said, using a familiar simile, to "blossom as the rose." At present Pueblo Viejo, from Buena Vista to Pima, which towns mark the author's acquaintance with it, is one succession of cultivated farms of corn, alfalfa, and melons, a garden of Arizona in which any crop can be raised....It seems incredible that in fifty years such great changes should have taken place, yet it was to be expected, for in prehistoric times Pueblo Viejo was a garden spot, and there is every reason to believe that when it was inhabited by aboriginal farmers more acres of its land were under cultivation than at present [Fewkes 1904:174-175].*

SUMMARY AND CONCLUSIONS

In summary, archaeological studies of the upper Gila and San Francisco rivers in Arizona have been fairly limited, and although archaeologists have documented some 11,000 years of human use of southeastern Arizona, most archaeological sites in the study area date to the period from about 50 B.C. to A.D. 1200 when farmers of the Mogollon archaeological culture lived in the area. The Mogollon farmers lived in farmsteads and hamlets of as many as 20 rooms scattered along the Gila River and in the vicinity of Clifton. Archaeological reconstructions suggest that streamflow changed little from the A.D. 740-1370 period to the A.D. 1800-1979 period, but no evidence of prehistoric irrigation agriculture has been reported above the Safford and Solomonville areas. In addition to the riverside farming communities, campsites and specialized activity sites were scattered throughout the uplands adjacent to the rivers. In the early historic period (circa A.D. 1540 to 1870) the area was occupied by the Yavapai and Apache, who lived primarily by hunting wild animals and gathering wild plants. Their sites consist primarily of rock overhangs, agave-roasting features, and campsites. Euroamerican sites of the recent historic period (1870 to present) include towns, farms, ranches, mines, mining facilities, and transportation routes. Archaeological research has not documented any use of the river for commercial trade and travel nor any regular flotation of logs.

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Section 3

HISTORICAL OVERVIEW OF THE UPPER GILA AND SAN FRANCISCO RIVER VALLEYS, ARIZONA

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INTRODUCTION

Historically the upper Gila and San Francisco Rivers were occupied by the Yavapai (until about 1700) and (after about 1700) the Western Apache and Chiricahua Apache. The Western Apache practiced some irrigation agriculture, but their fields were along streams higher in the mountains north of the Gila. The Chiricahua Apache only rarely practiced agriculture, but are reported to have built bullboats to cross streams (although not specifically the Gila or San Francisco rivers. The Spanish and Mexicans were largely kept out of the upper Gila and San Francisco rivers by the Apaches, but as early as 1825 or 1826, trappers from the United States (via the Santa Fe Trail and Taos, New Mexico) were traveling to the Santa Rita Copper Mines near modern-day Silver City, New Mexico, then trapping down the Gila and San Francisco rivers and beyond. Although these trappers constructed canoes and rafts to use on the Colorado River, they apparently did not float the upper Gila and San Francisco rivers.

In 1846, Stephen Watts Kearny and the Army of the West marched down the Gila River, guided by Christopher "Kit" Carson. Lieutenant William Emory of the Corps of Topographical Engineers described the study area in some detail. Despite this early use of the upper Gila River as a military route, however, later travelers took the 1846 route of Colonel Philip St. George Cooke and the Mormon Battalion across southern Arizona. Not until the 1860s did the United States begin to make a concerted effort to subdue the Apaches and open the upper Gila and San Francisco rivers to white settlement, and these military actions spanned nearly 25 years, from about 1862 to Geronimo's surrender in 1886. Army units made the first discoveries of mineral deposits in the area, resulting in the founding of the Clifton-Morenci mining district in 1872. Farming and ranching along the Gila and San Francisco rivers proceeded concomitantly with the development of mining. By 1901 most of the Gila River valley above the confluence of the San Francisco River was irrigated, but irrigation agriculture along the San Francisco was limited to only a few farms. Beginning in 1880, Clifton was struck by a series of floods from the San Francisco River. Early forms of transportation included horses, mule trains, wagons, and stagecoaches, and railroads to the mines began to be constructed in the late 1870s. In 1883 the Arizona and New Mexico Railroad was built to connect Clifton to the main line, which had been built across southern Arizona in 1881. During the early 1900s, Clifton was on one of the principal transcontinental highways, but this route was superseded by Route 66 and the current Interstate 20 route.

Both the upper Gila River and the San Francisco River are considered boatable streams today (Anderson and Hopkinson 1982, 1987). Several accounts describe boating on the upper Gila, and two accounts describes floating the San Francisco. Accounts of boating on the upper Gila date to 1895 (*Graham County Bulletin*, February 22, 1895, p. 3; *Phoenix Herald*, February 18, 25, 1895), 1909 (Granger 1983:259), and the 1980s (Salmon 1986). Accounts of floating the San Francisco River date to 1895 (*Graham County Bulletin*, February 22, 1895, p. 3; *Phoenix Herald*, February 18, 25, 1895), circa 1915-1926 (Shortridge 1990:41), and 1973 (Jones 1973).

HISTORICAL OVERVIEW/CHRONOLOGY

Historical documentation of the upper Gila and San Francisco rivers may have begun with the Coronado Expedition in 1540, although the Coronado's route is the subject of debate. Subsequently the Spanish apparently had little direct familiarity with the area, and it remained an Apache stronghold. During the Mexican period (1821 to 1848) American trappers penetrated the area, providing sketchy accounts of the stream. Guided by Christopher "Kit" Carson, Stephen Watts Kearny led the Army of the West down the Gila in 1846, and Lieutenant William Emory of the Corps of Topographical Engineers provided the first accurate maps and descriptions of the upper Gila River. The United States military began a concerted effort to subdue the Apaches in the area in 1862, and mining began in earnest on the San Francisco River in 1872, resulting in the founding of Clifton and other mining towns. Thereafter, an uninterrupted history exists for the area. A chronology of the principal historical events along the upper Gila and San Francisco rivers can be found at the end of this report. Historical maps showing the principal localities mentioned in the text are in Appendix A. Historical photographs are in Appendix B.

Historic Indian Use

Two Native American groups, the Yavapai and the Apaches, used the study area in historic times. The Yavapai preceded the Apache and probably used the area until about 1700, when the Apaches moved into the area.

The Yavapai are a Yuman-speaking tribe who are thought to have numbered about 2,000 in the 1860s (Khera and Mariella 1983:Table 1). Prehistorically the Yuman speakers lived on the lower Colorado River, and began to spread east about A.D. 1100-1300 (Dobyns and Euler 1970; Pilles 1981:172-177; Rogers 1945:190), migrating into the Mogollon Highlands by the sixteenth century when they were probably observed north of the Gila River by the Coronado Expedition in 1540 (Winship 1896), and certainly seen in the Verde Valley by the Espejo Expedition in 1582 (Hammond and Rey 1966). Although the Yavapai practiced some limited agriculture, their subsistence was based on hunting wild game and gathering wild plants (Khera and Mariella 1983). Agave could be harvested year-round by moving to different elevations. The fruits of saguaro and other cactus were available in the summer. Piñon nuts, sweet acorns, walnuts, sunflower seeds, and grass seeds were gathered and stored for use in the winter. Each family group operated independently, but when resources were abundant, groups of families would camp together. Because the Yavapai were so mobile, they often lived in natural shelters of rock overhangs and more rarely built dome-shaped huts of brush or mud.

In 1540, the Coronado found a few people living in the vicinity of Chichilticale, a ruin at the northern edge of the Sonoran Desert. These people, who were probably Yavapai, were described as "the most barbarous yet seen. They live in separate cabins and not in settlements. They live by hunting" (Winship 1896:143).

Some time between the Coronado Expedition of 1540 and about 1700, the Yavapai were largely displaced by the Apache, who were the principal group to use the Gila and San Francisco rivers in historic times. The Apache and Navajo speak mutually intelligible dialects of a single language, Southern Athapaskan. Southern Athapaskan speakers are believed to have split from the main group of Athapaskan speakers in the western subarctic regions of Canada about 1,000 years ago. Drifting south, the Southern Athapaskans probably entered the Southwest between about A.D. 1540 and 1582. Gunnerson (1956, 1974) notes that when the Coronado Expedition passed through the Southwest in 1540, they did not report seeing any groups of people that can be identified as the Apache. Once the Coronado Expedition reached the Great Plains, however, they came across a groups of people who lived in conical skin tepees, used dogs as beasts of burden, and hunted the buffalo. Coronado's Pueblo Indian guides reported that these people, who Gunnerson believes to have been Apaches, arrived in the area about 15 years before. In 1582, the Espejo Expedition reported Querechos near Acoma Pueblo in New Mexico, and this group of people is often interpreted as Apaches, perhaps the ancestors of the modern Navajo (Gunnerson 1956, 1974).

Once in the Southwest, the Southern Athapaskans split into seven groups, known since the late nineteenth century as the Kiowa-Apache, Lipan Apache, Jicarilla Apache, Mescalero Apache, Navajo, Western Apache, and Chiricahua Apache. These names are relatively recent, however. The term Apache was first used by Don Juan de Oñate in 1598 (Opler 1983:385). Apaches are said to have been allied with Acoma Pueblo during Oñate's siege of Acoma in 1598 (Di Peso 1956:33-35). Fray Alonso de Benavides mentioned the Apaches de Gila (probably ancestors of the Chiricahua Apache) in the 1620s (Benavides 1945:82, 84-85). In 1697, Captain Juan Manje observed Apaches de Gila at the junction of the Gila and San Pedro (Di Peso 1956:33-35; Manje 1954).

By the mid-nineteenth century, the San Francisco River was an informal dividing line between the Western Apache and the Chiricahua Apache. The Western Apache lived primarily by hunting wild animals and gathering wild plants, although practiced some agriculture (Basso 1983). Their winter camps were in the Salt, Black, and Gila River valleys; their summer camps were along streams in the mountains, where they practiced irrigated agriculture. The Western Apache lived in wickiups brush-covered wickiups. They comprised five divisions, the Northern Tonto, Southern Tonto, Cibecue, San Carlos, and White Mountain Apaches.

The Chiricahua Apaches lived almost exclusively by hunting wild animals (especially deer, more rarely antelope, and often small game) and gathering wild plants (especially agave). The

Chiricahua practiced only limited agriculture and even that probably dates to historic times. Dwellings were primarily brush-covered wickiups. Opler (1983:414) reports that the Chiricahua manufactured bull boats (hide-covered, wooden-frame boats) for crossing streams. Geronimo divided the Chiricahua Apaches into four groups (Barrett 1970); Opler (1983) recognizes three: the Eastern Chiricahuas (the Chihennes group described by Geronimo); the Central Chiricahuas (including Geronimo's own group, the Bedonkohes, and Cochise's band, the Choconens); and the Southern Chiricahuas (the Nednais of Mexico). Geronimo said that he was born in 1829 at the headwaters of the Gila, in Arizona. Since the headwaters of the Gila are in New Mexico, the exact location of Geronimo's birthplace is a matter of debate. Debo (1976) believes that it was at the junction of the San Francisco and the Gila.

In addition to hunting, gathering, and agriculture, a substantial portion of Apachean subsistence in historic times was based on raiding and warfare. Throughout the Spanish and Mexican periods (see below) the Apaches were considered a threat to neighboring Indian and European settlements. In 1862, the United States established a chain of forts in Arizona to control the Apaches, initiating nearly 25 years of warfare that ended with Geronimo's final surrender in 1886.

Spanish Period

Spanish exploration of the Southwest was originally prompted by the stories of Cibola heard by Cabeza de Vaca during his 1528-1536 trek from Florida to Mexico. Sometime near the end of April, 1536, Cabeza de Vaca, and three companions--the only survivors of 300 men who had debarked on the coast of Florida eight years before--arrived in Sinaloa, having walked across the Gulf Coast and through the American Southwest.

In 1539, Fray Marcos de Niza and Estevan (a black who had accompanied Cabeza de Vaca) set out from Culiacan to investigate the stories of Cibola. Estevan went as far as Zuni, where he was killed, and when Fray Marcos (who was traveling some distance behind Estevan) heard of Estevan's death, he retreated to New Spain, spreading tales of the wealth of Cibola. These stories led to the organization of the Coronado Expedition, which explored the Southwest from 1540 to 1542 (Winship 1990:37-57).

In February of 1540, Francisco Vásquez de Coronado set out from Compostela, Mexico, leading an expedition of over 230 mounted men, 62 foot soldiers, and over 800 Indian allies, to explore what is now the southwestern United States. The expedition's route to Zuni 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; Winship 1896; for a summary see United State Department of the Interior, National Park Service 1991). After entering what is now the United States near the International Four Corners, however, the expedition traveled through a *despoblado* (deserted area) most of the way to Zuni. 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 (Haury 1984; Riley 1985), and no consensus has been reached.

Castañeda heard that Chichilticale had been built by a people "who separated from Cibola," and he believed that "it must have been destroyed by the people of the district, who are the most barbarous people that have yet been seen. They live in separate cabins and not in settlements. They live by hunting" (Winship 1990:143).

Captain Juan Jaramillo (Winship 1990:206) described how, after following the Nexpa River (which Winship thought was the San Pedro) to Chichilticale, the Coronado Expedition had to cross a series of rivers, including the Rio de San Juan (Saint John's River), the Rio de los Balsas (River of Rafts), the Rio de la Barranca (Slough River), and El Rio Frio (Cold River) before reaching the Bermejo (Red) River, which was two days from Cibola (Zuni) and is usually considered to be the Little Colorado River. The Rio de las Balsas received its name because the army had to cross it on rafts. A number of students of the Coronado Expedition have suggested that the Rio de las Balsas was the Gila. Granger (1983:260) states that the Gila was the Rio de las Balsas (River of Rafts), a name based on Indian use of wicker baskets to cross the stream.

North of the Gila River, Coronado met a small group called Nixoras. Ferg (1992:5), Gifford (1932), and Schroeder (1974:1) say they were Yavapais; Goodwin (1942:67), Oakes (1996:Table 1), and Riley (1985:160) believe they could have been Apaches.

The Coronado Expedition entered Hawikuh on July 7, 1540. On August 3, 1540, while still at Zuni, Coronado wrote to Viceroy of Mexico, Don Antonio de Mendoza, describing the progress of the expedition. Coronado briefly described the difficulties in traveling through the mountains from the Sonoran Desert to the Mogollon Rim, "beyond which the country becomes pleasant, and there is a river called the River of the Flax (del Lino)" (Winship 1990:177).

As Coronado was working his way through what is now eastern Arizona, Captain Hernando de Alarcon sailed up the Colorado River as far as the mouth of the Gila, which he named the Rio Brazo de Miraflores, and it appears as such on the 1541 map of Domingo de Castillo (Granger 1983:259). In subsequent years, the Spaniards extended their knowledge of the Gila River, based on their encounters with the stream below the current study area. Juan de Oñate named the Gila "Rio del Nombre de Jesus" and explored the river to its junction with the Colorado River in 1604 (Granger 1983:259-260). Fray Alonso de Benavides, who wrote in the 1620s, referred to the Apaches de Xila, although he did not specifically state that the Xila was a river (Benavides 1945).

The first use of the name Gila River was in 1697, when Fr. Eusebio Kino and Lt. Cristobal Martin Bernal explored the San Pedro River to its junction with the Gila (Granger 1983:26-). "In 1701 Kino called it Rio Grande de Hyla. However, in 1701 he also named its upper reaches the Rio de los Santos Apostoles (="river of the sainted Apostles"), because he had already suggested naming its four principal tributaries after the four major Apostles and the name applied to their joining in forming the larger stream" (Granger 1983:260). "The Name Rio de los Santos Apostoles was still in use on a map made by Capt. Clark and sent to President Thomas Jefferson on April 7, 1805" (Granger 1983:260). Kino noted that Sir Francis Drake called the Gila the Rio del Coral (Red River) (Bolton 1916:444). Father Juan María de Salvatierra, the Provincial Father of New Spain, who got most of his information from Kino, called the Gila the Rio de Grande (Granger 1983:260).

From 1766 to 1768, the Marqués de Rubí inspected the presidios of New Spain. His cartographer, Nicolás de Lafora reported Apaches living along the Gila, San Francisco, and Mimbres rivers (Lafora 1958; Opler 1983:403). In 1775, Father Francisco Garces, who was familiar with the lower Gila, called the Gila the Rio Jaquesila (Granger 1983:260).

The Spanish began mining at Santa Rita del Cobre near present-day Silver City, New Mexico, about 1800 (Weber 1971). According to Calvin (1946:62), Apaches showed the copper deposits to Colonel José Carrasco in about 1800, and don Francisco Elguea subsequently received a land grant for the area and developed the mines.

Mexican Period and American Trappers

Mexico won its independence from Spain in 1821. The Mexican government sponsored few expeditions in to western Arizona. Despite Mexico's attempts to discourage incursions into its territories by citizens of the United States, fur trappers began exploring the Southwest while it was still part of Mexico. Contrary to their popular image, the mountain men generally rode horseback through the Southwest and did not normally use boats. On at least three occasions (Ewing Young's party in 1826, the Yount-Pattie group in 1827, and Leroux in 1837), however, trappers canoed the lower Colorado River (see below). The Santa Rita Mines in New Mexico and the Gila River were the gateway to the Southwest for these American trappers.

In the early 1800s, citizens of the United States began to settle in Santa Fe and Taos. The Mexican government discouraged trapping, but in 1826, James Ohio Pattie and his father Sylvester Pattie and 12 others made an illegal trip to the Gila (Weber 1971:96-67). (Note that Davis [1982] argues that the Patties' first trip to the Gila was in the winter of 1824-1825.) They went first to the Santa Rita copper mines, near what is now Silver City, New Mexico, then traveled westward to the Gila. While still in New Mexico, seven trappers deserted the Patties, going ahead of them to get the first chance at the beavers. On January 1, 1825 (Davis 1982) or 1826 (Weber 1971) they left the Gila and started up the San Francisco, returning to the Gila on January 19 (pp. 55-56). Between the mouth of the San Francisco and the mouth of Bonita Creek, they ran into the deserters, who had been attacked by Indians, resulting in the death of one man and the wounding of the others. On January 31, they reached the Safford Valley (p. 59). The group went as far west as the San Pedro River (which they called the Beaver River), trapped up the San Pedro, then went over the Galiuro Mountains back to the Safford Valley. They returned to the Santa Rita copper mines on April 29, 1825. James left Sylvester at the mines and returned to Santa Fe for horses and supplies. He then returned to the Gila to recover their caches, but they had been stolen.

Ewing Young and William Wolfskill also organized an expedition to the Gila in the summer of 1826, but Ewing Young became ill, and William Wolfskill led the group, which comprised 11 to 16 men, including Milton Sublette, Thomas (later to be known as "Pegleg") Smith, Maurice le Duc, Alexander Branch, S. Stone, Richard Campbell, and George C. Yount (Weber 1971:124). Templeton (1965:51) says that Ceran St. Vrain was in this group also. This group went to the Santa Rita mines, then down the Gila to the Salt. The group was subdivided into three smaller groups: Smith, Branch, and Stone were in one group; Ceran St. Vrain headed a third group; and Wolfskill and approximately 10 other men were in the third party. Wolfskill's group (which included Milton Sublette) got in a battle with Indians at the mouth of the Salt and had to retreat.

In the fall of 1826, four groups of trappers went to the Gila. One group, led by William Sherley ("Old Bill") Williams and Ceran St. Vrain, consisted of 20 men. A second group, led by John Rowland, consisted of 18 men. A third group, led by Antoine Robidoux, consisted of 30 men, including James Ohio Pattie. Finally, Ewing Young led a party of 18 (Weber 1971:119-120). The Robidoux party went to the Santa Rita, New Mexico, copper mines, then went down the Gila to the Salt River, where Indians killed all the men except for Robidoux, Pattie, and an unnamed French trapper (Weber 1971:123). The survivors joined Ewing Young's party. George C. Yount was with Ewing Young's 1826 group. Like Robidoux's group, Young's party had gone through the Santa Rita Mines on their way to the Gila. They had then gone through San Francisco Hot Springs and trapped up the San Francisco River, returning to the Gila. The combined Young and Robidoux parties continued on down the Gila to the Colorado. Yount wrote, *In trapping the Colorado it was found convenient to construct small water-craft, which was done by scooping out logs of Cottonwood, after the method practiced by the Indians--With these canoes our trappers ascended the River till they reached the nation of the Mohavies [Camp 1966:33].*

They went upstream to the bend in the Colorado River, then back to the Mohave villages (Camp 1966:38). At the mouth of the Virgin River, the group divided up (Weber 1971:125). Pattie and others went east and returned to Santa Fe by traveling down the Rio Grande (Weber 1971:125). George Yount returned to Santa Fe via Zuni Pueblo (Weber 1971:126). This group apparently went north of the San Francisco Peaks to Black Falls and across to Zuni (Camp 1966:33). Yount does not mention going through Hopi on this trip, but he does describe recovering from their arduous trip at Zuni (Camp 1966:38). Thomas ("Pegleg") Smith, S. Stone, and Alexander Branch may have taken a still different route back to New Mexico; Humphreys (1966:318) says that after they left the main group at the mouth of the Virgin River, they built rafts and crossed the Colorado River. Ewing Young returned to Santa Fe in May, 1827 (Weber 1971).

On April 23, 1827, the Mexican government confiscated 115 beaver pelts, trapped along the Gila, from Ira A. Emmons, even though he claimed to be a resident of Santa Fe (Weber 1971:127-128).

In September of 1827, George C. Yount and Sylvester Pattie led a group of 24 men "including servants and campkeepers" to the Gila and Colorado rivers. On this trip, the Patties' third, they left Santa Fe in September of 1827 and reached the Gila River on October 6, 1827. "They followed the usual route--to the Copper Mines, down the Gila to the Pima Villages" and then to the Colorado (Camp 1966:43). At the Colorado, Sylvester Pattie, James Ohio Pattie, and six others "became insubordinate, and parted from the main body, above the mouth of the Gila, built canoes, and descended the Colorado to try their fortunes alone" (Camp 1966:45). Reaching the Gulf of California, the Patties and their followers went across Baja California to Santa Catalina, where they were imprisoned for traveling to the Gila and California without proper authorization. Sylvester died in prison, but James was released and returned to Kentucky in 1830 (Weber 1971:139-140). The rest of Yount's group continued along the route followed in 1826, going up the Colorado to the vicinity of present Lake Mead, returning to the Mohave villages, then traveling overland to the Grand Canyon (at the mouth of Spencer Canyon), then to Grand Falls and Hopi (Camp 1966:53-54). From Hopi, they went through Zuni and Laguna to Taos (Weber 1971:140-141).

In August of 1829, Ewing Young led a group of 40 American, Canadian, and French trappers (including Kit Carson on his first trapping expedition) from Taos to Zuni, and then to the Salt River. The group went up the Verde River to its headwaters, where the group split up, some of the men going back to Taos, while Young, Carson, and others went to California (Weber 1971:142-143), crossing the Colorado River at the later site of the Eldorado Ferry, some 40 miles northeast of modern-day Needles (Holmes 1967). In September of 1830, Young and Carson went back to the Colorado River, down to the Gila, then up the Gila to the Santa Rita mines (arriving at Santa Rita in January of 1831). They continued on to Santa Fe (Carter 1968:44-50).

Trapping on the Gila continued throughout the 1830s, until as late as 1842. Antoine Leroux arrived in Taos in 1824, and explored the West from 1833 to 1840. Leroux was on the Gila in 1825 or 1826. Parkhill (1965:57) quotes Stanley (1917:29) as saying, "He [Leroux] had trapped the Gila River for beaver and his party being discovered by the Apaches, he kept up a fight with them for three weeks." Lingenfelter (1978:16) says that Leroux rafted the Colorado from the mouth of the Virgin River in 1837.

United States Military Exploration

Kearny

American military exploration of the Gila began in 1846, when General Stephen Watts Kearny and the Army of the West went down the Gila (see Cutts 1965; Emory 1848; Griffin 1943; Johnston 1848; Turner 1966). Kearny was guided by Kit Carson. Lieutenant William Emory of the Corps of Topographic Engineers mapped the route and recorded information about it (Emory 1848). Dr. John Griffin, the expedition's surgeon, and Captain Abraham R. Johnston also kept journals that describe the route through eastern Arizona.

The group passed Steeple Rock, near present-day Lordsburg, New Mexico, on October 22, and on October 23 camped near the present-day New Mexico-Arizona border. In the last miles of New Mexico, Emory remarked that "the general appearance, width of the valley, and soil" along the Gila reminded him of the Rio Grande in New Mexico, so it is not surprising that on that day, they came across "one of the long-sought ruins," rectangular stone alignments and "immense quantities of broken pottery, extending for two miles along the river." (Emory 1951:105). Dr. Griffin wrote,

> *This morning we left camp about 9 oclock, crossed the River, and marched down the bottom on the north side of the stream, the road was quite level, but ye gods the dust. I never suffered or saw men suffer more from any trifling annoyance in my life. The grass & weeds indicated quite strong soil, and might be cultivated by proper irrigation. We saw one or two wild geese & two or three flocks of ducks--the advanced guard saw the black quail & the common quail of the United States. No other game was seen, the fact is Carson says he never knew a party on the Gila, that did not leave it starving [Griffin 1943:26].*

Johnston took great interest in the prehistoric ruins the group encountered and made sketch maps of several of them, recording dimensions of the ruins and drawing the potsherds. He marveled at the notion that farming could ever have been practiced in the area:

> *It can scarcely be believed that this sterile region was ever inhabited by a people differing much from the savage race now found here, the country does not afford resources for a civilized population. The soil is sterile beyond conception, producing the cactus in every variety, and in great abundance, but nothing else save a sparse growth of grass, which though scarce, is of excellent quality--as a stock raising country it might have been settled at one time, and maybe settled again, but nothing else I feel assured [Johnston 1848:89].*

On October 24, the group passed additional ruined villages, including house foundations measuring 20 by 60 feet. Emory wrote that "We feasted to-day on blue quail and teal, and at night Stanly came in with a goose. 'Signs' of beaver and deer were very distinct; these, with the wolf, constitute the only animals yet traced on the river." (Emory 1951:106). Griffin (1943:26) wrote, "We have been fishing & caught nothing. ... No fish caught and only one goose killed."

On October 25, Emory described the country "as much the same as before represented" (Emory 1951:106), and they passed two more ruins, including house foundations measuring up to 30 by 40 feet (Emory 1951:107). Towards evening, the terrain "broke into irregular and fantastic-looking mountains" (Emory 1951:106), and that night they camped just east of the confluence of the Gila and the San Francisco (which Emory called the Prieto River). Johnston (1848:90) wrote, "We have marched today about 20 miles--greater part of the time on the bottom of the river, then taking to the hills marched several miles over precipitous hills and deep ravines, and are encamped on a high hill which enables us to the course of the river for miles." Johnston (1848:91) further remarked on seeing "innumerable partridges" that day.

On October 26,

> *Soon after leaving camp, the banks of the river became gullied on each side by deep and impassable arroyos. This drove us insensibly to the mountains, until at length we found ourselves some thousand feet above the river, and it was not until we had made sixteen miles that we again descended to it [Emory 1951:108].*

Emory noted that the mountains to the north were "deeply indented by the ingress into the Gila of the Prieto (Black) [today's San Francisco] and Azul (Blue) [today's Eagle Creek] rivers" (Emory 1951:108). Emory (1951:109) heard from Londreau (Antoine Leroux?) stories about the Pattie misfortunes some 20 years before:

> *As the story goes, the Prieto flows down from the mountains, freighted with gold. Its sands are said to be full of this precious metal. A few adventurers, who ascended this river hunting beaver, washed the sands at night when they halted, and were richly rewarded for their trouble. Tempted by their success, they made a second trip, and were attacked and most of them killed by the Indians. My authority for this statement is Londreau [Leroux?], who, though an illiterate man, is truthful [Emory 1951:109].*

"The Name Rio de los Santos Apostoles was still in use on a map made by Capt. Clark and sent to President Thomas Jefferson on April 7, 1805" (Granger 1983:260).

The Boundary Survey

The Gila was the boundary between the United States and Mexico from 1848 to 1853, when the Gadsden Purchase extended United States territory to the south. 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 Guadelupe 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.

Bartlett (1854[II]:160) commented on the navigability of the Gila as follows, concluding that in the best of circumstances the Gila was navigable only in its lower reaches (below its confluence with the Salt). He wrote, "It is doubtful whether it can ever be navigated, except at its floods, and these are by no means regular. At such times flat-bottomed boats might pass to the mouth of the Salinas, near the Pima villages" (Bartlett 1854[II]:160). Furthermore, Lieutenant Amiel Weeks Whipple of the Corps of Topographical Engineers, who did virtually all of the actual surveying, felt that the Gila River was an impracticable route for a wagon road or railroad because of the canyons along it:

> *From what precedes [Whipple's descriptions of various canyons] it may be inferred that it would hardly be practicable to construct "a road, canal, or railway" to run wholly upon the river Gila. The Cañon of the Pinall Leño Mountains is a complete barrier. The Pass below the junction of the Rio San Pedro, is equally impracticable. Between the Pimo settlements and the junction of the Gila with the Colorado, nature imposes no serious obstacle to the construction of a way of communication, such as the travelling public may demand. But from the Pimo village to the Rio Del Norte, I know of no practicable route even for a wagon road, except by entering the State of Sonora to avoid the Pinall Leño Mountains [Whipple 1852:599].*

One of the stipulations of the Treaty of Guadalupe Hidalgo was that the United States would recognize Spanish and Mexican land grants. Subsequently, numerous claims of land grants had to be adjudicated. The Peralta-Reavis claim, which was found not to be valid, included 13,000,000 acres in the Gila River Valley from the Arizona-New Mexico border nearly to the Gila-Salt confluence (Tellman and Yarde 1996:18).

The Apache Wars

Beginning in the 1860s, the United States miliary began establishing a system of military posts throughout southeastern Arizona to control the Apaches. Among these bases were Fort Aravaipa (later Fort Breckinridge, then Camp Grant, and finally Fort Grant), Fort Bowie, Fort Goodwin (on the Gila River below the study area), Fort Apache, Camp San Carlos, and Fort Thomas (on the Gila River below the study area). The Apaches were then forced onto reservations that were usually outside the traditional homelands of most of the Apaches who were expected to live there. Furthermore, boundaries of reservations were reduced to accommodate mining, grazing, and other interests, and even entire reservations (such as the Chiricahua Apache Indian Reservation) were abolished. The Apachean groups that used the San Francisco and upper Gila rivers in eastern Arizona were expected to move first to the Chiricahua Apache Indian Reservation, established in 1872 and abolished in 1876, and then were ordered to move to the San Carlos Apache Indian Reservation, established in 1872. Resistance to these moves resulted in a number of conflicts in the study area, perhaps the most famous of which was the 1882 attack on the York ranch by a band of Chiricahua Apaches led by Loco, Chatto, and Naiche (Woody and Schwartz 1977:57-). Apachean resistance continued until 1886, when Geronimo surrendered for the final time.

Mining

During the Apache wars, troops discovered copper deposits on the San Francisco River. These deposits began to be developed in 1872, resulting in the creation of the Clifton-Morenci mining district.

According to Granger (1983:158), "Lt. John G. Bourke says that he was with an army scouting expedition c. 1869 which found rich ore in the vicinity of the later Clifton. The men took pieces of ore to Tucson, but not until c. 1872 did prospectors and miners from Silver City, New Mexico, explore the area and establish copper mine locations." Bourke (1891) wrote:

> *We were among the very first to come upon the rich ledges of copper which have since furnished the mainstay to the prosperity of the town of Clifton, on the border of New Mexico, and we knocked off pieces of pure metal, and brought them back to show the people there, on returning from our scouts in the upper Gila [Bourke 1891:98-99].*

In 1871, J. H. Holbrook led a group of 21 prospectors (including "Mase" Greenlee) from Pueblo, Colorado, to the Gila River Valley, and they prospected in the area that would later become Clifton and Morenci, but they were forced out by Indians (Patton 1977:155 n.14).

In 1872, three groups of prospectors established claims for copper mines in the Clifton area (Patton 1977:9). The first group included J. M. Bullard, Joe Yankie, and six others from Silver City, New Mexico. The second group was led by Captain Jay and I. N. Stevens. These two parties located the Montezuma, Copper Mountains, Yankie, and Arizona Central Mining Claims. The third group of miners who staked claims in the area were led by Bob and Jim Metcalf, who established the Longfellow and Metcalf mines. According to Granger (1983:158), the prospectors and miners from Silver City, New Mexico included Charles M. Shannon, Charles Lezinsky, and Lezinsky's brother. In August, 1872, the Copper Mountain Mining District was organized (Patton 1977:9).

Among the first miners in the Clifton area were Charles and Baylor Shannon, nephews of Robert and Jim Metcalf. Charles located claims on Chase Creek. At what was later Metcalf, he built the Shannon smelter for the Shannon Copper Company on [Shannon Mountain]" (Granger 1983:555). "The smelted ore which Lesinsky produced at this time he shipped by ox and mule team to Kansas City twelve hundred miles away" (Patton 1977:13). Patton (1977:48) published a photograph of one of the burro trains with the caption, "Burro ore trains were used to transport the ore in the beginning."

In 1883, James Colquhoun arrived in Clifton, having taken the train from Lordsburg. Colquhoun described the communities along the Gila River as follows (Patton 1977):

> *Duncan was a mere hamlet, the home of the Parks family, a hardy fearless race of natural pioneers. Seven miles north of Duncan we passed the York ranch, home of the beautiful York girls whose father was slain by the Apaches. Nearer Guthrie was the Coronado ranch. These were the only settlements found between Lordsburg and Clifton [Patton 1977:20].*

At this time "The courthouse, made of canvas, stood in what is now the river bed" (Patton 1977:21).

> *The bridge over the Gila near Old San Carlos, one of the biggest on the road, was severely damaged in the summer of 1898, half of it being washed away by a flash flood. The missing supports were replaced temporarily by a sort of matchstick method using 5000 railroad ties. The next day, another flash flood took all 5000 of them downstream toward the Gulf of California [Woody and Schwartz 1977:199].*

Circa 1900, "The only means of crossing the river was by means of swinging bridges. ... Since these bridges were small and intended only for foot passengers, horses and wagons had to ford the stream" (Patton 1977:27).

Clifton reached its peak population about 1910, when it had about 5,000 residents (Patton 1977:70). According to Patton (1977:70), "The greatest building boom in Clifton's history was in 1912 and 1913. At that time the Chase Creek, Shannon Hill, and High School buildings, were built, and Mrs. Reardon had the fine little hotel constructed in South Clifton which was soon to replace the Clifton Hotel as the town's leading hostelry." The Arizona Copper Company built a mansion for its president at "the site of the old circus grounds on Eastside. ... It was low, so a ten foot levee was built and the ground filled in behind it to the top of the wall" (Patton 1977:71). In 1912, the "Southern Pacific Railway Company built a fine new passenger and freight station" (Patton 1977:71).

Farming and Ranching

Farming and ranching developed at about the same time as mining in the study area, during the 1870s. Farming was concentrated on the Gila River, which provided water for irrigation of adjacent fields. A number of farming communities--including Duncan, Franklin, Guthrie, Purdy, Sheldon, and York--were located along the Gila River. A limited amount of irrigation agriculture was also practiced on the San Francisco River.

One of the earliest cattle trails through Arizona passed through the upper Gila River valley along the old Kearny route. As described by Haskett (1935):

> *The one leading into central Arizona diverged from this [Goodnight-Loving or Pecos] trail near Roswell, New Mexico, ran west by way of Tularosa and Silver City to the San Francisco River, thence down that stream to its juncture with the Gila on into Arizona, where it divided, its branches going to various parts of the territory [Haskett 1935:21].*

York Ranch was one of the earliest ranches in the region, and a small community grew up around it. As described by Woody and Schwartz (1977):

> *The York family came to the Gila country from Colorado in 1877, stopping in Silver City and ranching for a time in New Mexico. The settled as ranchers in wild country in 1878 in a large adobe house, located on a bench above the Gila River, which often served as a resting place for travelers en route to Clifton [Woody and Schwartz 1977:57].*

In 1882, York ranch was attacked by a band of Chiricahua Apaches that included Loco, Chatto, and Naiche (Woody and Schwartz 1977:57-60).

One of the largest ranches in the Clifton area was the Double Circle Ranch. It was started in the late 1870s as a sheep ranch. In 1884, Joseph H. Hampson purchased it and began running cattle. He sold the ranch in 1908 to a group that formed the Double Circle Cattle Company in 1909. The ranch was dissolved in 1936 (Patton 1977:118-120).

George Wells started a ranch on the San Francisco River above Clifton in the late 1870s. By 1886 it was being farmed by Charley Wing (Granger 1983:452).
One of the most luxurious ranches in the area belonged to Dell Potter. Patton (1977) described it as follows:

> *Early in the twentieth century he had a beautiful home built on his ranch two miles above Clifton. He sent to Los Angeles and had an architect draw up plans for it. The design was a mixture of Spanish and southern plantation. When complete it was the show place of Clifton and one of the finest residences in Arizona. It had hardwood floors and running water. A broad verandah extended around two sides of it. The grounds were beautified with fruit trees and shrubbery. The water supply was pumped by an ingenious pumping device, which utilized a large amount of water from the river to furnish power to pump a small amount to a tank high on the side of the mountain from which it flowed into his fields and orchards. He planted an acre of mulberry trees and sodded the ground with fine grass. Anyone who wished could go there for picnics under the mulberry trees free of charge [Patton 1977:74 n.15].*

A notation on a photograph of Clifton in April of 1905 (University of Arizona, Special Collections, File: Clifton [Ariz.] File 1, Fol. 1, and Stereographs, Photographs) described Potter's Ranch as follows: "Up the cañon on the right, the train takes you to the camp of Metcalf, and the stage road to Morenci also runs in this direction. There is a beautiful farm up this canyon owned by a man named Potter. The home is exceptionally attractive and the orchard and flower beds are a veritable Eden compared with the surrounding walls of high, barren mountains."

A map of irrigated areas in Arizona in 1901 (Bureau of the Census 1901) shows most of the Gila River valley above the confluence with the San Francisco River was irrigated, but only one small area of the San Francisco River (well above Dell Potter's ranch) was irrigated.

From about 1900 to 1905, large herds of goats were introduced to the mountains above Clifton, and caused so much erosion that they were blamed for the floods that occurred in Clifton in subsequent years. In response to this overgrazing, the federal government closed the area north of Clifton to further settlement in 1905 (Olmstead 1919:65).

Rush (1922) described the irrigation agriculture in Greenlee County circa 1922, stating, "At present there are about 54 miles of main irrigation canals in the valley, carrying water to about 4500 acres of farm land. Winding through the valley is the Gila River, which furnishes water for the cattle that feed on the ranges adjacent to the valley, and also irrigation water for the many fertile farms which have been developed along the banks of the river."

Cities and Towns

A number of cities and towns were located in the vicinity of the study area. Clifton is located on the San Francisco River. Oroville, now abandoned, was located upstream. The communities of Duncan, Franklin, Guthrie, Purdy, Sheldon, and York were located on the Gila River. Benton, Boyles, Coronado Mining Community, and Morenci were among the communities located nearby.

Benton. Benton, now the Rail H U Ranch, was located 3.5 miles above the junction of the Blue and Little Blue. It was named after a "cattle rancher (first name unknown) killed in the first Apache raid on the Blue River c. 1889" (Granger 1983:60). Benton was the location of a Sawmill run by Ira Harper. It also had a school. 1904-6 flooding destroyed the town. The post office was established in 1903 and abandoned in 1907 when postmaster Max A. Balke and his family left.

Boyles. Boyles was at the location of the Dick and Abe Boyles Ranch. "After Benton was flooded out of existence, Mr. and Mrs. Dick Boyles stated a saloon and little store which contained the post office. It was first called Carpenter after the name of its postmistress. (Boyles had bought out the old Carpenter Ranch.) The name was later changed to Boyles Ranch" (Granger 1983:88-89). The post office was established as Carpenter on February 12, 1903, replaced by Boyles on April 4, 1906, and dissolved on October 31, 1906. Note that these dates indicate that Boyles and Benton were contemporaneous.

Clifton. As has been described above, Clifton was settled in 1872 as a mining camp, but grew to become the largest town in the study area and in 1899 was named the county seat of Greenlee County. Located along the San Francisco River, Clifton suffered from regular flooding.

Duncan. Duncan, named after J. Duncan Smith (whose brother was sheriff Guthrie Smith) was built in 1883 along with the Arizona and New Mexico Railroad (Granger 1983:218). In 1922, Duncan had a population of 750 and contained 15 businesses, 2 garages, 1 bank, 2 hotels, restaurants, churches, and a high school (Rush 1922). A dairy farm was nearby (Rush 1922), and a dairy had been operated by Ed and Wayne Lunt since 1919 (Fenn 1977:37).

Coronado Mining Community. Coronado Mining Community on Coronado Mountain had a post office from 1913 to 1919. On August 15, 1913, nine miners were killed in an ore car accident (seven survived) (Granger 1983:175-176).

Franklin. Thomas A. McGrath was the first settler along the Gila River in the area that later became Franklin (McClintock 1921:250). In 1895, a group of Utah Mormons led by Thomas J. Nations settled the community and began irrigation works. In 1898, the community was organized as a ward and named for Franklin D. Richards, a deceased apostle of the LDS church (McClintock 1921:250). The community was 7 miles long and extended into New Mexico (McClintock 1921:250). Franklin had numerous orchards (Rush 1922).

Guthrie. Guthrie Smith and J. Duncan Smith sold land in 1883 to the Arizona Copper Company, which built the Arizona and New Mexico Railroad. Guthrie was a railroad station (Granger 1983:282).

Morenci. About 1871, John A. "Slim" Joy operated Joy's Camp at this location. In 1881, "William Joy sought a loan of $50,000 from the Phelps Dodge Corp. in New York City and offered his copper mine and smelter in Morenci as security" (Granger 1983:421).

Oroville. Oroville was located on the San Francisco River a few miles above Clifton, across the river from the Wells Ranch, established by George Wells in the 1870s and farmed by Charley Wing in 1886 (Granger 1983:452). According to Granger (1983),

> *Chinese living here raised produce for Clifton residents. ... Unfortunately, local Mexican-Americans knew that the Chinese hoarded money to pay their passage to China, and in January 1904, a dynamite blast forced the Chinese to leave their homes, which were then subject to looting. About four Chinese were killed as they fled [Granger 1983:452].*

Purdy. Purdy, across the river from Duncan, was replaced by Duncan when the railroad was constructed in 1883 (Granger 1983:218).

Sheldon. Sheldon was a railroad station established in 1884 (Granger 1983:557). Circa 1922 it had stores, farms, and ranches (Rush 1922).

York. York and the York Valley were named after the George R. York Ranch. In 1882 (elsewhere it says 1883), the railroad was built, and a station was established at York. On April 22, 1882, Loco and 500 other Apaches attacked the station/ranch (Granger 1983:691). Circa 1922 York had stores, farms, and ranches (Rush 1922).

Floods in Clifton

Floods in Clifton occurred in the 1870s, in 1880, in 1891, in 1903, twice in 1905, in 1906, and in 1916 (Patton 1977:79-84). The 1903 flooding killed at least 13 people, and prompted the Arizona Copper Company to build a stone wall 10 feet high along one side of Chase Creek to protect its property. Residents on the other side of Chase Creek were then forced to build their own flood wall, which was paid for using local subscriptions and city and county aid (Patton 1977:79-81). Two floods occurred in 1905. The first flood killed five people; the second flood caused less damage, primarily because areas and buildings that were susceptible to flooding were destroyed by the first flood (Patton 1977:81). On December 4, 1906, another flood struck Clifton, and this one killed 18 people (Patton 1977:81-82). After this flood, "Floodwalls were built along the river banks to supplement the ones already along Chase Creek. They were constructed of slag which was mortared together and were sixteen inches thick" (Patton 1977:84). A flood in 1916 went over the flood walls but did not cause much damage. As a result of this flood, however, the citizens of Clifton raised the floodwalls 2 feet (Patton 1977:84).

National Forests

In 1896 President McKinley created the Black Mesa Forest Preserve (Haskett 1896:36). By 1908 the Black Mesa Forest Preserve had been divided into Apache National Forest (Greer, Springerville, Blue River, and Clifton), and Sitgreaves National Forest (everything north) (Applewhite 1979:52). In the meantime, large herds of goats introduced into the mountains above Clifton from about 1900 to 1905 were thought to have overgrazed the area so extensively that they were blamed for much of the flooding in Clifton in 1905 and 1906 (Olmstead 1919:65). As a result, the federal government closed the area north of Clifton to further settlement in 1905 (Olmstead 1919:65).

HISTORICAL DESCRIPTIONS

The earliest descriptions of the upper Gila and San Francisco rivers are those of the trappers who found both streams were perennial and supported populations of beaver. When Kearny and the Army of the West passed down the Gila in 1846, they found a perennial stream that was often narrow and shallow enough to allow travel down the riverbed, although it often descended into impassable canyons. Emory (1951:106) reported seeing signs of beaver, deer, and wolf along the river, and Griffin (1943:26) and Johnston (1848:89) mentioned geese, ducks, quail, and partridges. Griffin (1943:26), though, noted that attempts at fishing were unsuccessful. Emory, Griffin, and Johnston mentioned the presence of ruins along the river, expressing amazement that sedentary farmers could ever have lived there. Bartlett (1854[II]:244) felt that the Gila, above its confluence with the Salt, was the smaller of the two rivers: "The quantity of water passing down the Salina is more than double that of the Gila, which only becomes a respectable river after it receives the water of the former." The *Weekly Arizonan* (April 7, 1859, p.1, col. 1-2) has a description of the Gila River and Valley and the ruins there. In later years, residents of the upper Gila River valley only rarely commented on the river.

The San Francisco River also has been little remarked upon, except when it flooded (see above). Shortridge (1990:1, 41) notes that circa 1915-1926 it was usually "relatively shallow" with "uncontaminated, cold mountain water" flowing across a "large expanse of white sand and reeds."

Carothers et al. (1982) describe the Frisco Canyon of the San Francisco River, between Frisco Hot Springs, New Mexico, and the Martinez Ranch, above Clifton, Arizona, as follows:

> *The San Francisco River between Frisco Hot Springs and Martinez Ranch flows through a steep-walled canyon with a relatively flat floodplain averaging 300-600 ft (100-200 m) in width. The average elevational descent of the canyon is approximately 23 ft (7 m) per mile. Under nonflood conditions, the permanent flow stream width is generally less than 30 ft (10 m), and meanders back and forth across the floodplain. Changes in the position of the stream occur with each flood, ranging from minor shifts in channel preference to major changes which scour gravel bars, cut terraces, and topple large trees. During maximum flood stage the river flows from wall to wall across the floodplain, often with major effects on the riparian vegetation and channel position [Carothers et al. 1982:27].*

> *The flow of the San Francisco River meanders from wall to wall throughout it narrow confining canyon. These meanders often abut the canyon wall on either side, necessitating numerous river crossings for vehicular as well as foot traffic between Frisco Hot Springs and the Martinez Ranch [Carothers et al. 1982:87].*

Historical Uses

The primary uses of the upper Gila and San Francisco rivers have been for mining and irrigated agriculture, as described above.

Regional Transportation

The Gila River served as the pathway into southern Arizona by American trappers from the 1820s to the 1840s. In 1846 it also served as the pathway through southern Arizona by Kearny and the Army of the West. That same year, though, Colonel Philip St. George Cooke and the Mormon Battalion pioneered a route farther south that became the preferred route through southern Arizona. Thus, it was not until the mines at Clifton were established that regular transportation routes began to be established along the upper Gila and San Francisco rivers.

The earliest transportation in the area was by horseback, ox and mule team, and stagecoach. Railroads between mines and smelters began to be constructed in 1878, and in 1883-1884 the Arizona and New Mexico Railroad constructed a line that connected Clifton to the Southern Pacific line. Toll roads were constructed in the 1880s and 1890s, and by the early 1900s, highways suitable for automobile traffic were in place.

"The smelted ore which Lesinsky produced at this time he shipped by ox and mule team to Kansas City twelve hundred miles away" (Patton (1977:13). Patton (1977:48) published a photograph of one of the burro trains with the caption, "Burro ore trains were used to transport the ore in the beginning."

> *In the very earliest days of Clifton, i.e. in the 1870's, the town had two connections with the outside world. One of these was a stage road to Solomonville forty-five miles down the river. There was another stage road to Silver City, New Mexico a hundred miles to the southeast. These roads were typical of the western roads of that day in that they were made by merely cutting down the mesquite bushes and other desert plants. There were no bridges or culverts so a heavy rain made them impassable. During the eighties the road to Solomonville was made a toll road by Graham county, after which there was constant conflict between the people of Clifton and the county officials concerning rates. During the eighties and nineties Wells Fargo operated a stage and freighting business into Clifton from Solomonville [Patton 1977:72].*

The earliest railroads in the area connected mines and smelters. A railroad was built from Clifton to Longfellow in 1878 (Patton 1977:vi). In 1881, the Southern Pacific Railroad reached Lordsburg, New Mexico (Patton 1977:18). In 1883, the Arizona and New Mexico Railroad was built to connect Clifton to the main line (Granger 1983:218). Duncan and Guthrie were established at this time (Granger 1983:218, 282). Walker and Bufkin (1879:46-47) date the construction to 1883-4, and note that the Arizona and New Mexico Railroad included the Clifton & Southern Pacific (New Mexico) and Clifton & Lordsburg (Arizona) (Walker and Bufkin 1979:46-47). Patton (1977:72) also says that the railroad reached Clifton in 1884.

Dell Potter built a 20 gauge railroad from Clifton to his ranch 2 miles upstream. He called it the Clifton and Northern, but it consisted of ore cars pulled by mules (Patton 1977:74 n.15).

Around 1901, Dell Potter began to advocate a state road running east to west across southern Arizona (Patton 1977).

> *By 1911 he had gotten a broader vision and was advocating an ocean to ocean highway through Clifton. He organized a state Ocean to Ocean Highway Association of which he became president. ... In 1912 ... he made a trip from Los Angeles to New York with a party sponsored by the Los Angeles Times, who were supposed to find the most feasible route for and ocean to ocean highway. Potter persuaded them to come through Clifton. For awhile he though he had them convince that a route through Phoenix, Globe, Fort Thomas, Clifton, and on to Silver City via Mule Creek was practicable. He sent jubilant telegrams from New York City saying that Clifton was assured of being on the trans-continental route. Later, when one of the State's trans-continental routes went a hundred miles south through Duncan, Potter lugubriously admitted that there 'really was only one good route for a highway through Clifton, and the San Francisco River got it first' [Patton 1977:76].*

From 1896 to 1899 Victorian Carrasco, Jose Morales, Francisco Montez, and Andrez Serna built toll road from Buena Vista to the Coronado Station on the Arizona-New Mexico Railroad (Fenn 1977:41-42). The Coronado Trail, the highway from Clifton and Morenci north to Alpine and Springerville, was completed in 1926 (Shortridge 1990:68).

Boating

Several accounts describe boating on the upper Gila, and two accounts describe floating the San Francisco. Accounts of boating on the upper Gila date to 1895 (*Graham County Bulletin*, February 22, 1895, p. 3; *Phoenix Herald*, February 18, 25, 1895), 1909 (Granger 1983:259), and the 1980s (Salmon 1986). Accounts of floating the San Francisco River date to 1895 (*Graham County Bulletin*, February 22, 1895, p. 3; *Phoenix Herald*, February 18, 25, 1895), circa 1915-1926 (Shortridge 1990:41), and 1973 (Jones 1973).

The Graham County Bulletin (2/22/1895, p. 3) has a story by G. W. Evans and Amos Adams, who started at Clifton, January 2, and reached Riverside. The Arizona Pioneers Historical Society in Tucson did not allow this article to be photocopied, but the text of the article is as follows:

DOWN THE GILA

G. W. Evans and Amos Adams Report a Perilous Trip between San Carlos and Riverside

THE BULLETIN is in receipt of a long letter from Evans and Adams, who started from Clifton sometime ago for a voyage down the Gila in a boat. The letter is dated at Riverside, February 4. They report having had what a Pike county man would call a "hog killing" time until San Carlos was reached. Here the boys were advised by Marijilda Grijalva and others not to attempt to go down through the box canyon below there in a boat. The advice was not heeded and the navigators went through, but they were six days making 20 miles. Now we will let Evans speak:

"The canyon is a continuous series of rough rapids and falls for 81 miles. There was one place where the side of a quartzite cliff probably a thousand feet high had peeled off into the river, making an immense jam of boulders from the size of I. M. Solomon's brick store to a hen egg. We had supplied ourselves with about two hundred feet of half-inch rope and it came in very good play. In one place I did not see the boat for more than one hour, the water made so much spray and the chute was so narrow and crooked. I could not hear Adams' voice and had to pay the rope out by jerks. One place the rope broke and I thought good bye, poor Amos Adams; you can imagine my lonely feelings there amidst all that roaring, seething foaming mass of rocks and water. Hoping that perhaps the boat might be safe I concluded to try and reach it by swimming and plunged in clothes and all. After going some 75 feet, around a large rock, the water dashed me up against the cliff so hard that I was compelled to stay there and rest. In looking around for some way to get farther down stream, I happened to see a narrow shelf leading down stream, but with an upward trend of some 15 degrees; so pulling myself upon it, I looked directly down narrow chute of boiling and roaring water and beheld Adams, up to his knees in water in the boat, with nothing in sight except the top of the cabin in the center. As the boat seemed to be in very still water, I concluded to try and reach it by following the rock shelf I was on; after following it for 150 feet it ended in a dropoff of 50 feet. It was an awful looking distance to me, but `needs must when the devil drives,' so making a large knot in the end of my rope I secured it in a crevace of the rock and began lowering myself down; but soon found that the rope would not let me to the water by 20 feet, and not being able to hold any longer, I gave myself a shove with my feet, so as to clear all projecting rocks, and letting all holds go, I made as nice a kerplunk as was ever seen, so Adams says. I know I never touched any bottom. I left a nice piece of new rope hanging there for any fool tourist that may try the same route in the future. We finally got the boat to an eddy where we found one end is [sic] stove in. After taking off four inches we got it repaired and made a camping place, a pair of the most forlorn specimens of cold and wet humanity you ever saw. We are out of the box canyon now and have a smoother stretch of river ahead."

From Sacaton, the two hauled the boat overland to Phoenix, and then boated down the Salt and Gila rivers to Yuma (*Phoenix Herald*, February 18, 25, 1895).

In 1909, Stanley Sykes of Flagstaff canoed the entire length of the Gila River in Arizona, according to Granger (1983:259). This float trip is not mentioned, however, in Giclas's (1985) biographical sketch of Sykes.

In his reminiscences about his boyhood in Clifton from about 1915 to 1926, Harold Shortridge describes building a raft and taking a short trip down the San Francisco River:

> *The San Francisco River was one of the favorite places where we boys liked to be, although our mother expressly forbade our going there. There was a large expanse of white sand and reeds and the river itself was relatively shallow, lending itself beautifully to our needs. One of these needs was to float a raft. At one time we dressed ourselves as pirates, got aboard our raft waving wooden swords, and imagining great deeds. We decided to embark upon a long journey down to the sea and join Blackbeard. Since we overloaded our craft with eager boys, she foundered. The venture was reluctantly abandoned [Shortridge 1990:41].*

M. H. Salmon (1986) describes a trip down the Gila, on foot and in a canoe, from the headwaters of the Gila in New Mexico to below the Arizona Box, between Clifton and Safford. The entire portion of the trip in Arizona was made in a canoe. Salmon (1986:205-208) also describes 1970s and 1980s discussion about wilderness designation for Frisco Canyon (the San Francisco River canyon between Frisco Hot Springs in New Mexico and Clifton, Arizona). For the Frisco Canyon, he cites studies by Carothers (1982) and Hubbard and Hayward (1973).

The two float trips down the San Francisco are the one made by G. W. Evans and Amos Adams in 1895 from Clifton to the Gila (described above) and the one made by Jones (1973) in 1973.

Anderson and Hopkinson (1982, 1987:120) state that the Safford District Office of the Bureau of Land Management wrote them as follows:

> *The policy of this office is not to encourage floating the Gila and San Francisco Rivers. Submerged debris, such and fence wire and trees, and fluctuating water levels (flooding) make floating these rivers very hazardous. However, floating does occur in a variety of water craft [Anderson and Hopkinson 1982, 1987:120].*

Anderson and Hopkinson (1982, 1987:120) found other literature from the Safford District Office of the Bureau of Land Management indicating that the river could be run in rubber rafts or aluminum canoes. Currently, the BLM website describes boating the Gila River Box Canyon reach in less dire terms.

SUMMARY AND CONCLUSIONS

Both the upper Gila and the San Francisco rivers are perennial streams and are considered boatable streams today. The first accounts of boating the San Francisco River from Clifton to the Gila and then downstream on the Gila date to 1895. Apparently Stanley Sykes of Flagstaff boated the Gila from state line to state line in 1909. Shortridge describes trying to raft the San Francisco River at Clifton circa 1915 to 1926. Jones (1973) describes floating the San Francisco River in modern times; Salmon (1986) describes floating the upper Gila in recent years. Boating and rafting of the San Francisco River occurred during the heydays of mining, which began in the 1870s. Farming along the Gila River began in the 1870s, at about the time that mining began in the Clifton-Morenci area, and a map of irrigated areas in Arizona in 1901 (Bureau of the Census 1901) shows most of the Gila River valley above the confluence with the San Francisco River was irrigated, but only one small area of the San Francisco River was irrigated. Historical accounts describe irrigation agriculture at Oroville and Dell Potter's ranch, both above Clifton, in the early years of the twentieth century. Although both the upper Gila and the San Francisco rivers have been considered boatable both before and after the time of Arizona statehood, transportation has almost always been overland.

A NOTE ON SOURCES

Many of the primary sources on upper Gila and San Francisco River history are published and are available at the three major research libraries in the state: the University of Arizona library, the Hayden Library at Arizona State University, and the Cline Library at Northern Arizona University. The Flagstaff Public Library also has many of the key references. Each of these research libraries has photographic collections, which contain numerous historic photographs of the San Francisco River as it flows and floods through the town of Clifton. A few photographs of Dell Potter's ranch and of isolated reaches of the upper Gila River are also in these collections (see Appendix B).

General histories of Arizona (Bancroft 1888, 1889; Farish 1915; Hamilton 1928; Lockwood 1932; McClintock 1916a, 1916b; Wallace W. Elliott & Co. 1884) began to appear in the 1800s. At about the same time, promotional literature and guidebooks (Guild 1891; Hamilton 1884; Hinton 1878; Hodge 1877; James 1917) were published that provide contemporary descriptions of rivers, towns, mining, agriculture, transportation, and so forth.

More recent histories of Arizona include Faulk (1970), Trimble (1977, 1986), Wagoner (1970, 1975, 1977). Walker and Bufkin's (1986) historical atlas is extremely useful. Granger (1960, 1983, 1985) provides histories of Arizona place names. Often inaccurate, these books are nonetheless useful introductions to general historical patterns in a region. Davis (1982) is a good summary of the wildlife encountered by the earliest explorers of various parts of Arizona.

Corle (1951) is the classic history of the Gila River. Calvin (1946) is another general history of the Gila. The Arizona State Land Department, Arizona Geological Survey, and SWCA, Inc., Environmental Consultants (1996) did a study of Gila River navigability. McNamee (1994) has written a history of the Gila that has been criticized by a number of historians (Barbara Tellman: personal communication, 8/31/95).

The physical environments of the two streams are described in Anderson and Turner (1978); Carothers et al. 1982); Hjalmarson (1990); Humbard and Hayward (1973); Turner (1974); United

States Department of the Interior, Bureau of Land Management (1984); United States Department of the Interior, Bureau of Reclamation (1974); and United States Department of Agriculture, Forest Service, and United States Department of the Interior, Bureau of Land Management (n.d.).

Khera and Mariella (1983) is usually cited as the ethnography of the Yavapai. Pilles (1981) discusses the archaeology of this group. Gunnerson (1956, 1974) is the authority on the migration of the Apaches to the American Southwest, and Di Peso (1951, 1956), Ferg (1992), and others have discussed evidence for the arrival of the Apaches in southeastern Arizona. Basso (1983) is an excellent, recent, accessible description of the Western Apache; Opler (1983) fills the same need for the Chiricahua. Barrett (1970) and Debo (1976) are standard biographies of Geronimo, who (according to Debo) was born in the study area. Opler (1983) is also an excellent summary of the Apache wars.

The Spanish period is discussed generally in Officer (1987). Winship (1896, 1990) published the primary sources on the Coronado Expedition. Other accounts of the Coronado Expedition, its antecedents, and reconstructions of its route can be found in Bolton (1949, 1990), Day (1964), Di Peso (1951, 1956), Di Peso and Fenner (1974), Haury (1984), Hodge (1933), Hodge and Lewis (1907), Riley (1985), Sauer (1932, 1937), Schroeder (1955, 1956), and United State Department of the Interior, National Park Service (1991). Later Spanish explorations in the region are described in Benavides (1945), Bolton (1916), Hammond and Rey (1966), Lafora (1958), and Manje (1954).

The history of the fur trade in the Southwest has many students, although the primary documents are almost hopelessly inexact about dates and personnel. Hafen (1965) edited a ten-volume set of biographical sketches of individual mountain men involved in the fur trade. Weber (1971) is a general history of the fur trade in the Southwest. Pattie (1831, 1905, 1930, 1988) is the primary source on James Ohio Pattie's story of his years in the Southwest. Pattie is also discussed in Hill (1923a) and Kroeber (1964). Hill (1923b) and Holmes (1967) are biographies of Ewing Young. Carter (1968) is a biography of Kit Carson. Biographies of George C. Yount include Camp (1936, 1966), Wood (1941), and Yount (1923). Foreman (1941a, 1941b) and Parkhill (1965,

1966) have published biographies of Antoine Leroux. Templeton (1965) has published a biography of Thomas "Pegleg" Smith.

Emory (1848) is the foremost account of the 1846 Kearny expedition; Emory (1951) is a more accessible edition. The United States-Mexico Boundary Survey was described by Bartlett (1854). The Apache wars have an immense bibliography. Bourke (1891) is the classic primary account. Opler (1983) is a concise and dispassionate summary of the Apache wars.

A number of community histories have been written about Clifton (Carmichael and Keddie 1924; Colquhoun 1924, 1935[?]; Dillon 1992; Fenn 1977; Hatch, Dahood, and Fernandez 1982; Patton 1945, 1977; Rush 1922; Shortridge 1990; Vinson 1992). Dreyfus's (1972) history of Arizona counties includes information on Clifton. Fenn (1977) and Rush (1922) have information on neighboring towns. McClintock (1921) is the standard account of Mormon settlement in Arizona, including the town of Franklin. Sarah York (1928) described her family's settling in the area. Haskett (1935, 1936) has provided histories of stock raising in Arizona.

Development of transportation is described by B. Harris (1960) and C. Harris (1973) on the Gila Trail, Myrick (1975) on railroads, Applewhite (1979) on highways. Modern boating of the Gila and San Francisco rivers is described by Anderson and Hopkinson (1982, 1987), Jones 1973, and Salmon (1986a, 1986b).

CHRONOLOGY

1764 "Fr. Figueroa inaccurately mapped a San Francisco River" (Granger 1983:246).

1821 Mexican independence

1824-5 Sylvester and James Ohio Pattie trapped along the upper Gila and San Francisco rivers (Granger 1983:246). Granger cites Pattie (:90).

1826 William Wolfskill, Milton Sublette, George Yount and others trapped along the upper Gila in the summer of 1826 (Weber 1971).

1826 In the fall of 1826, at least four trapping expeditions were operating along the upper Gila: (1) a group led by Bill Williams and Ceran St. Vrain; (2) a group led by John Rowland; (3) a group led by Antoine Robidoux (and including James Ohio Pattie); and (4) a group led by Ewing Young (Weber 1971).

1827 In the fall of 1827, a group of trappers led by George C. Yount and Sylvester Pattie trapped along the upper Gila (Pattie 1831; Weber 1971).

1830 In September of 1830, Young and Carson went back to the Colorado River, down to the Gila, then up the Gila to the Santa Rita mines (arriving at Santa Rita in January of 1831). They continued on to Santa Fe (Carter 1968:44-50).

1846-8 Mexican War

1846 Stephen Watts Kearny and "The Army of the West?" passed down the Gila. Kearny was guided by Kit Carson. Lieutenant William Emory of the Corps of Topographical Engineers accompanied the expedition and described it.

1853 Gadsden Purchase

1856 U.S. Army officers reported outcrops of minerals in the Clifton area (Patton 1947:vi).

1869 "Lt. John W. Bourke says that he was with an army scouting expedition c. 1869 which found rich ore in the vicinity of the later Clifton. The men took pieces of ore to Tucson, but not until c. 1872 did prospectors and miners from Silver City, New Mexcio, explore the area and establish copper mine locations" (Granger 1983:158).

1870 Clifton established (Hjalmarson 1990). Note that this does not agree with Granger (1983) or Patton (1947), below. Granger and Patton are probably correct.

1871 J. H. Holbrook led a group of 21 prospectors (including "Mase" Greenlee) from Pueblo, Colorado, to the Gila River Valley, and they prospected in the area that would later become Clifton and Morenci, but they were forced out by Indians (Patton 1977:155 n.14).

1872 15 Mexicans founded Pueblo Viejo, later Solomonvillle, the first settlement in the Gila Valley (Granger 1983:503).

1872 Prospectors and miners from Silver City, New Mexico (including Charles M. Shannon, Charles Lezinsky, and Lezinsky's brother), established claims for copper mines in the Clifton area (Granger 1983:158). Patton (1947:9) says that three groups were in the area. In August, 1872, the Copper Mountain Mining District was organized.

1875 Clifton Post Office established (Granger 1983:158).

1878 Railroad built from Clifton to Longfellow (Patton 1977:vi).

1879-80 Coronado Rail Road built to Morenci (Walker and Bufkin 1979:46-47).

1880 Flood in Clifton (Hjalmarson 1990:30; Patton 1977:79).

1881 Southern Pacific Railroad reached Lordsburg, New Mexico (Patton 1977:18).

1882? York established (Granger 1983:691).

1883 Arizona and New Mexico Railroad built to connect Clifton to the main line (Granger 1983:218). Duncan, Guthrie established (Granger 1983:218, 282).

1883-4 Arizona and New Mexico Railroad built. Included Clifton & Southern Pacific (New Mexico) and Clifton & Lordsburg (Arizona) (Walker and Bufkin 1979:46-47).

1884 Sheldon established as railroad station (Granger 1983:557).

1885 Flood in Clifton (Hjalmarson 1990:30).

1891 Flood in Clifton (Hjalmarson 1990:30; Patton 1977:79). "The 1891 flood extended from mountain to mountain and inundated nearly all of Clifton" (Hjalmarson 1990:30).

1895 Mormons colonize Franklin (Granger 1983:247; McClintock 1928).

1896 President McKinley created Black Mesa Forest Preserve (Haskett 1896:36). By 1908 divided into Apache National Forest (Greer, Springerville, Blue River, and Clifton), and Sitgreaves National Forest (everything north) (Applewhite 1979:52).

1896-9 Victorian Carrasco, Jose Morales, Francisco Montez, and Andrez Serna built toll road from Buena Vista to the Coronado Station on the Arizona-New Mexico Railroad (Fenn 1977:41-42).

1901 Morenci Southern Railroad built (Walker and Bufkin 1979:46-47).

1903 Flood in Clifton killed at least 13 (Patton 1977:79-80).

1903 Boyles Post Office (Granger 1983:88-89).

1905 Two floods in Clifton, the first killed 5, the second was not as bad (Patton 1977:81).

1906 A major flood on the San Francisco River on December 4, 1906, killed 18 in the Clifton area (Granger 1983:158; Patton 1977:81-82).

1909 Shannon-Arizona built (Walker and Bufkin 1979:46-47).

1909 Clifton incorporated (Granger 1983:158).

1909 Stanley Sykes of Flagstaff canoed the entire length of the Gila River in Arizona (Granger 1983:259).

1909 Greenlee County created March 10, 1909, but did not begin operation until 1911 (Granger 1983:278; Patton 1977:157).

1910 Clifton made county seat of Greenlee County, November 8, 1910 (Granger 1983:158).

1912 Arizona Statehood.

1916 Two floods in Clifton (Hjalmarson 1990:30; Patton 1977:84).

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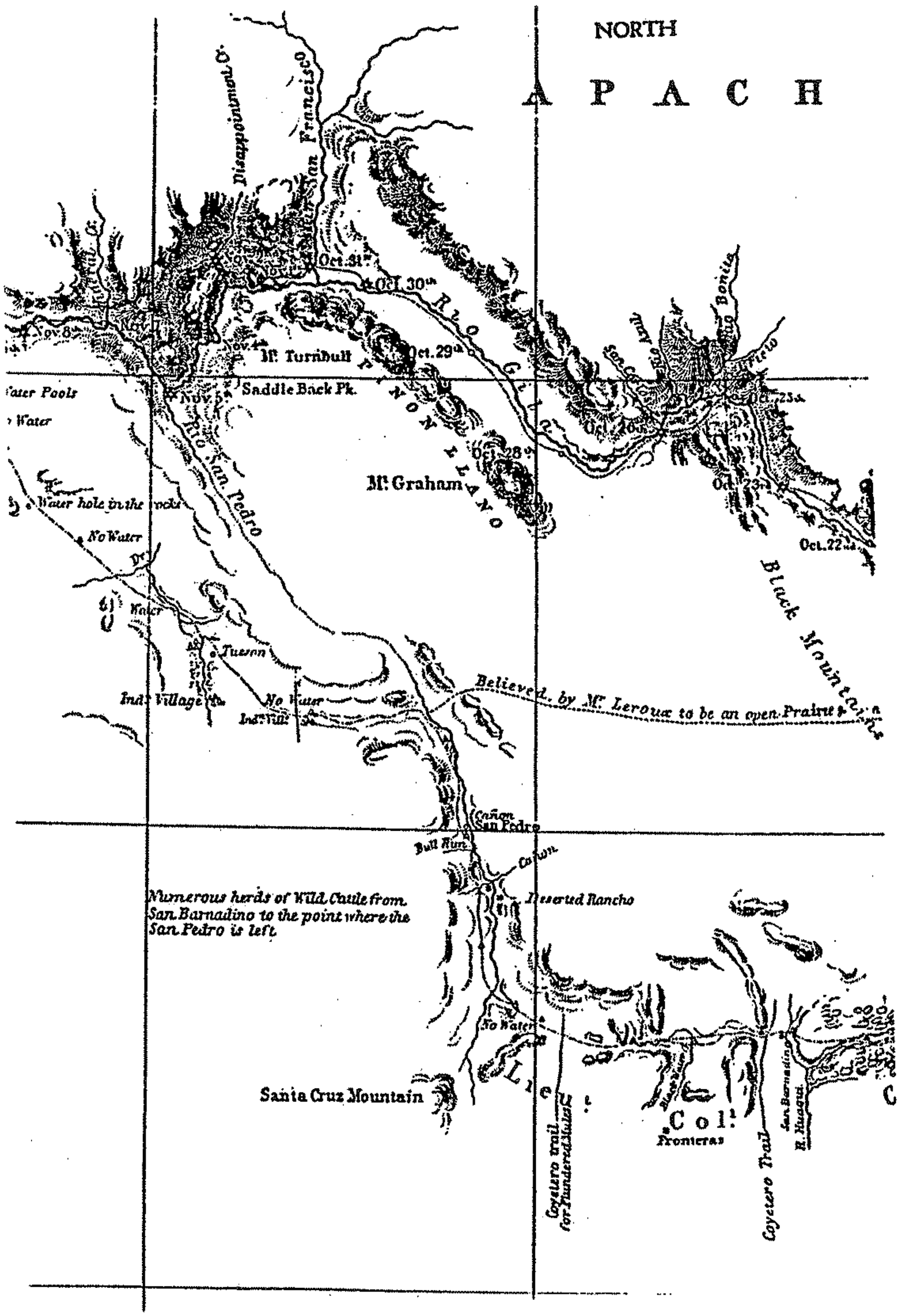
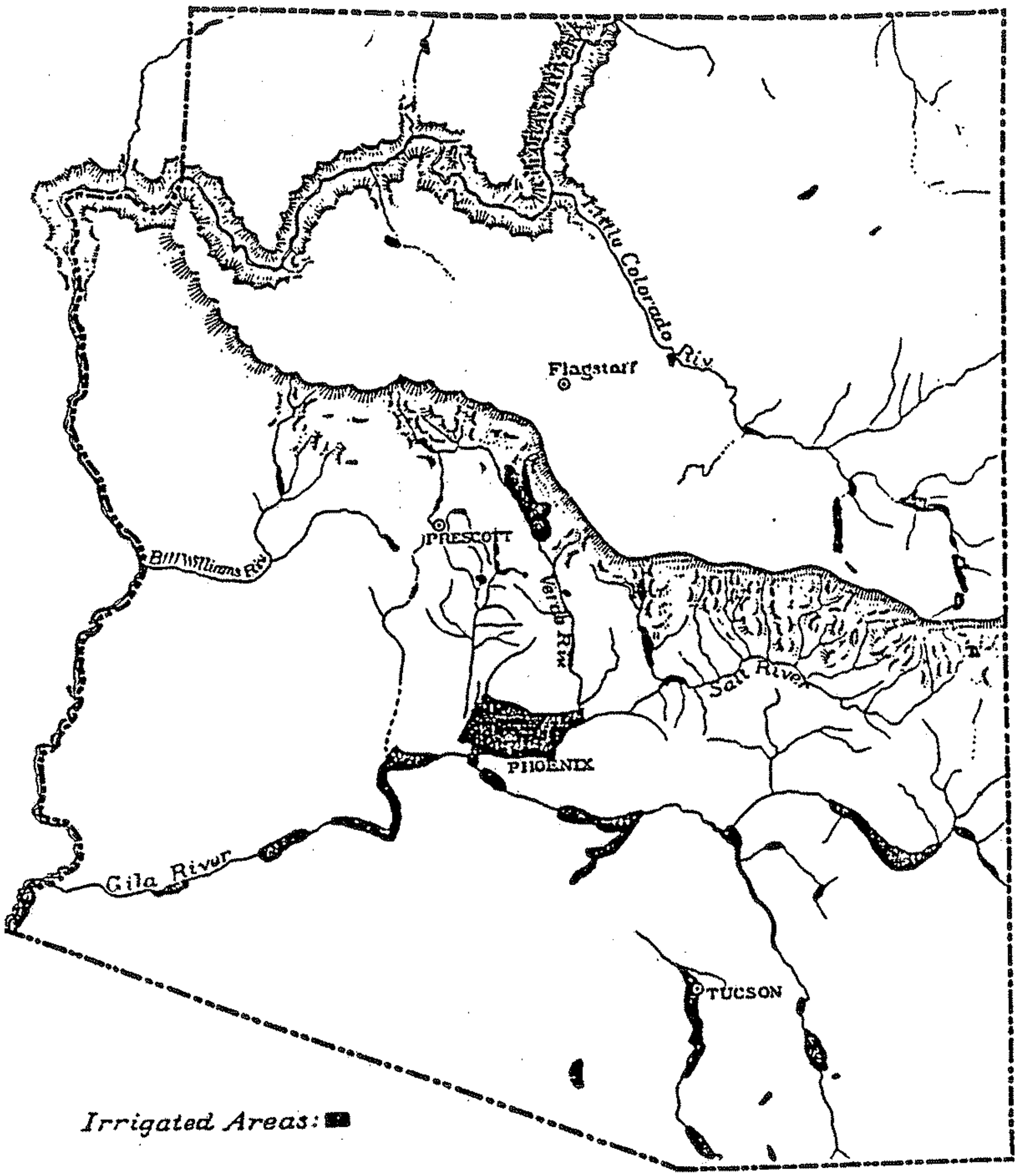
APPENDIX A

MAPS

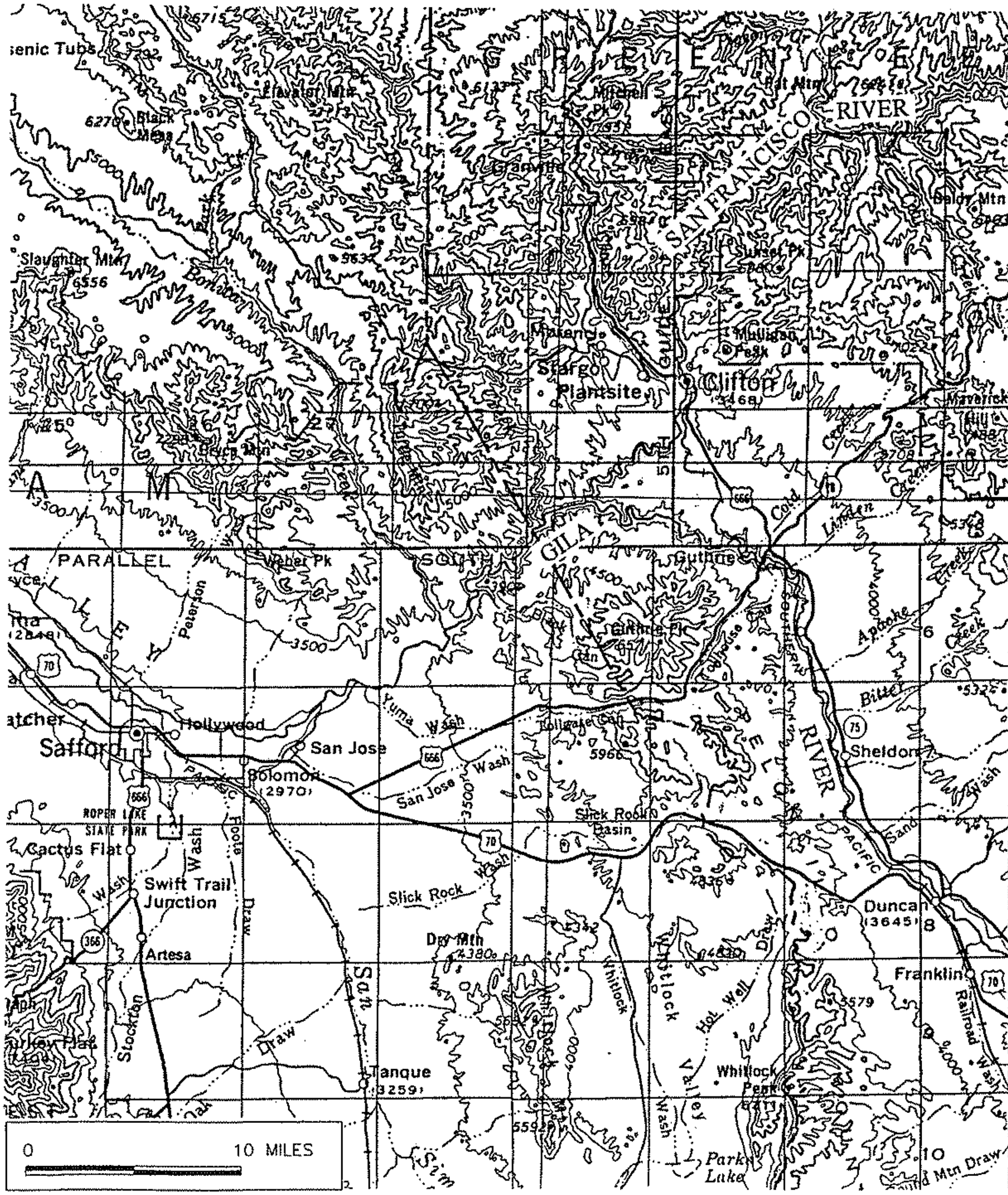


Portion of Emory's (1848) map showing Kearny's route from October 23, 1846 (current Arizona New Mexico border), to October 25, 1946 (east of mouth of San Francisco River, which Emory called the Rio Prieto)



From Census Bulletin No. 62, July 29 1901

Map of irrigated areas in Arizona from Census Bulletin No. 62, July 29, 1901.



Enlarged detail of modern map showing Upper Gila and San Francisco rivers (from State of Arizona, 1:500,000 USGS base map, revised 1981).

APPENDIX B

HISTORICAL PHOTOGRAPHS

INVENTORY OF HISTORICAL PHOTOGRAPHS
UPPER GILA AND SAN FRANCISCO RIVERS

Upper Gila River

Title: Gila River between Ft. Thomas and Solomonville, Oct. 7, 1885
Location: Arizona Pioneers Historical Society, Tucson; File: Estate of Charles B. Gatewood, Folder 13
Number: 19,677
Description/Comments: Estate of Charles B. Gatewood; since this is below the confluence of the Gila and the San Francisco, it may not be relevant to the navigability study.

Title: Gila River
Location: Arizona Pioneers Historical Society, Tucson; File: Places - Gila River
Number: 50192
Description/Comments: From Mrs. Arthur Curtis Hall, July 1971. Post card produced by Feldman's, El Paso.

Title: Gila Bridge between Safford and Clifton
Location: Arizona Pioneers Historical Society, Tucson; File: Places - Gila River
Number: 50193
Description/Comments: From Mrs. Arthur Curtis Hall, July 1971. Post card produced by Feldman's, El Paso.

Title: Gila River along the Silver City-Clifton Highway
Location: Arizona Pioneers Historical Society, Tucson; File: Bledsoe, Dr. Nelson C., Collection, Box 2
Number: 55109
Description/Comments: "Gila River, very much alive near its headwaters in southwwestern New Mexico." Since this is in New Mexico, it is probably not relevant to the navigability study.

Title: Gila River near the Silver City-Mogollon Highway
Location: Arizona Pioneers Historical Society, Tucson; File: Bledsoe, Dr. Nelson C., Collection, Box 2
Number: 59020
Description/Comments: "Gila River near Silver City, N. M." Since this is in New Mexico, it is probably not relevant to the navigability study.

Title: Crossing the Gila with Freight Team a Quarter Century Ago
Location: Published photograph in Rush (1922)
Number: N/A
Description/Comments:
Title: Duncan Bridge - Method of Crossing Gila Today
Location: Published photograph in Rush (1922)
Number: N/A

Description/Comments:

Title: On the Road from Duncan to Clifton
Location: Published photograph in Rush (1922)
Number: N/A
Description/Comments: Gila River bridge and dirt road

Title: A. & N. M. R. R. Bridge at Guthrie, Arizona
Location: Published photograph in Segal (n.d.)
Number: N/A
Description/Comments: View across bridge with Gila River in normal flow below.

Title: R. R. Bridge of the A. & N. M. R. R. at Guthrie, Arizona
Location: Published photograph in Segal (n.d.)
Number: N/A
Description/Comments: View under bridge with Gila River in normal flow on left.

San Francisco River

Title: Railroad along San Francisco River in Flood
Location: Arizona Pioneers Historical Society, Tucson
Number: 51196; File: Places - Clifton - Floods
Description/Comments: Risdon Photograph, from James J. O'Neil, M.D.

Title: Railroad Bridge in River - Clifton Flood 1905
Location: Arizona Pioneers Historical Society, Tucson
Number: 58651; File: Pictures - Places - Clifton - Floods
Description/Comments: From Mrs. Roy W. Hagan (Flossie Whipple) April 12, 1976

Title: Water in Front of Row of Houses - Clifton Flood 1905
Location: Arizona Pioneers Historical Society, Tucson
Number: 58652; File: Pictures - Places - Clifton - Floods
Description/Comments: From Mrs. Roy W. Hagan (Flossie Whipple) April 12, 1976

Title: Railroad along San Francisco River in Flood
Location: Arizona Pioneers Historical Society, Tucson
Number: 51196; File: Pictures - Places - Clifton - Floods
Description/Comments: Risdon Photograph, from James T. O'Neil, M.D., Dec. 1971

Title: Flood at Clifton, Arizona - February 27, 1891.
Location: Arizona Pioneers Historical Society, Tucson
Number: 2296; File: Places - Clifton - Floods
Description/Comments: "Flood at Clifton, Arizona - February 27, 1891. Salcidos and the bridge at Clifton during the flood. No. 1 where section house stood before the flood. The

following information from Samuel Kelly, 3/11/74. Far end of RR bridge leads to what was later called H ills a ddition. C anyon l eading o ff t o l eft b etween d ark h ill (foreground) and light mountain (background) is Word's Canyon. Where No. 1 is shown on photo is the site of the early Arizona and New Mexico RR freight sheds. Tracks, old depot and about 100 yards north (up stream) were the residences of the officials of the Arizona Copper Company (not in photo)."

Title: Clifton, Arizona, Looking North Up River, Jan. 3, 1891
Location: Arizona Pioneers Historical Society, Tucson
Number: 2302; File: Places - Clifton- Floods
Description/Comments: "Clifton, Arizona, Looking North Up River, Jan. 3, 1891. Photo taken before the flood that occurred February 27, 1891. In center below prominent peak is Arizona Copper Company Smelter, and the Arizona and New Mexico RR shops. To right of this peak and at river's `East Side' buildings and footbridge across river. Left half of picture shows railroad tracks."

Title: Clifton, Arizona, During the Flood of Feb. 27, 1891
Location: Arizona Pioneers Historical Society, Tucson
Number: 2303; File: Places - Clifton - Floods
Description/Comments: "Clifton, Arizona, During the Flood of Feb. 27, 1891. From right to left: Sherman's, Hopkins, the old Arizona and New Mexico Depot, and the residence of James Colquhous, Supt. on the Arizona Copper Co."

Title: Clifton, Arizona During Flood of Feb. 27, 1891
Location: Arizona Pioneers Historical Society, Tucson
Number: 2304; File: Places - Clifton - Floods
Description/Comments: "Clifton, Arizona During Flood of Feb. 27, 1891. From right to left: Shermons, Hopkins and residence of James Colquhoun (Supt. at Arizona Copper Co.). Vacant space between homes is where the Arizona and New Mexico R.R. Depot was just before the flood carried it away. See Photo #2303."

Title: Flood in Clifton, Arizona - ca 1903
Location: Arizona Pioneers Historical Society, Tucson
Number: 51028; File: Places - Clifton - Flood
Description/Comments: "Flood in Clifton, Arizona - ca 1903. Woodoen bldg at left center has Herald over door." Original Card Print by J. Nephew, Photographer. Original from Mrs. Tyler, Overpeck, Dec. 1971.

Title: Clifton, Arizona, After the Flood that Occurred Feb. 27, 1891
Location: Arizona Pioneers Historical Society, Tucson
Number: 2299; File: Places - Clifton - Floods
Description/Comments: "Clifton, Arizona, After the Flood that Occurred Feb. 27, 1891. The following information is from Samuel S. Kelly, 3/12/1974. Looking north upriver, the buildings in center below prominent peak is Arizona Copper Company smelter and Arizona and New Mexico R.R. shops. The 2 story frame building *may* have been an early general offices building of the Arizona Copper Co. To the right of the peak and at river's edge is North Clifton. To left of peak is chase Creek Canyon (in front of the smoke stack). Right half of photo shows `East Side' buildings and foot bridge across river."

Title: Clifton, An Arizona Mining Camp
Location: Arizona Pioneers Historical Society, Tucson
Number: 24960; File: Places - Clifton - General
Description/Comments: Original Card Print from Geo. H. Smalley estate. Same view as #, to north with San Francisco River in normal flow bottom center, smelter in center.

Title: The Arizona Copper Company's Reduction Plant at Clifton, Arizona Territory.
Location: University of Arizona, Special Collections
Number: None; File: Clifton, Arizona - Photographs (Oversize)
Description/Comments: "The Arizona Copper Company's Reduction Plant at Clifton, Arizona Territory. In 1882 the Metcalf brothers, Jim and Bob, sold the mines to the Arizona Copper Company of Edinburgh, Scotland. This picture was taken by early Arizona photographer, Albert S. Reynolds, who recorded the Territory in the 1880s and 1890s. Courtesy AHS."

Title: San Francisco River (N.M. & Ariz.)
Location: University of Arizona, Special Collections
Number: N-6027 a124; File: San Francisco River (N.M. & Ariz.) Photographs, Folder 1
Description/Comments: View from mountainside looking down at a footbridge across a bend in the river, which is at normal flow. Apparently from the L. Burr Hall collection, date circa 1920s, exact location unknown, although other photographs in this series were taken in the vicinity of Del Potter's ranch, upstream from Clifton. This is definitely the same footbridge that is shown in #N-6027 a129 (and possibly the footbridge in #N-6028 a126).

Title: San Francisco River (N.M. & Ariz.)
Location: University of Arizona, Special Collections
Number: N-6027 a129; File: San Francisco River (N.M. & Ariz.) Photographs, Folder 1
Description/Comments: Illustrates a suspension footbridge over a river at normal flow. Cottonwoods are present on the sandy banks. View is from river bed up towards footbridge. Apparently from the L. Burr Hall collection, date circa 1920s, exact location unknown, although other photographs in this series were taken in the vicinity of Del Potter's ranch, upstream from Clifton. This is definitely the same footbridge that is shown in #N-6027 a124 (and possibly the footbridge in #N-6028 a126).

Title: San Francisco River (N.M. & Ariz.)
Location: University of Arizona, Special Collections
Number: N-6027 a131; File: San Francisco River (N.M. & Ariz.) Photographs, Folder 1
Description/Comments: L. Burr Hall, Box 462, Tucson, Arizona, "#82," "1920s," illustrates a bend in the river, which is at normal flow, with a two-track dirt road on the left side. Two photographs designated N-6249 illustrate this same general scene and describe it as the San Francisco River in the vicinity of Del Potters, a ranch located upstream from Clifton.

Title: San Francisco River (N.M. & Ariz.)
Location: University of Arizona, Special Collections
Number: N-6028 a121; File: San Francisco River (N.M. & Ariz.) Photographs, Folder 1
Description/Comments: L. Burr Hall, Box 462, Tucson, Arizona, "#82," "1920s," illustrates a wooded floodplain, river not visible. From the L. Burr Hall collection, date circa 1920s, exact location unknown, although other photographs in this series were taken in the vicinity of Del Potter's ranch, upstream from Clifton.

Title: San Francisco River (N.M. & Ariz.)
Location: University of Arizona, Special Collections
Number: N-6028 a126; File: San Francisco River (N.M. & Ariz.) Photographs, Folder 1
Description/Comments: Illustrates sandy river bed, partly vegetated, river not visible, but a footbridge crosses the river. Apparently from the L. Burr Hall collection, date circa 1920s, exact location unknown, although this could be the same footbridge that is shown in #N-6027 a124 and #N-6027 a129. Also note that other photographs in this series were taken in the vicinity of Del Potter's ranch, upstream from Clifton.

Title: San Francisco River (N.M. & Ariz.)
Location: University of Arizona, Special Collections
Number: N-6028 a130; File: San Francisco River (N.M. & Ariz.) Photographs, Folder 1
Description/Comments: Illustrates a bend in the river, view upstream, with a road on the right side. Sandy river bottom, wooded floodplain. Apparently from the L. Burr Hall collection, date circa 1920s, exact location unknown, although other photographs in this series were taken in the vicinity of Del Potter's ranch, upstream from Clifton.

Title: San Francisco River Burro Wood Train, Late 1920s?
Location: University of Arizona, Special Collections
Number: N-6247; File: San Francisco River (N.M. & Ariz.) Photographs, Folder 1
Description/Comments: Illustrates a train of burros hauling wood across the river. Apparently from the L. Burr Hall collection, date circa 1920s, exact location unknown, although other photographs in this series were taken in the vicinity of Del Potter's ranch, upstream from Clifton.

Title: San Francisco River Scene about Del Potters, Late 1920s?
Location: University of Arizona, Special Collections
Number: N-6249; File: San Francisco River (N.M. & Ariz.) Photographs, Folder 1
Description/Comments: Same scene generally as N-6027 a131. Apparently from the L. Burr Hall collection, date circa 1920s, exact location unknown, although other photographs in this series were taken in the vicinity of Del Potter's ranch, upstream from Clifton.

Title: San Francisco River Scene about Del Potters, Late 1920s?
Location: University of Arizona, Special Collections
Number: N-6249; File: San Francisco River (N.M. & Ariz.) Photographs, Folder 1
Description/Comments: This is labeled the same as above, but it is a different scene. It is the same scene generally as N-6027 a131 and was taken from the same angle but from farther away. Apparently from the L. Burr Hall collection, date circa 1920s, exact location unknown, although other photographs in this series were taken in the vicinity of Del Potter's ranch, upstream from Clifton.

Title: Flood Flow in San Francisco River at Clifton, Ariz., December 1906
Location: University of Arizona, Special Collections
Number: N-6188; File: Floods - Arizona Photographs, Folder 2
Description/Comments: "Flood flow in San Francisco River at Clifton, Ariz., December, 1906. Damage at Clifton alone was estimated at $150,000." This photograph is in an envelope labeled "Photographs of Floods and Flood Damage in Arizona from files of Wilbur Weir, formerly with US Forest and Range Experiment Station, Tucson, Ariz. Photographs of flood waters of San Francisco River at Clifton, Ariz. were taken in 1906."

Title: 14-Mule Team in Morenci
Location: University of Arizona, Special Collections
Number: N-150; File: Clifton (Ariz.) File 2, Folder 1, Photographs - Lucas & Burlan; also File: Clifton (Ariz.) File 1, Fol. 1, and Stereographs, Photographs
Description/Comments: A 14-mule team in Morenci. "Gift of Peter Riley, 1960." Photograph by Lucas and Burlan, Silver City, N.M. This photograph does not show the river, but it is a good example of transportation. N-11291 (35 mm) is the same shot.

Title: The Old Smelter
Location: University of Arizona, Special Collections
Number: N-151; File: Clifton (Ariz.) File 2, Folder 2, Photographs - Gift of Walter Hadsell, 1961 (This photograph may be misfiled. It should probably be filed under Clifton [Ariz.] File 2, Folder 1, Photographs - Lucas & Burlan). Also in File: Clifton (Ariz.) Photographs File 1, Folder 3
Description/Comments: "The old smelter and where the present bridge is located. Gift of Peter Riley, 1960." A Lucas & Burlan photograph (#45). this is the same general view as #N-155, looking straight across the river at the smelter with a little water at the bottom of the photograph. This photograph is not very informative with regard to streamflow or navigability.

Title: Clifton in 1882
Location: University of Arizona, Special Collections
Number: N-153; File: Clifton (Ariz.) File 2, Folder 1, Photographs - Lucas & Burlan; also in File: Clifton (Ariz.) Photographs File 1, Folder 3
Description/Comments: "Clifton in 1882. Stream to left is from Hot Springs rising where the depot now stands. Gift of Peter Riley, 1960." Photograph by Lucas and Burlan, Silver City, N.M. This photograph shows the river (a braided stream) at normal flow looking upstream. The distinctive peak above Clifton is at left center. A garden in located in the floodplain in the left foreground.

Title: The Smelter in Clifton Nearing Completion
Location: University of Arizona, Special Collections
Number: N-155; File: Clifton (Ariz.) File 2, Folder 1, Photographs - Lucas & Burlan; also in File: Clifton (Ariz.) Photographs File 1, Folder 3
Description/Comments: "The smelter in Clifton nearing completion. Gift of Peter Riley, 1960." Photograph by Lucas and Burlan, Silver City, N.M. Like N-151, this photograph shows the smelter as seen from directly across the river, which appears as an area of slack water in normal flow at the bottom of the photograph. This picture is not very informative with regard to river flow or navigation.

Title: Footbridge, Smelter, Store, Chase Creek Business Section and Residences in Clifton in 1884
Location: University of Arizona, Special Collections
Number: N-157; File: Clifton (Ariz.) File 2, Folder 1, Photographs - Lucas & Burlan; also in File: Clifton (Ariz.) Photographs File 1, Folder 3
Description/Comments: "This picture shows the footbridge, smelter, store, Chase Creek business section and residences of the company officials of the Copper Co. The first house with windows was where the brewery was located. 1884. Gift of Peter Riley, 1960." Photograph by Lucas and Burlan, Silver City, N.M. The smelter is on the right, the footbridge on left.

Title: Railroad into Clifton about 1884
Location: University of Arizona, Special Collections
Number: N-158; File: Clifton (Ariz.) File 2, Folder 1, Photographs - Lucas & Burlan; also in File: Clifton (Ariz.) Photographs File 1, Folder 3
Description/Comments: "Clifton in 1882. Gift of Peter Riley, 1960." Front is labeled "Clifton, A.T." and numbered "47." Photograph by Lucas and Burlan, Silver City, N.M. This photograph shows a railroad bridge across the river at normal flow in a gravel streambed. The town of Clifton is not visible.

Title: Flood Scene about 1884 at Clifton, Arizona
Location: University of Arizona, Special Collections
Number: N-159; File: Clifton (Ariz.) File 2, Folder 1, Photographs - Lucas & Burlan; also File: Clifton (Ariz.) File 1, Fol. 1, and Stereographs, Photographs
Description/Comments: "Flood scene about 1884 at Clifton, Arizona. Chinamen lived in the house shown in the stream. This scene is north of the bridge in Clifton. Gift of Peter Riley, 1960." Photograph by Lucas and Burlan, Silver City, N.M." This photograph shows the river

flowing from mountain to mountain with two houses or tents and two trees on a tiny island in midstream.

Title: The Flume Bringing Water from the ? Frisco River above Clifton
Location: University of Arizona, Special Collections
Number: N-160; File: Clifton (Ariz.) File 2, Folder 1, Photographs - Lucas & Burlan; also in File: Clifton (Ariz.) Photographs File 1, Folder 3
Description/Comments: "The flume bringing water from the ? Frisco River above Clifton. Gift of Peter Riley, 1960." Photograph by Lucas and Burlan, Silver City, N.M. This photograph shows a railroad on the right and the river at normal flow in a gravel streambed.

Title: This Was the 1884 Flood
Location: University of Arizona, Special Collections
Number: N-161; File: Clifton (Ariz.) File 2, Folder 1, Photographs - Lucas & Burlan; also in File: Clifton (Ariz.) Photographs File 1, Folder 3
Description/Comments: "This was the 1884 flood, shows the narrow guage railroad that ran to Clifton from Lordsburg, New Mexico. The depot and stores in the background. Gift of Peter Riley, 1960." Photograph by Lucas and Burlan, Silver City, N.M. This photograph shows the railroad apparently still under construction, with pilings, but no bridge, crossing the river to a floodplain flat (Metz's Flat?). The river is high and solid, but does not stretch from mountain to mountain. On the flat, a few buildings are visible on both sides of the railroad. "Bridge on Metz's Flat, 1885(?) shows this same location.

Title: None
Location: University of Arizona, Special Collections
Number: N-167; File: Clifton (Ariz.) Photographs, File 1, Folder 3
Description/Comments: This is a view looking down at the stream from a hillside. Houses, tents, and garden plots are visible.

Title: San Francisco River Flows By
Location: University of Arizona, Special Collections
Number: None; File: Clifton (Ariz.) File 2, Folder 2, Photographs - Gift of Walter Hadsell, 1961
Description/Comments: Post card. "San Francisco River flows by, enters into the Gila River, then into the Salt River, & ends in the Colorado River. Notice that all the bldgs, Post office RR Depot, Bank all bang up against the mountain not afraid of rocks falling down." This is the standard shot of Clifton looking towards the smelter with the river in the lower center of the photograph and the river at normal flow. It is undated.

Title: Clifton, A.T., When the Snow Melts in the Mountains
Location: University of Arizona, Special Collections
Number: None; File: Clifton (Ariz.) File 2, Folder 2, Photographs - Gift of Walter Hadsell, 1961
Description/Comments: Post card. "Clifton, A.T. When the snow melts in the mountains look out for high water in the river." This is the same shot as N-6188 showing flooding from mountain to mountain.

Title: Bridge on Metz's Flat, 1885(?)
Location: University of Arizona, Special Collections
Number: None; File: Clifton (Ariz.) File 2, Folder 2, Photographs - Gift of Walter Hadsell, 1961
Description/Comments: "Bridge on Metz's Flat, 1885(?)" This photogaph is another Lucas & Burlen photograph (#48), but is not a Peter Riley gift. It shows the same location as N-161.

Title: Lower Clifton from Road to Morenci
Location: University of Arizona, Special Collections
Number: None; File: Clifton (Ariz.) File 2, Folder 2, Photographs - Gift of Walter Hadsell, 1961 (Walter Hadsell Album 1901)
Description/Comments: "Lower Clifton from Road to Morenci." This photogaph shows the river in normal flow with fields in the floodplain.

Title: Clifton, 1923
Location: University of Arizona, Special Collections
Number: None; File: Clifton (Ariz.) File 1, Fol. 1, and Stereographs, Photographs
Description/Comments: "Clifton 1923 No. 46" This photograph is a view across the river at a church. It is not very informative with regard to streamflow or navigability.

Title: Clifton, Arizona, April, 1905, Bird's Eye View
Location: University of Arizona, Special Collections
Number: None; File: Clifton (Ariz.) File 1, Fol. 1, and Stereographs, Photographs
Description/Comments: "Clifton, Arizona, April, 1905 This is sort of a bird's eye view of Clifton.... The last rain washed away thirteen buildings and rendered many others unsafe.... Up the cañon on the right, the train takes you to the camp of Metcalf, and the stage road to Morenci also runs in this direction. There is a beautiful farm up this canyon owned by a man named Potter. The home is exceptionally attractive and the orchard and flower beds are a veritable Eden compared with the surrounding walls of high, barren mountains. Population of Clifton about 5000 at present...." This is a good panorama of Clifton measuring approximately 3 x 12 inches. The river has normal flow.

Title: Clifton, Arizona, April, 1905
Location: University of Arizona, Special Collections
Number: None; File: Clifton (Ariz.) File 1, Fol. 1, and Stereographs, Photographs
Description/Comments: "Clifton, Arizona, April, 1905 This photo shows the `A.C.' smelter more distinctly.... The suspension footbridge leads to the entrance of the hotel. There is no other bridge, so all baggage is carried over by those human pack-animals, the Mexicans." This is a good panorama of Clifton measuring approximately 3 x 12 inches. The river has normal flow.

Title: 1903 Clifton, AZ
Location: University of Arizona, Special Collections
Number: N-3079; File: Clifton (Ariz.) File 1, Fol. 1, and Stereographs, Photographs; also File: Clifton (Ariz.) File 1, Fol. 1, and Stereographs, Photographs
Description/Comments: Stereograph, "1903 Clifton, AZ. Underwood & Underwood Publishers, New York, London, Toronto, Canada, Ottawa, Kansas Works and Studios Orlington, N.J., Westwood, N.J., Washington, D.C." This is a view to the north from the southeastern section of Clifton among the houses on the hillslope. A rock and adobe building is shown in the foreground, a circus tent in the floodplain on the left in the middle ground, the distinctive peak in the far background. Just a thin sliver of the river is visible in the far background, and thus the photograph is not very informative with regard to streamflow or navigability.

Title: Arizona Copper Co. 1906
Location: University of Arizona, Special Collections
Number: N-5037; File: Clifton (Ariz.) File 1, Fol. 1, and Stereographs, Photographs
Description/Comments: "Arizona Copper Co. 1906 General view of smelter Arizona Copper Co., Clifton, Arizona." The river is visible in front of the smelter, but the photograph provides little information on streamflow or navigability.

Title: Clifton (Ariz.) ca. 1910
Location: University of Arizona, Special Collections
Number: None; File: Clifton (Ariz.) File 1, Fol. 2, Photographs
Description/Comments: This photograph (which may be a view to the west) shows the river running along the base of the photograph and crossed by a footbridge. Beyond the river is the railroad and a mountain. The river then curves back into the photograph and is crossed by the railroad bridge on the left side of the photograph.

Title: Clifton
Location: University of Arizona, Special Collections
Number: None; File: Clifton (Ariz.) File 1, Fol. 2, Photographs
Description/Comments: This is the standard view of Clifton, looking north up the river with the smelter and the distinctive mountain in the center of the photograph. The footbridge across the river is visible in the foreground and the circus tent is present on the right bank of the river just to the right of the footbridge. Since the stereograph "1903 Clifton, AZ" also shows the circus tent, this photograph probably also dates to 1903. Here the river is in normal flow and is sort of braided.

Title: Arizona Copper Co., Clifton
Location: University of Arizona, Special Collections
Number: None; File: Clifton (Ariz.) File 1, Fol. 2, Photographs
Description/Comments: This view is looking directly across the river at the smelter, but it was taken from high enough on the opposite slope that the dry riverbed, with only a few damp spots, is clearly visible.

Title: Clifton 1911
Location: University of Arizona, Special Collections
Number: N-2805; File: Clifton (Ariz.) Photographs, File 1, Folder 3
Description/Comments: "Clifton 1911 Percy Jones Collection" This photograph is looking across a mostly dry river bed with a small stream perhaps 10 feet wide and 6 inches deep in the foreground. Houses are visible, but no other landmarks.

Title: Concrete Bridge over San Francisco River
Location: Published photograph in Rush (1922)
Number: N/A
Description/Comments: Concrete bridge in Clifton

Title: Steel Bridge at Clifton over San Francisco River
Location: Published photograph in Rush (1922)
Number: N/A
Description/Comments:

Title: Clifton, Arizona, Looking North
Location: Published photograph in Segal (n.d.)
Number: N/A
Description/Comments: This is the standard view of Clifton, looking north up the river with the smelter and the distinctive mountain in the center of the photograph. The footbridge across the river is visible in the foreground and the circus tent is present on the right bank of the river just to the right of the footbridge. Since the stereograph "1903 Clifton, AZ" also shows the circus tent, this photograph probably also dates to 1903. This is pretty much the same view as in "Clifton," above, but here the river flows bank to bank.

Title: South Clifton, Shannon Works in the Distance, A. & N. M. Railway Bridge
Location: Published photograph in Segal (n.d.)
Number: N/A
Description/Comments: View downstream with railroad bridge in center foreground, river in normal flow with some sand or gravel bars.

Title: Cottonwood trees on the `Frisco.
Location: Published photograph in Segal (n.d.)
Number: N/A
Description/Comments: Cabins on sandy banks beneath cottonwood trees with San Francisco River on right, full and placid.

Title: South Clifton
Location: Published photograph in Segal (n.d.)
Number: N/A
Description/Comments: View to west; San Francisco River appears to be almost dry.

Title: Arizona Copper Co.'s Reduction Works, Clifton, Arizona
Location: Published photograph in Segal (n.d.)
Number: N/A
Description/Comments: View to north across Chase Creek, San Francisco River appears as a braided stream on right side of photograph.

Title: Scenery on the San Francisco Three Miles Above Clifton
Location: Published photograph in Segal (n.d.)
Number: N/A
Description/Comments: Buggy on sandy bank, telephone/telegraph pole on left, cottonwood tree on right, fence in background, river not visible.

Title: On the Frisco River, Three Miles Above Clifton
Location: Published photograph in Segal (n.d.)
Number: N/A
Description/Comments: River fills foreground, placidly flowing, with small cataract in middle ground and placid pool beyond.

Title: Birdseye View of the Arizona Copper Co.'s Reduction Plant, Clifton
Location: Published photograph in Segal (n.d.)
Number: N/A
Description/Comments: View to west up Chase Creek on left, with river forming braided stream past slag heaps from mill.

Title: Portion of Clifton, Looking South
Location: Published photograph in Segal (n.d.)
Number: N/A
Description/Comments: View to south from east side of river, south end of Clifton; river bend can be seen in background.

Title: Clifton, Looking South
Location: Published photograph in Segal (n.d.)
Number: N/A
Description/Comments: View downriver from braided riverbed.

Title: Foot Bridge, Clifton
Location: Published photograph in Segal (n.d.)
Number: N/A
Description/Comments: View to west across footbridge.

Title: Burro Ore Train
Location: Published photograph in Segal (n.d.)
Number: N/A
Description/Comments: Although the river is not shown in this photograph, the photograph is an excellent picture of one of the burro trains that transported ore from mine to mill.

Title: "To the Log Camp" Scenery on the `Frisco, Four Miles Above Clifton
Location: Published photograph in Segal (n.d.)
Number: N/A
Description/Comments: Train of horse-drawn wagons crossing a placid but full San Francisco River.

Title: Railroad Bridge and Hospital at Clifton
Location: Published photograph in Segal (n.d.)
Number: N/A
Description/Comments: Railroad bridge crossing San Francisco River in normal flow.

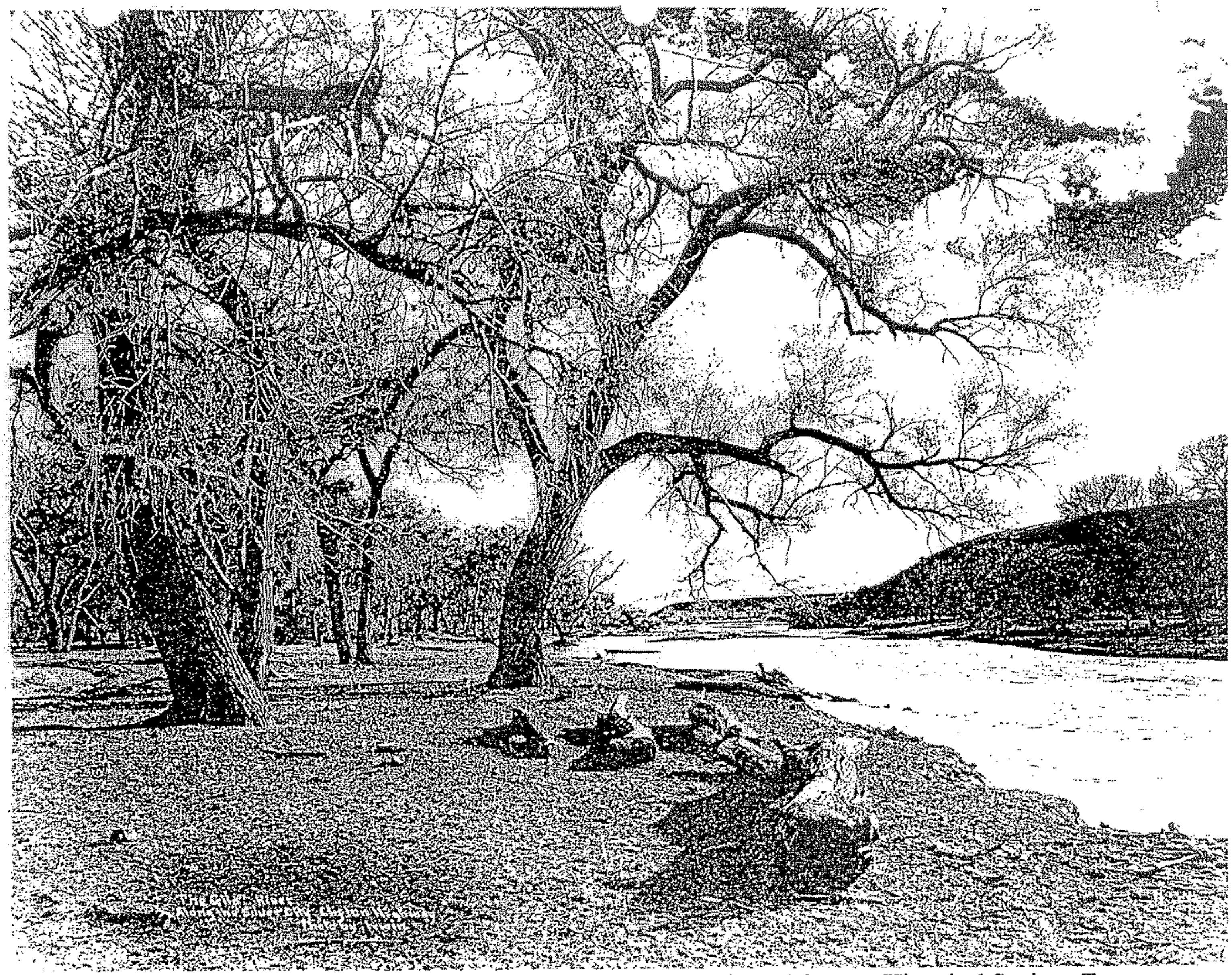
Title: Upper Reaches
Location: Published photograph in Olmstead (1919:Plate 19)
Number: N/A
Description/Comments: Stream flowing through meadows, probably near Alpine, Arizona.

Title: At Junction with Gila
Location: Published photograph in Olmstead (1919:Plate 19)
Number: N/A
Description/Comments: Stream flowing through canyon.

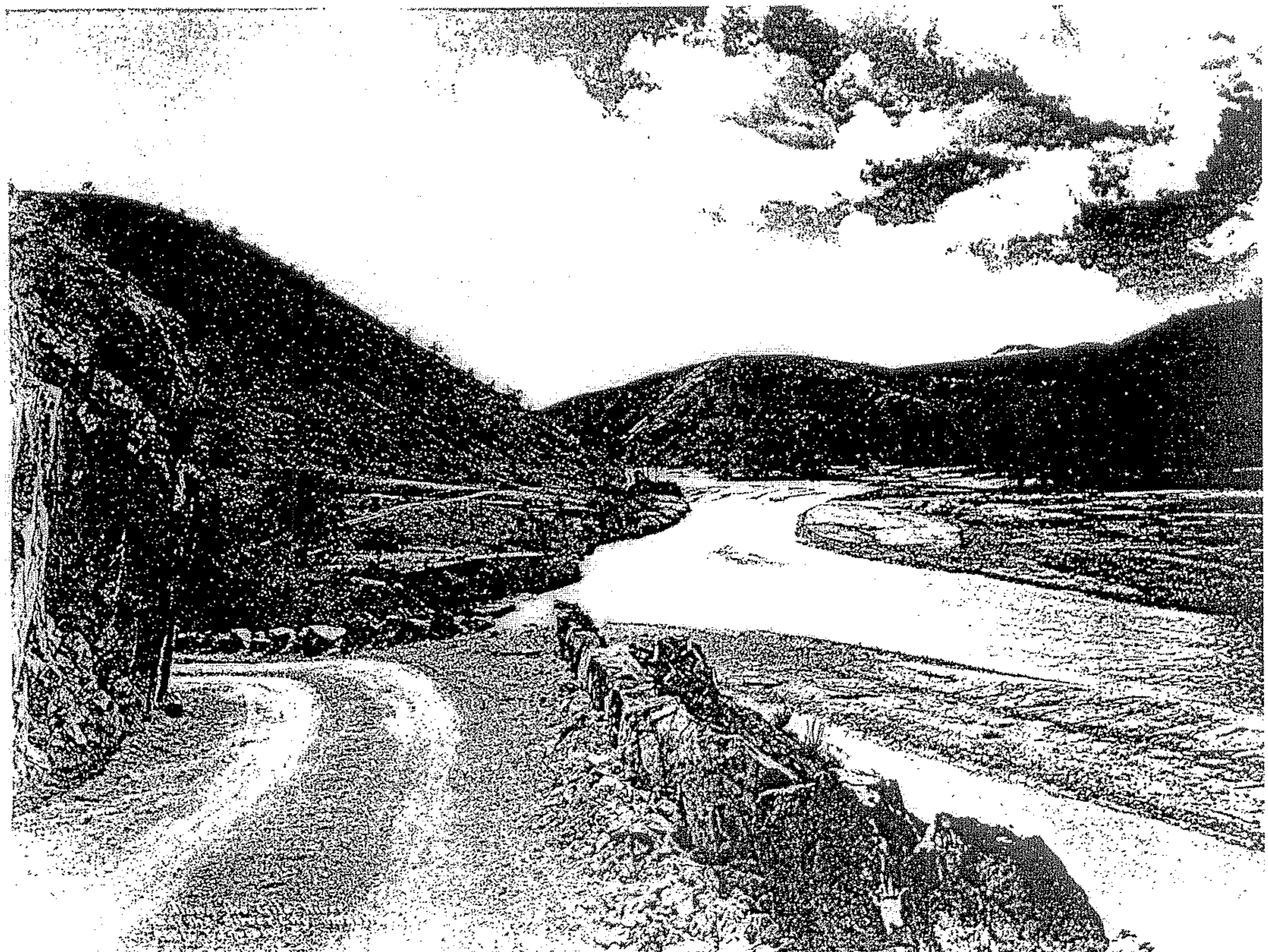
Title: Scenes of San Francisco River at Clifton, Ariz.
Location: Published photographs (3) in Olmstead (1919:Plate 29)
Number: N/A
Description/Comments: (Top) Francisco River in flood looking south towards railroad bridge; (Middle) San Francisco River in flood looking south from mouth of Chase Creek; (Bottom) dry bed of San Francisco River looking upstream to bridge.

Gila River between Ft. Thomas and Solomonville, October 17, 1885. #19,677 Arizona Pioneers Historical Society, Tucson

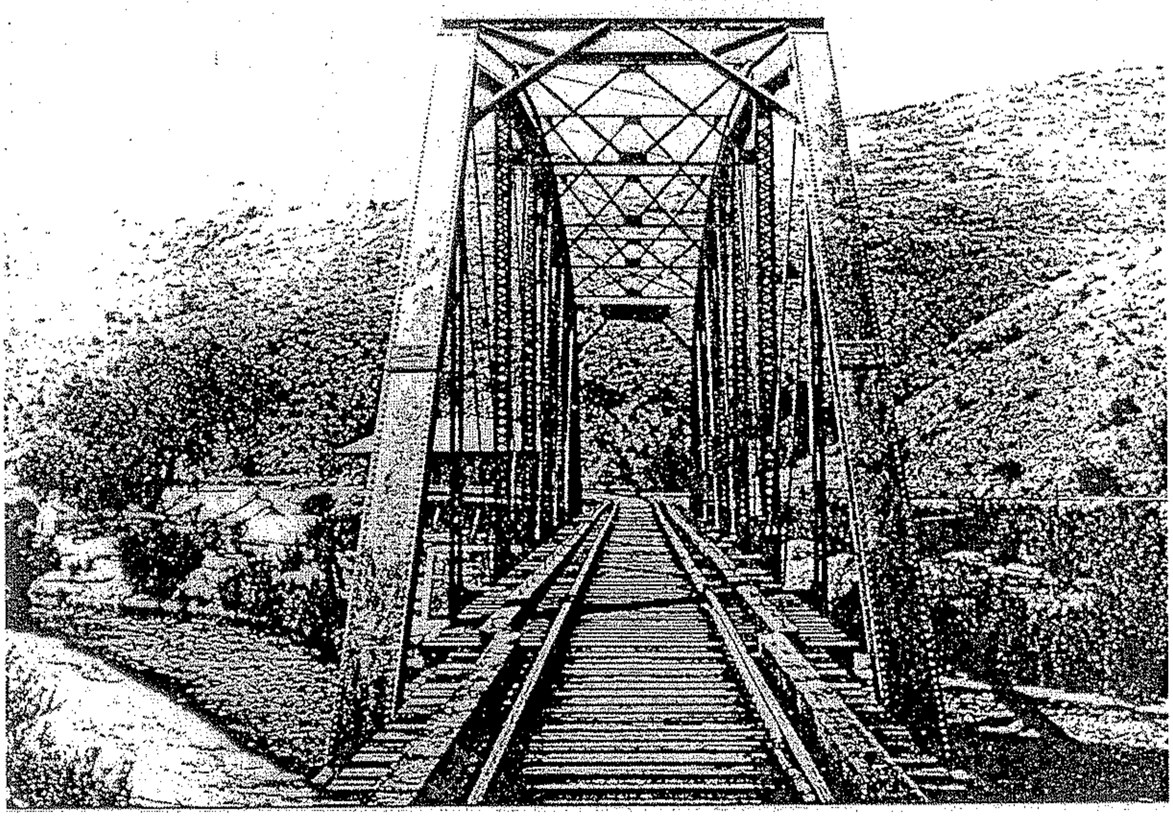
Gila River. #50192 Arizona Pioneers Historical Society, Tucson



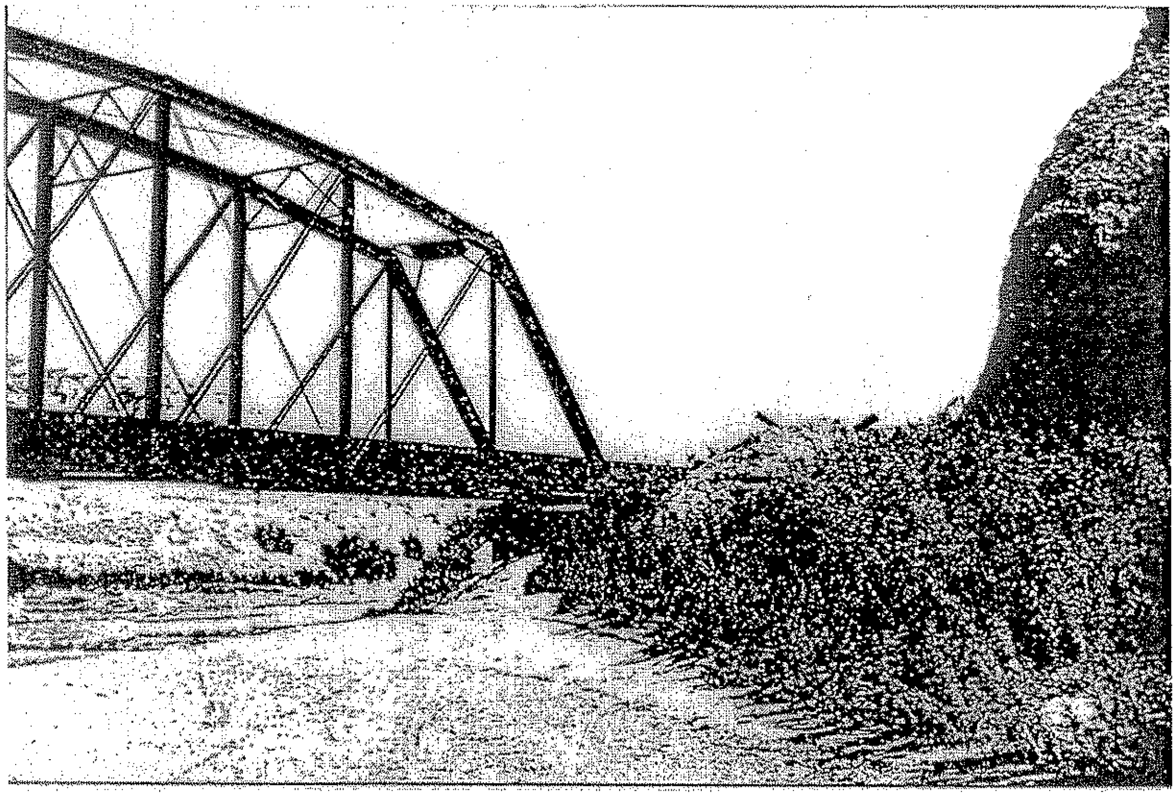
Gila River along the Silver City – Clifton Highway. #59109 Arizona Pioneers Historical Society, Tucson



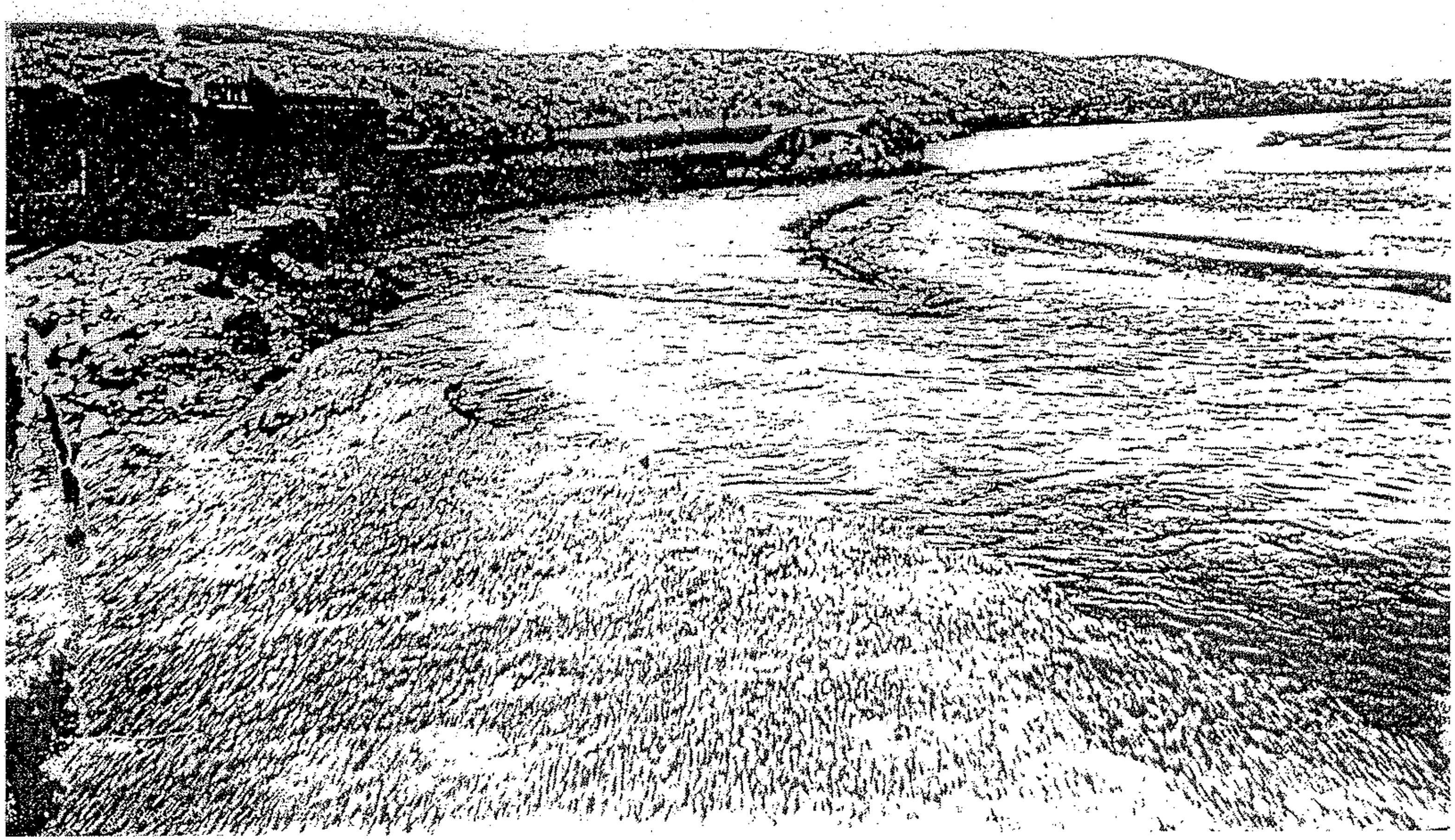
Gila River near the Silver City – Mogollon Highway. #59



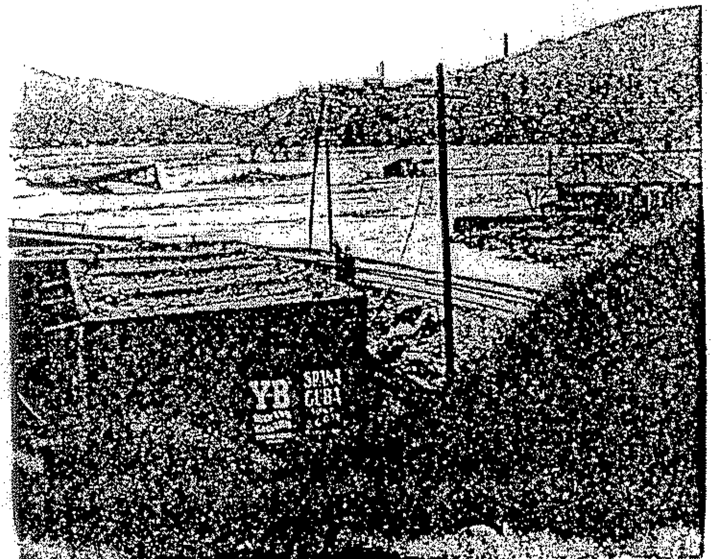
A. & N. M. R. R. Bridge at Guthrie, Arizona. Segal (n.d.)



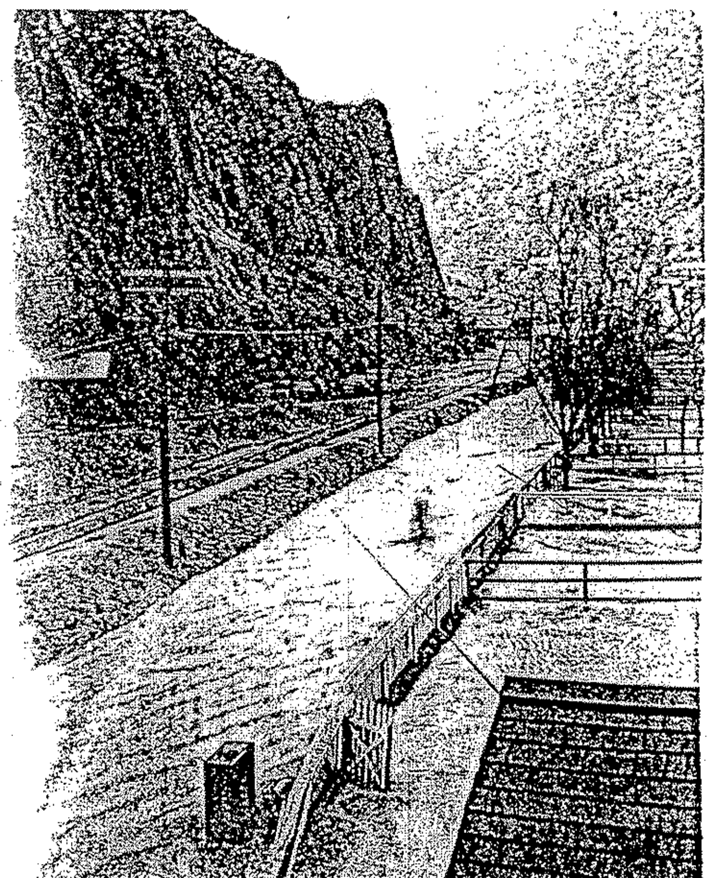
R.R. Bridge of the A. & N. M. R. R. at Guthrie, Arizona. Segal (n.d.)



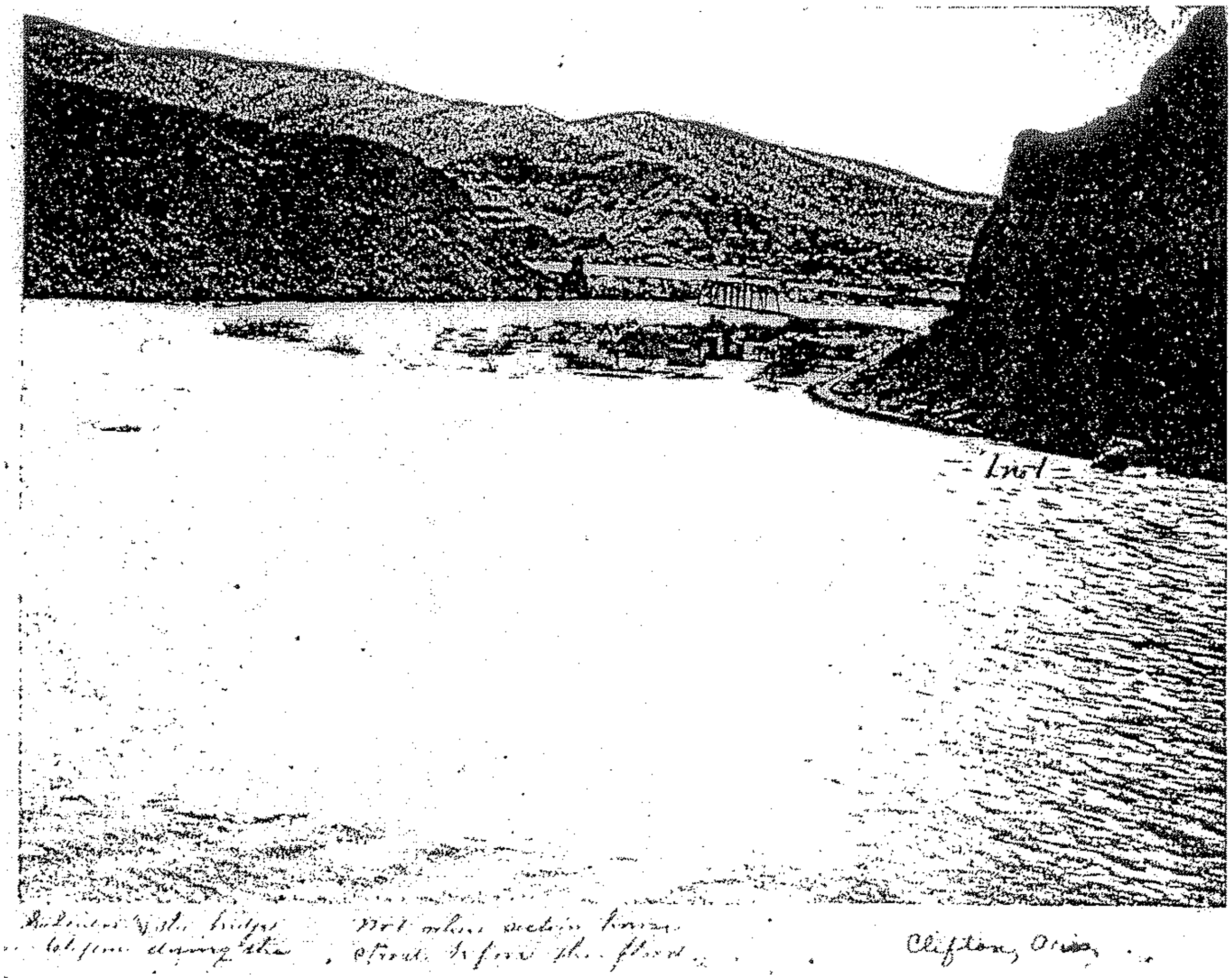
Railroad along San Francisco River in flood. #51196 Arizona Pioneers Historical Society, Tucson



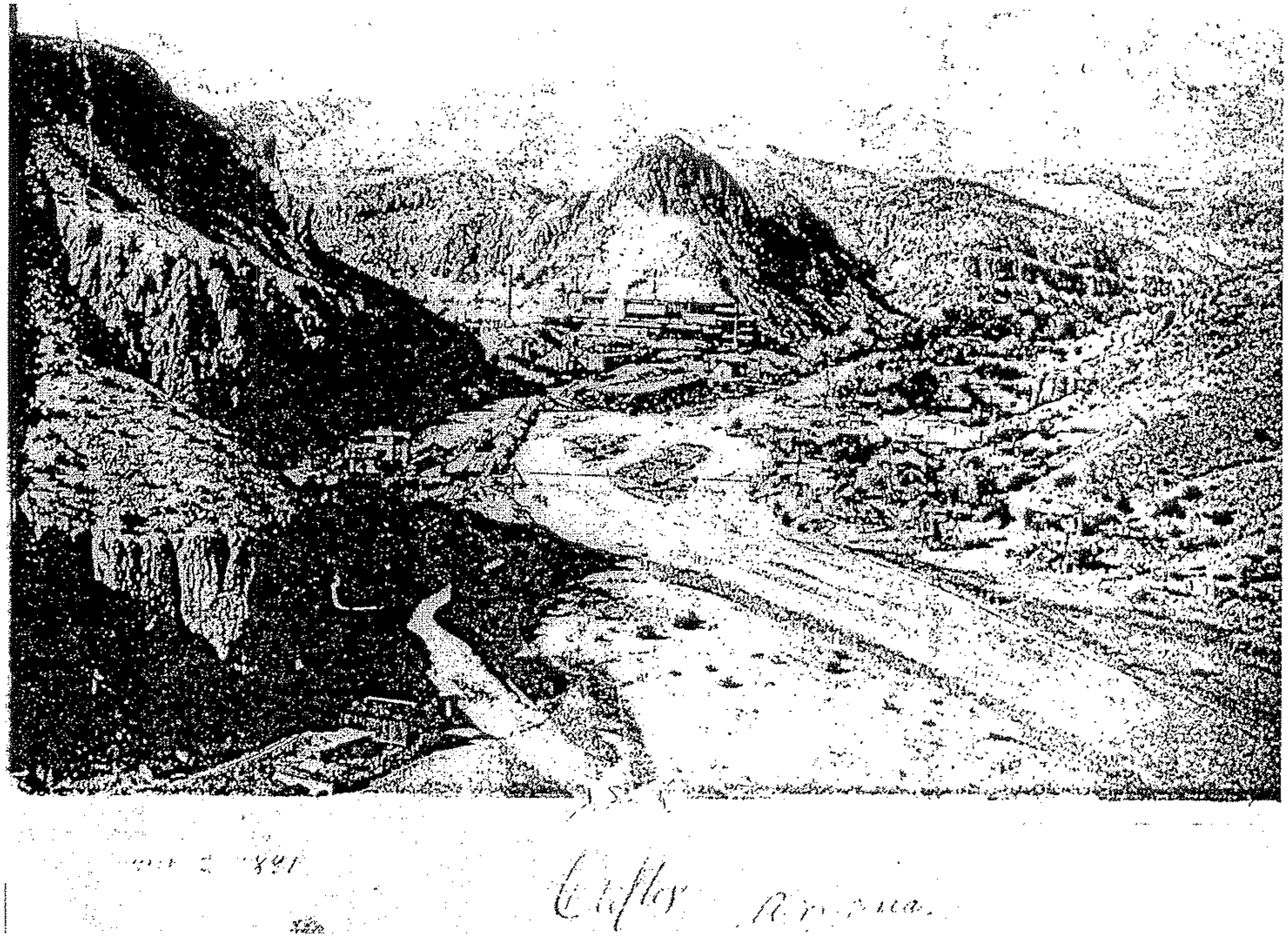
Railroad bridge in river, Clifton Flood 1905. #58651 Arizona Pioneers Historical Society, Tucson



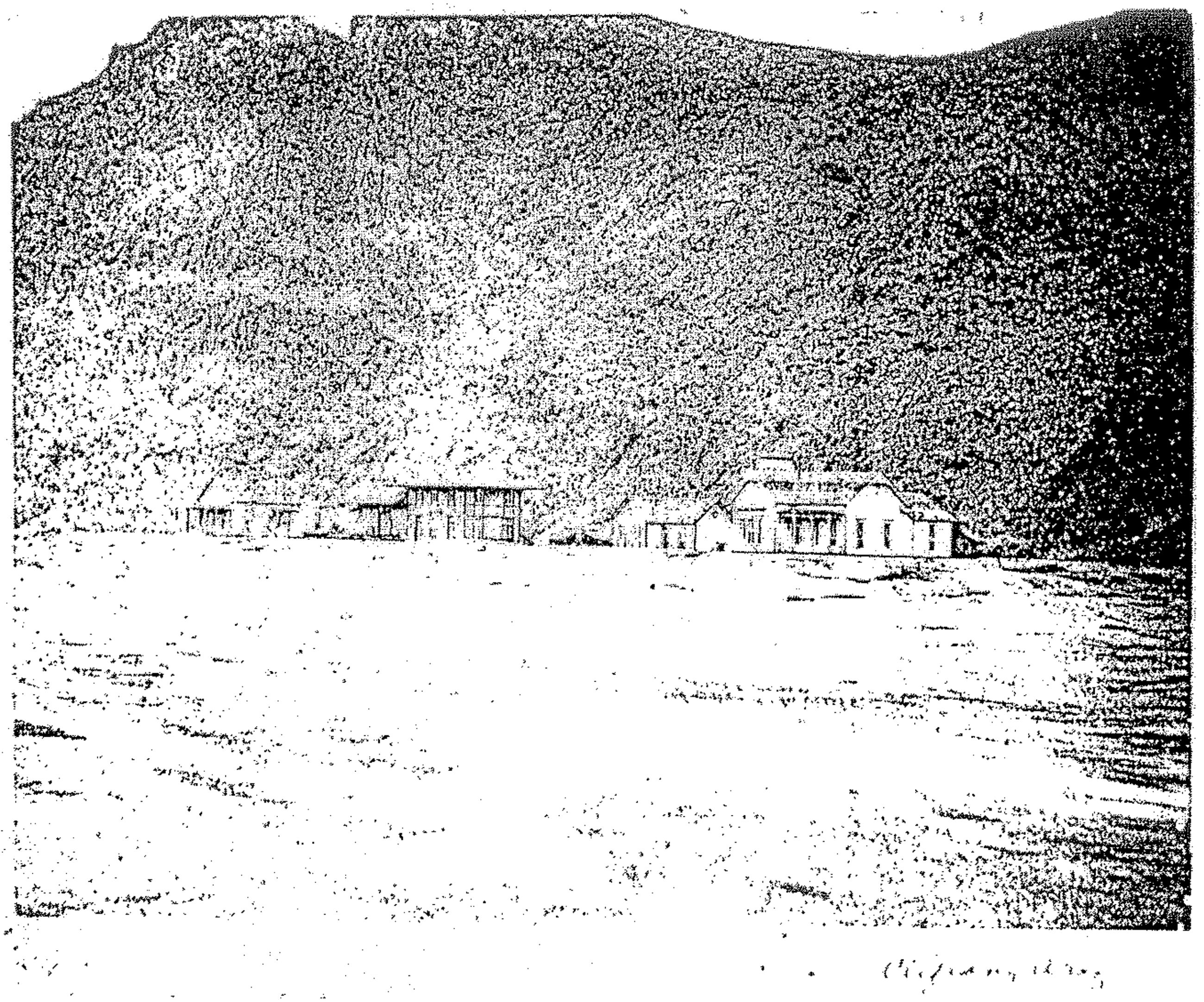
Water in front of row of houses, Clifton Flood 1905. #58652 Arizona Pioneers Historical Society, Tucson



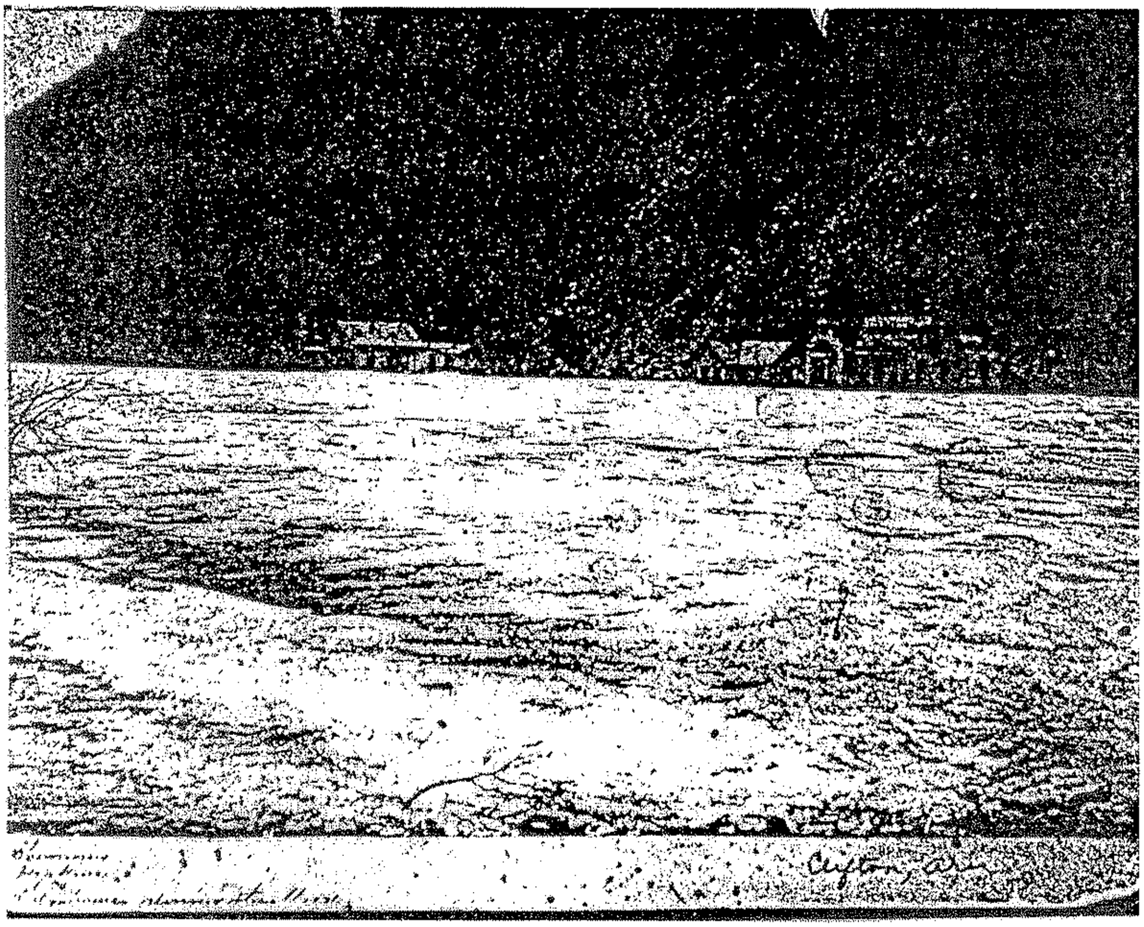
Flood at Clifton, Arizona, February 27, 1891. #2296 Arizona Pioneers Historical Society, Tucson



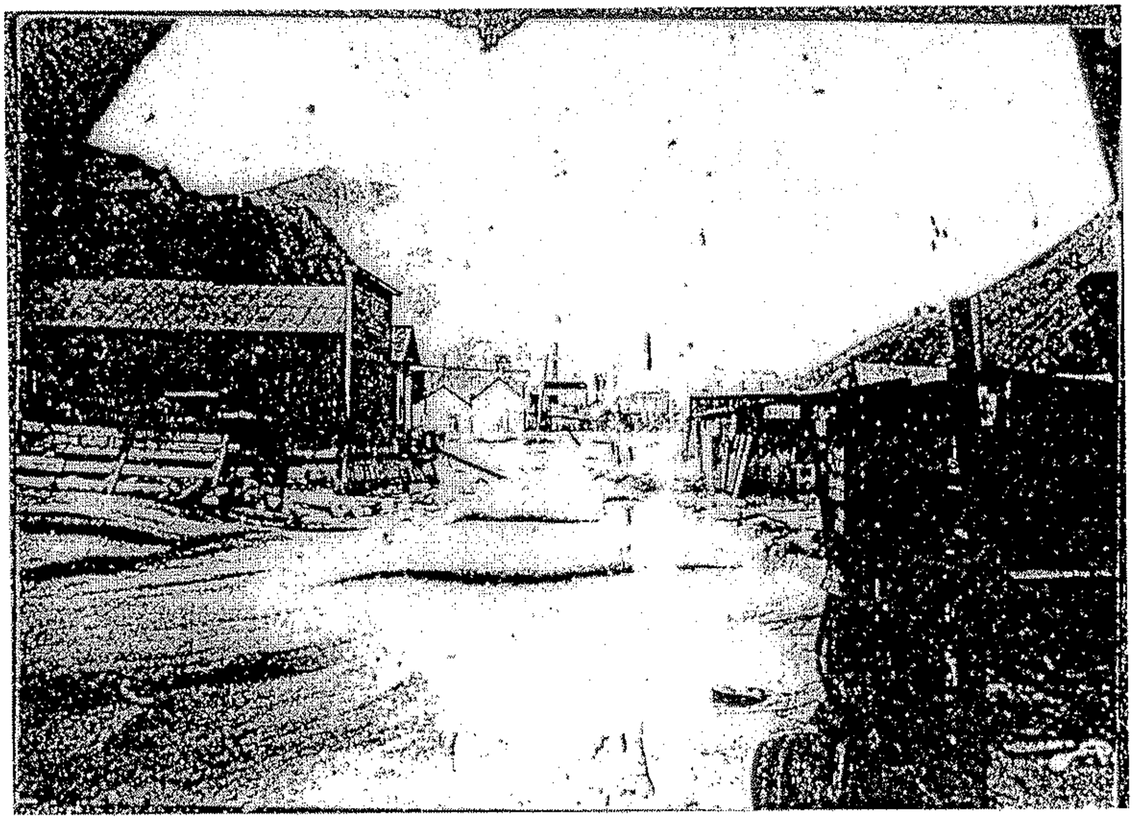
Clifton, Arizona, looking north up river, January 3, 1891. #2302 Arizona Pioneers Historical Society, Tucson



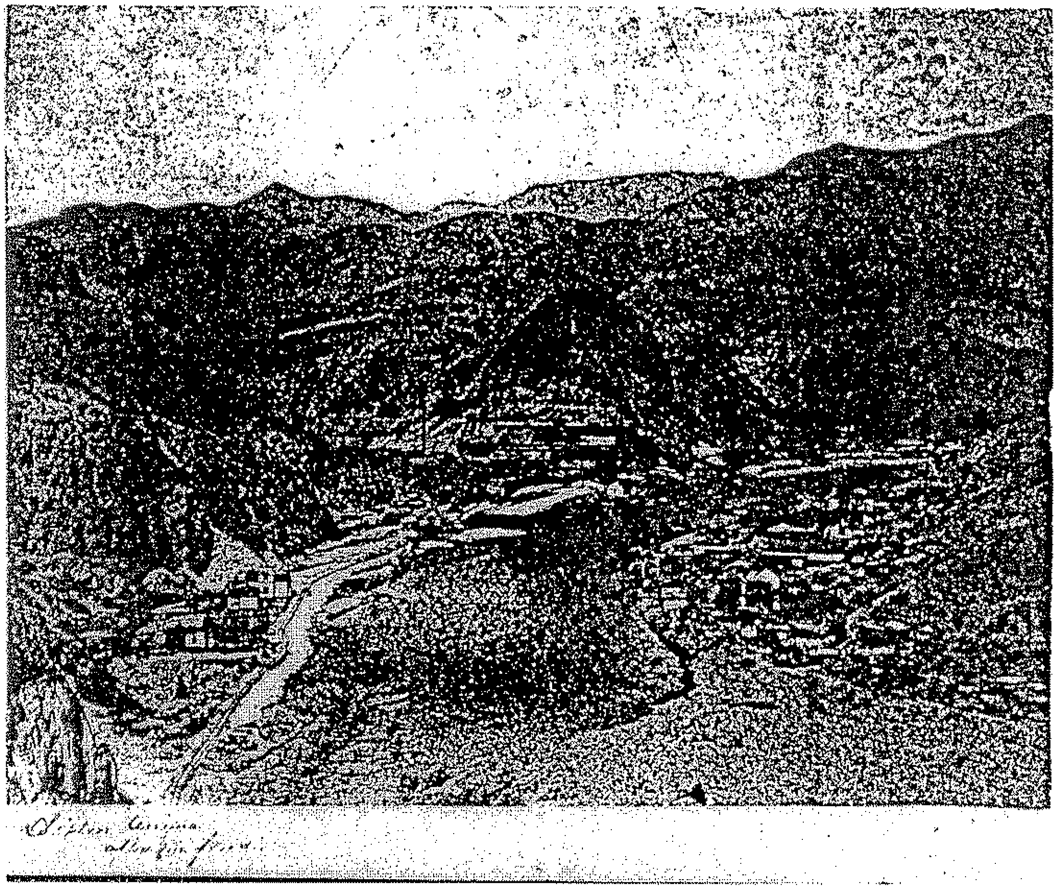
Clifton, Arizona, during the flood of February 27, 1891. #2303 Arizona Pioneers Historical Society, Tucson



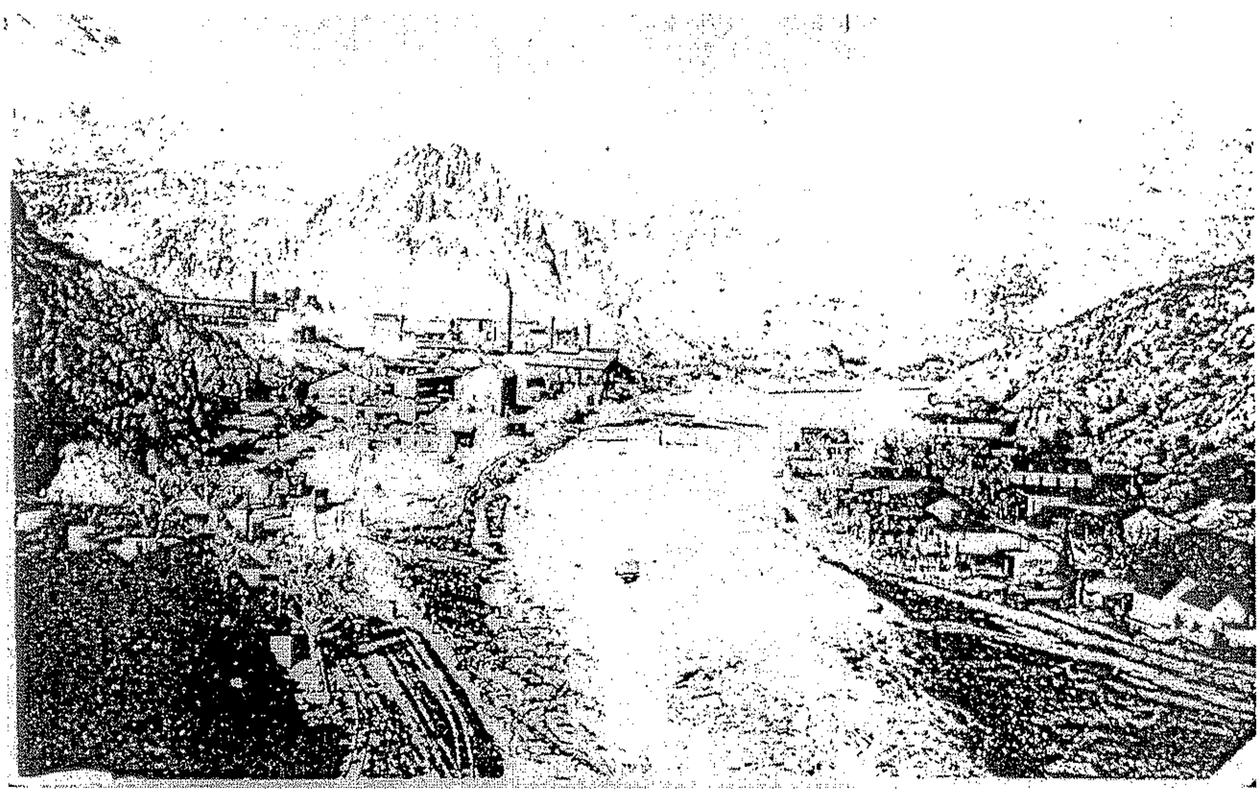
Clifton, Arizona, during the flood of February 27, 1891. #2304 Arizona Pioneers Historical Society, Tucson



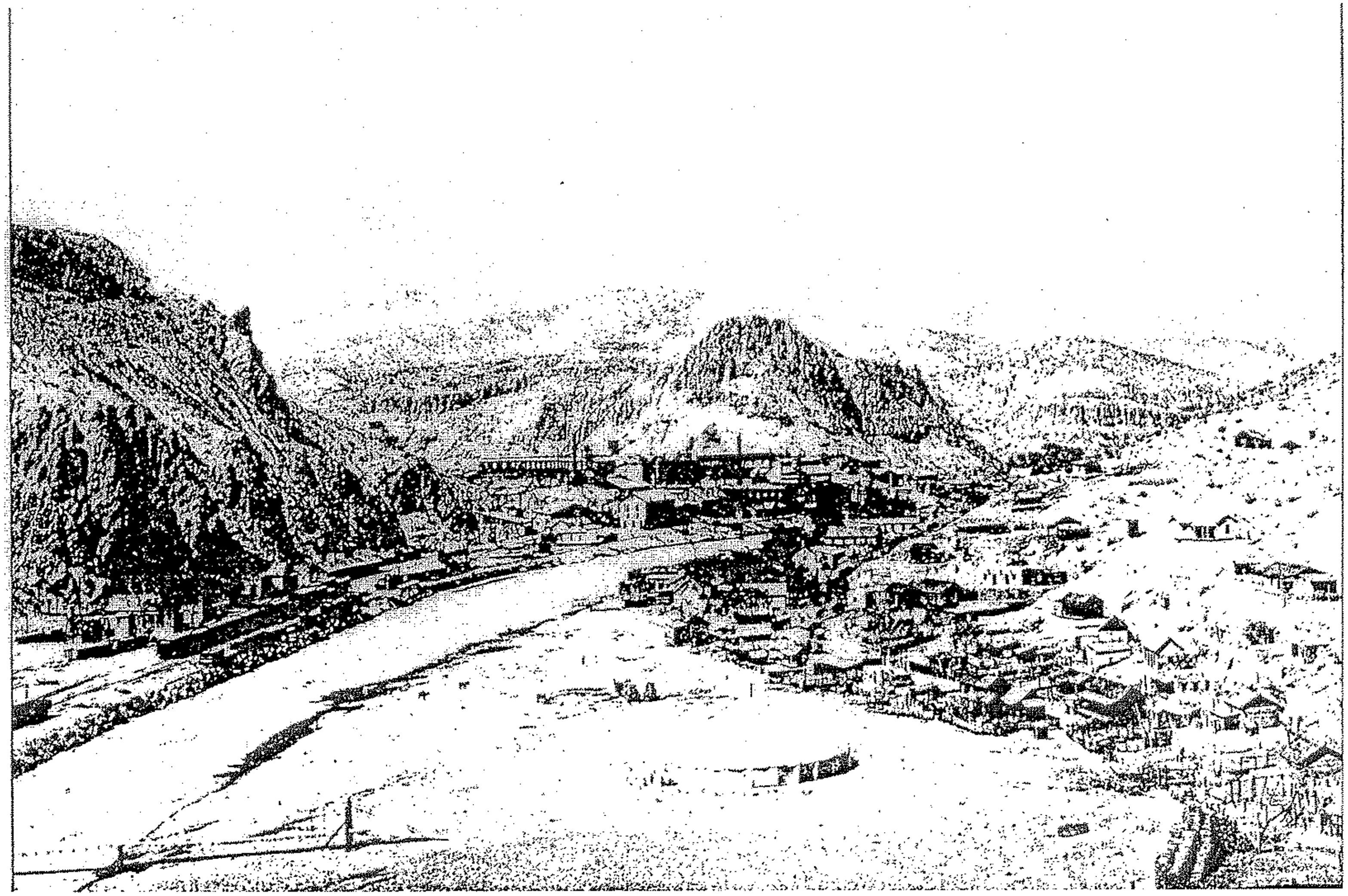
Flood in Clifton, Arizona, ca. 1903. #51028 Arizona Pioneers Historical Society, Tucson



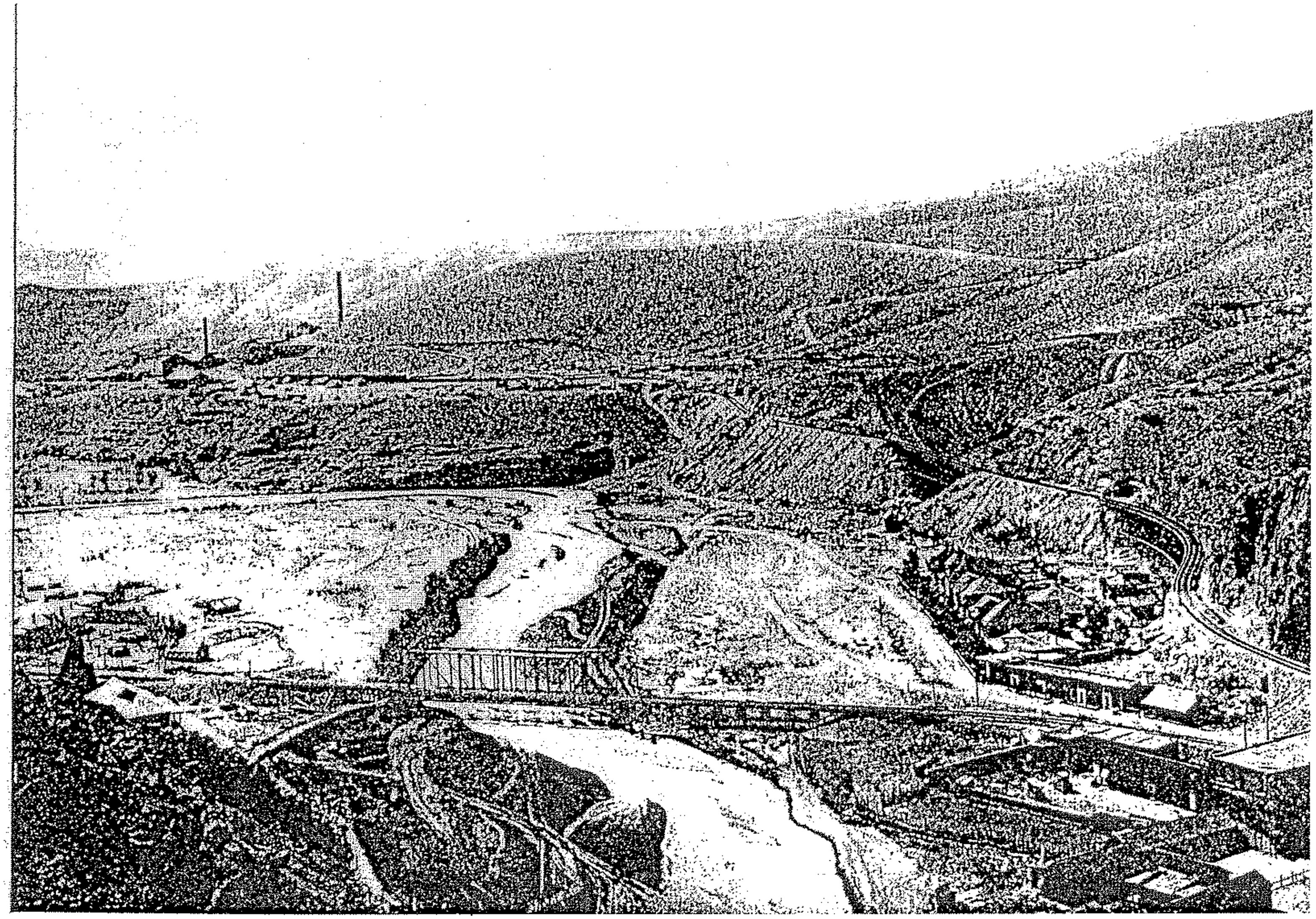
Clifton, Arizona, after the flood that occurred February 27, 1891. #2299 Arizona Pioneers Historical Society, Tucson



Clifton, an Arizona mining camp. #24960 Arizona Pioneers Historical Society, Tucson

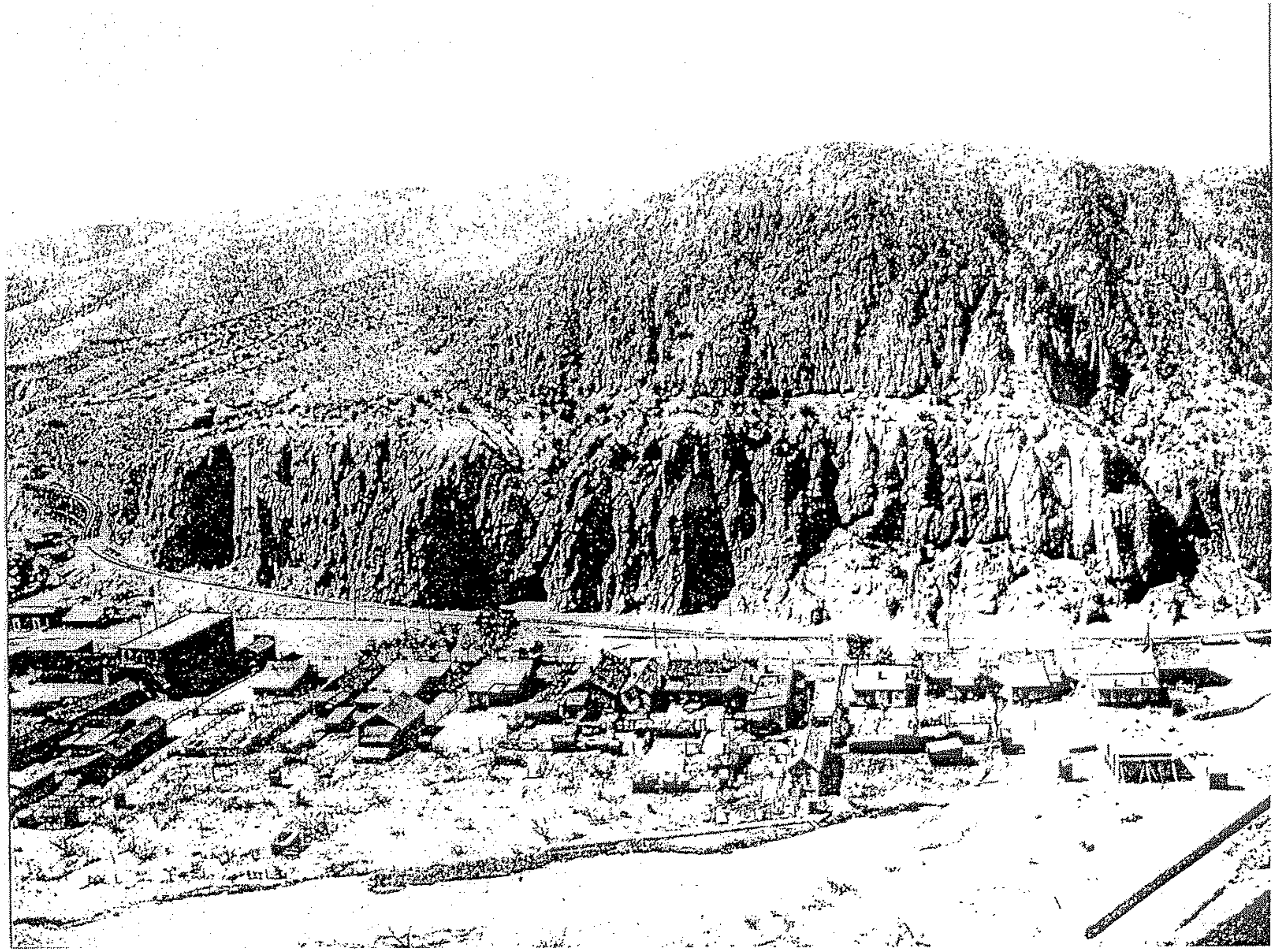


Clifton, Arizona, looking north. Segal (n.d.)

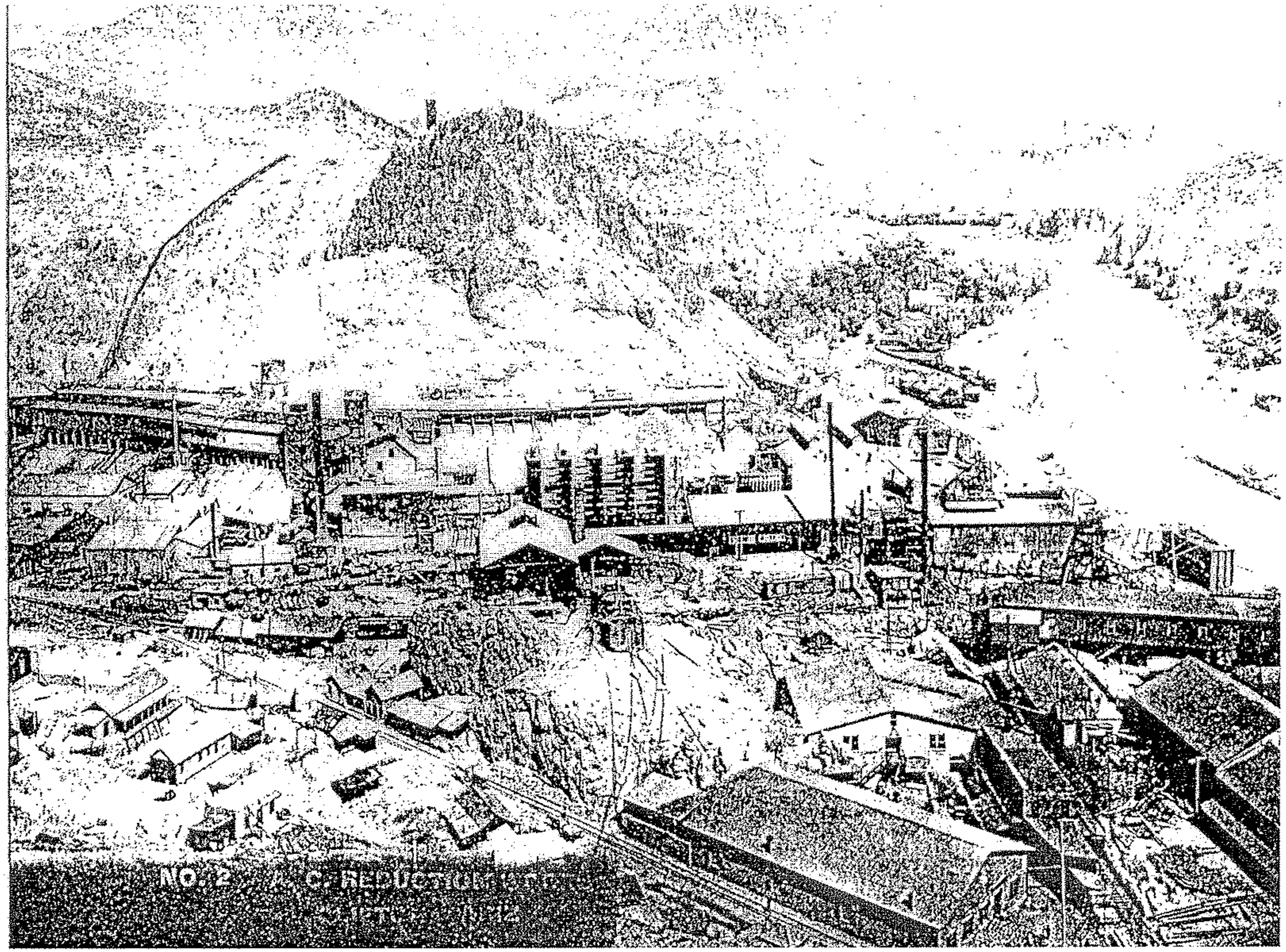


South Clifton, Shannon Works in the distance, A. & N. M. Railway Bridge. Segal (n.d.)

Cottonwood tress on the 'Frisco. Segal (n.d.)

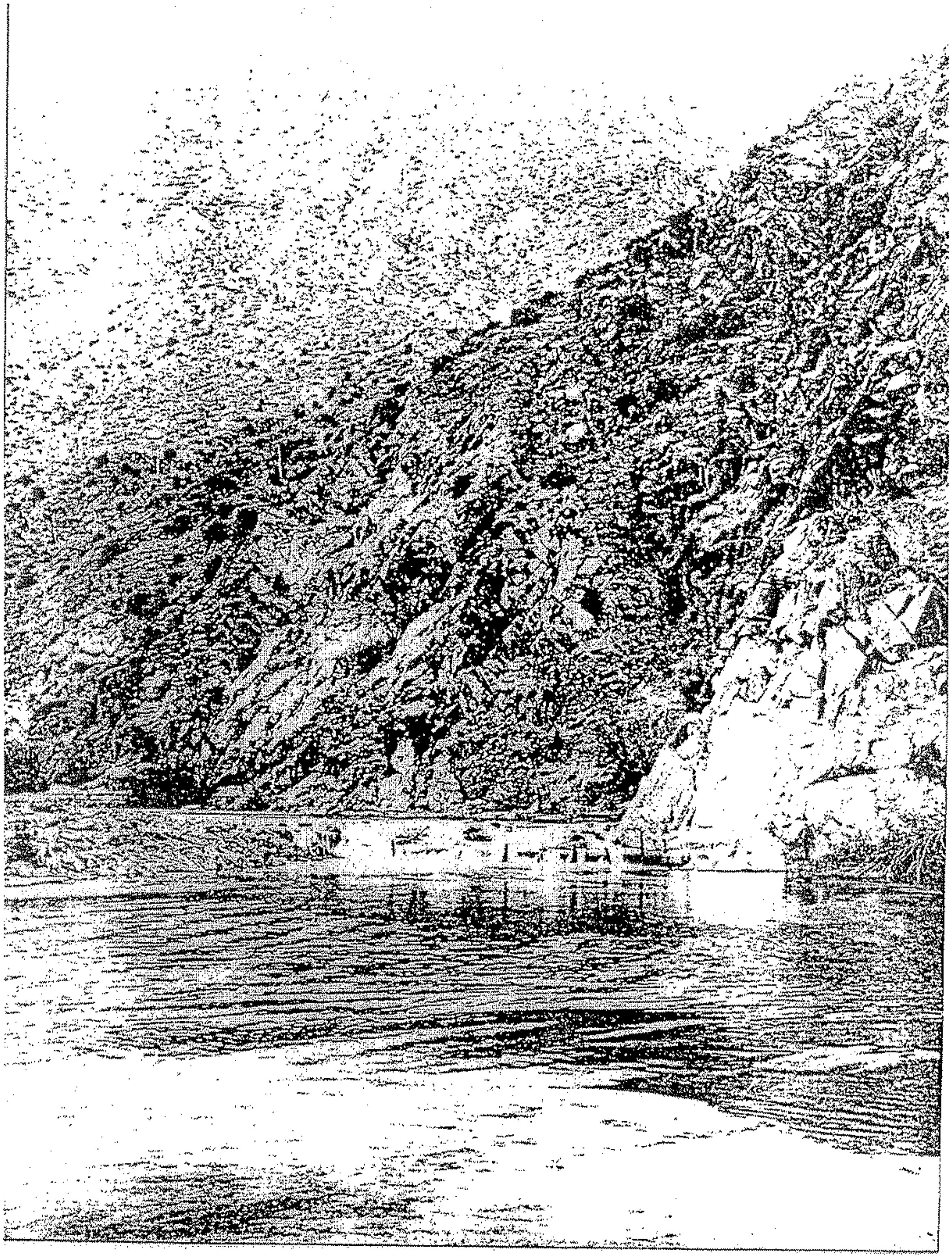


South Clifton. Segal (n.d.)

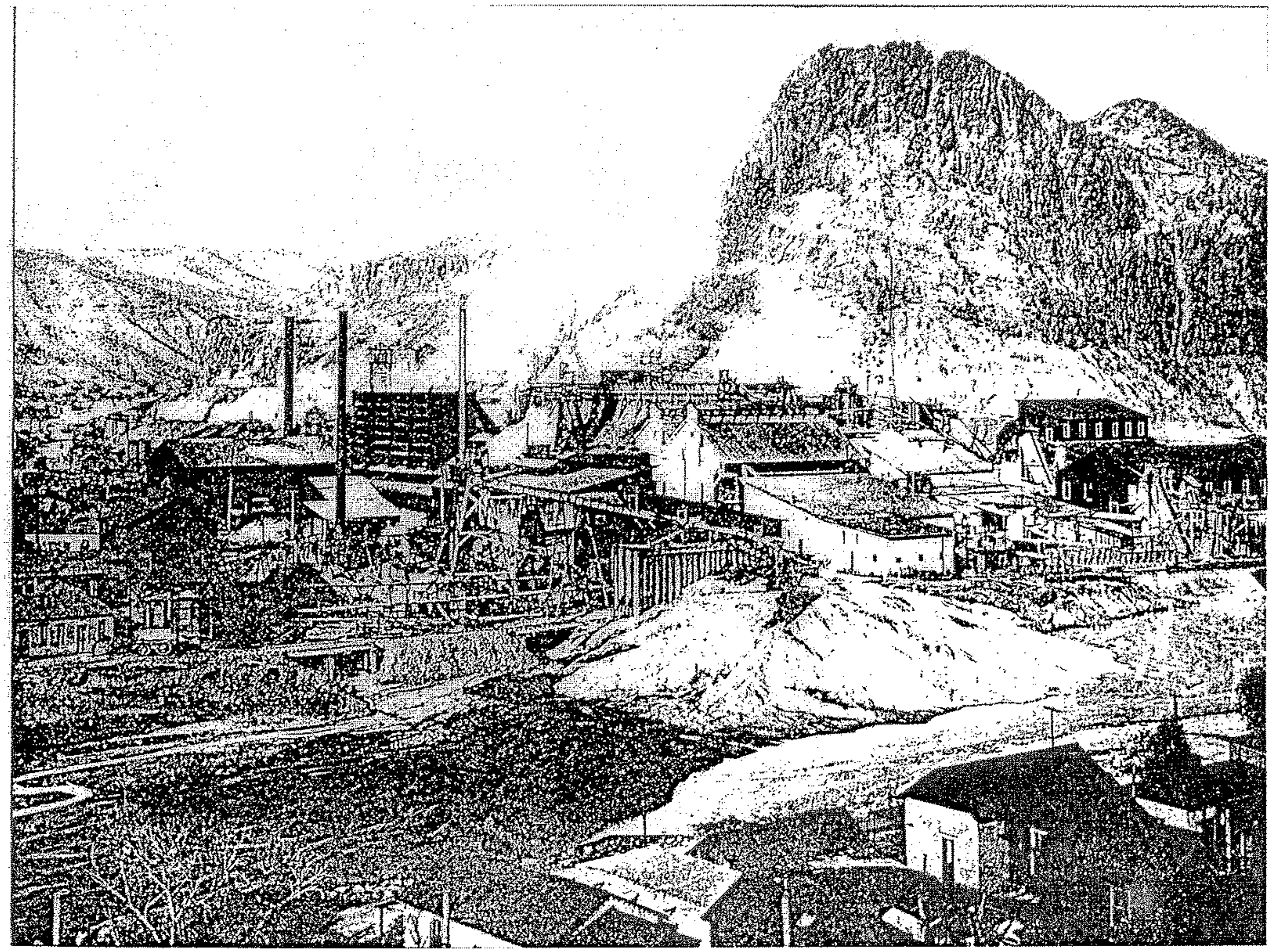


Arizona Copper Co.'s Reduction Works, Clifton, Arizona. Segal (n.d.)

Scenery on the San Francisco three miles above Clifton. Segal (n.d.)

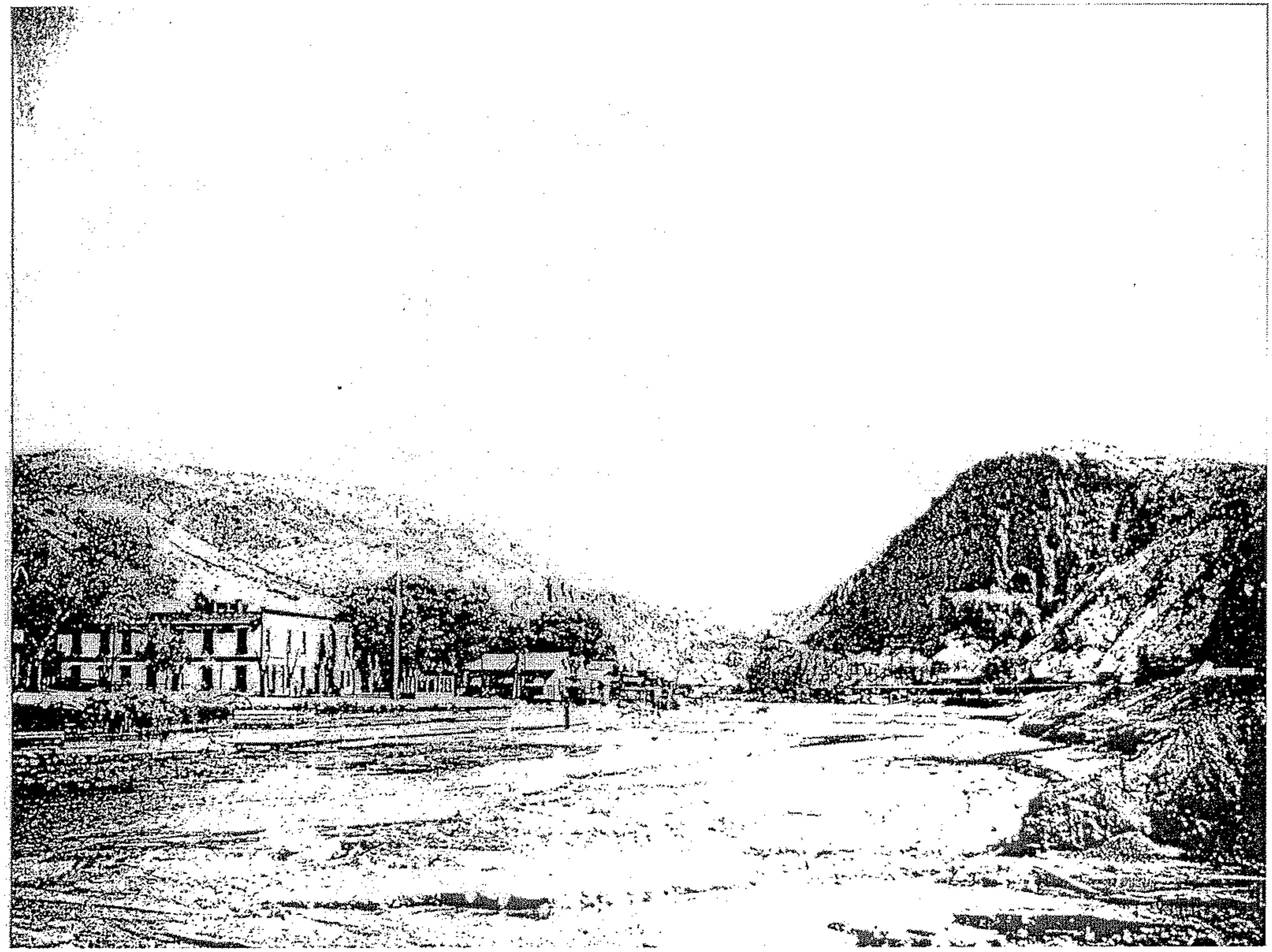


On the Frisco River, three miles above Clifton. Segal (n.d.)

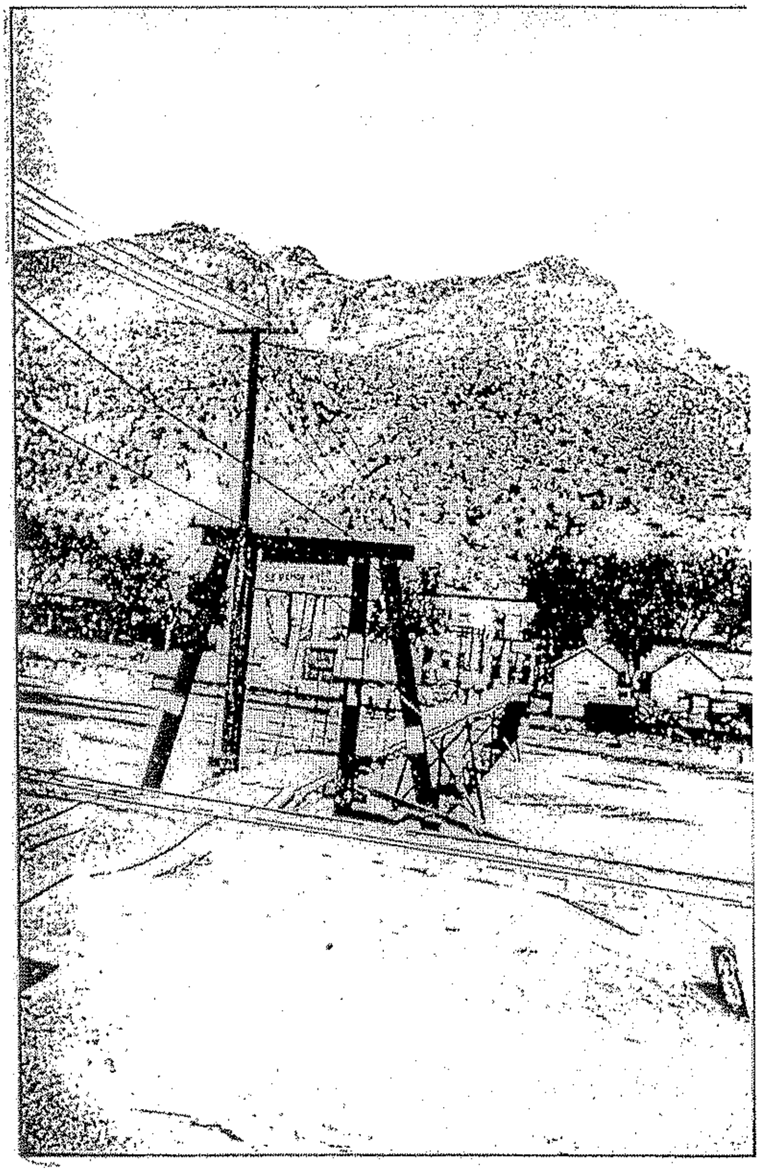


Birdseye view of the Arizona Copper Co.'s Reduction Plant, Clifton. Segal (n.d.)

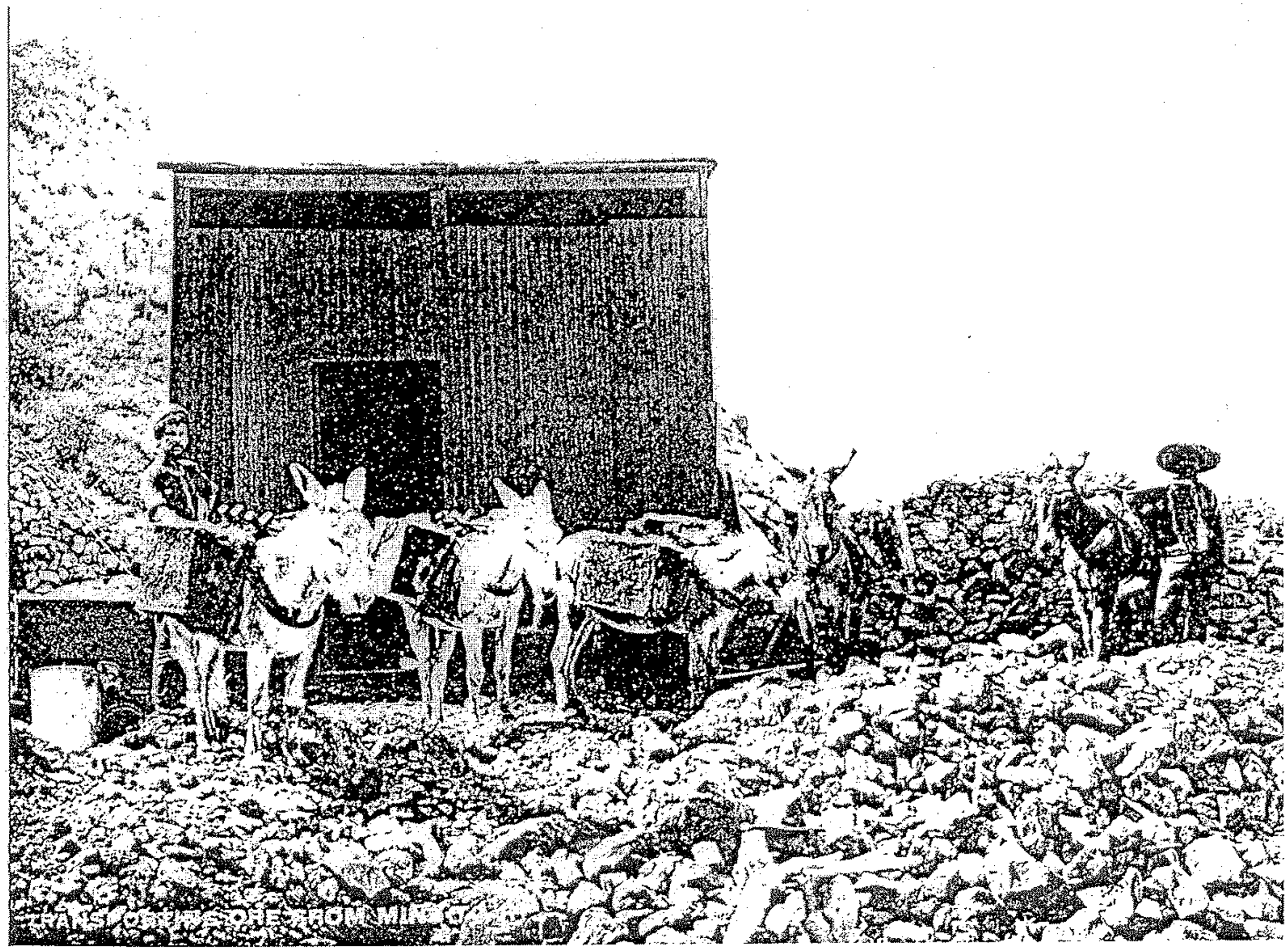
Portion of Clifton, looking south. Segal (n.d.)



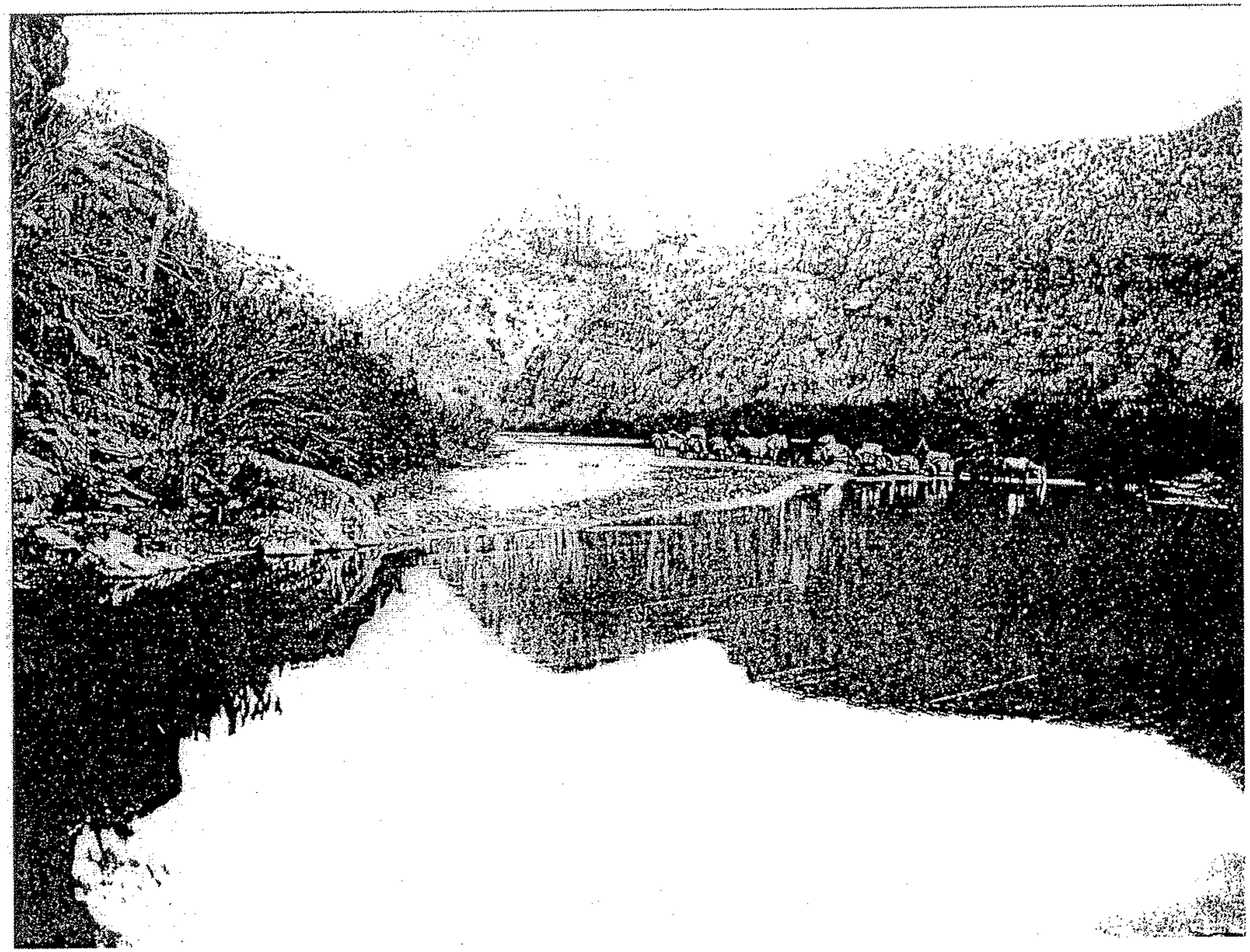
Clifton, looking south. Segal (n.d.)



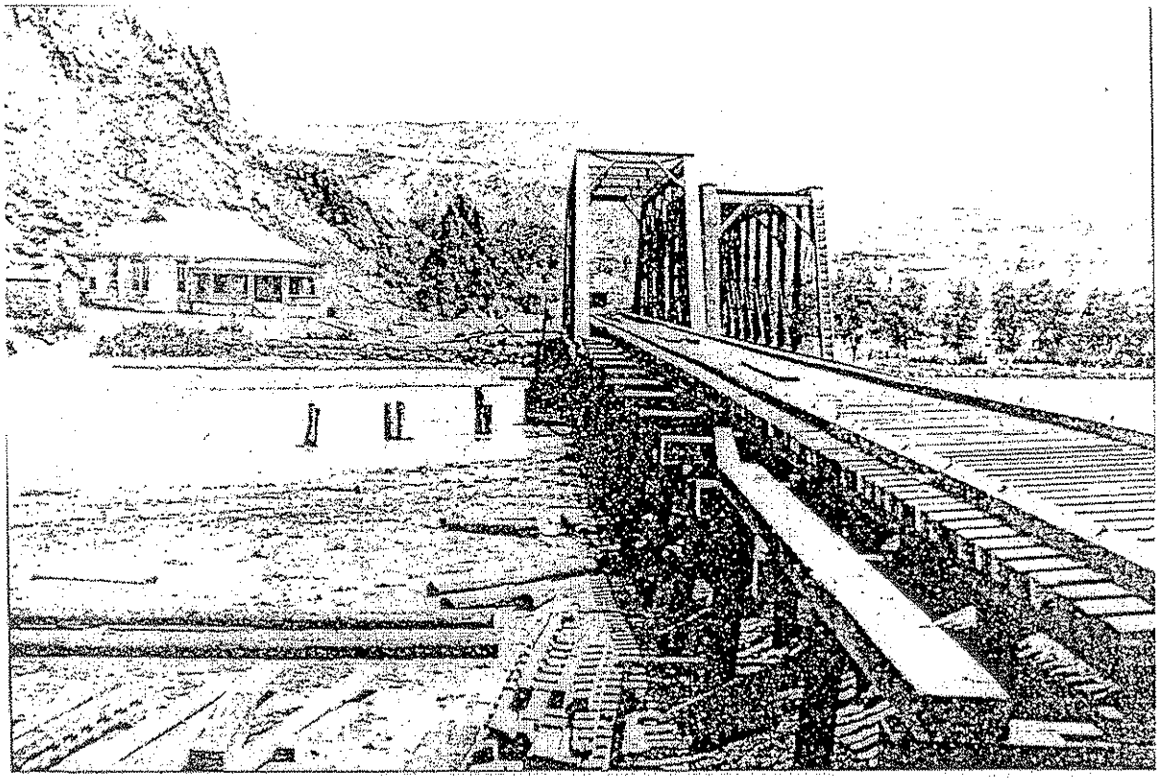
Foot Bridge, Clifton. Segal (n.d.)



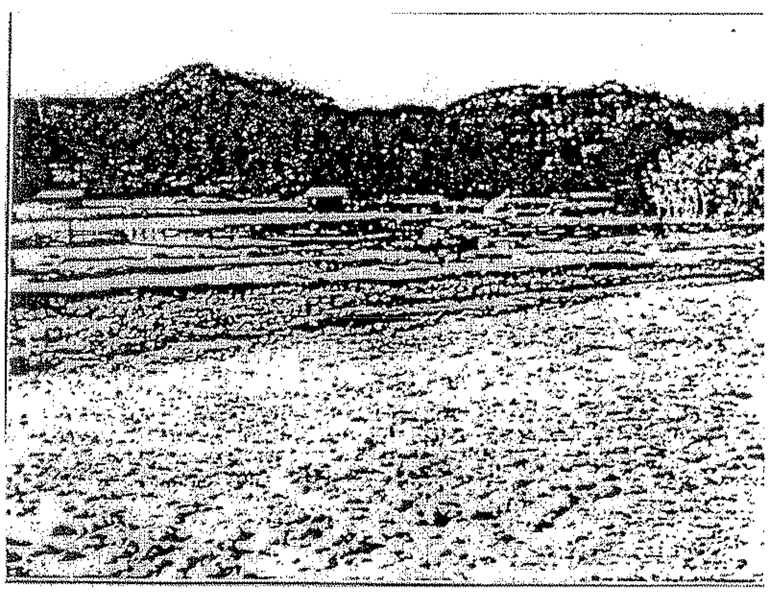
Burro Ore Train. Segal (n.d.)



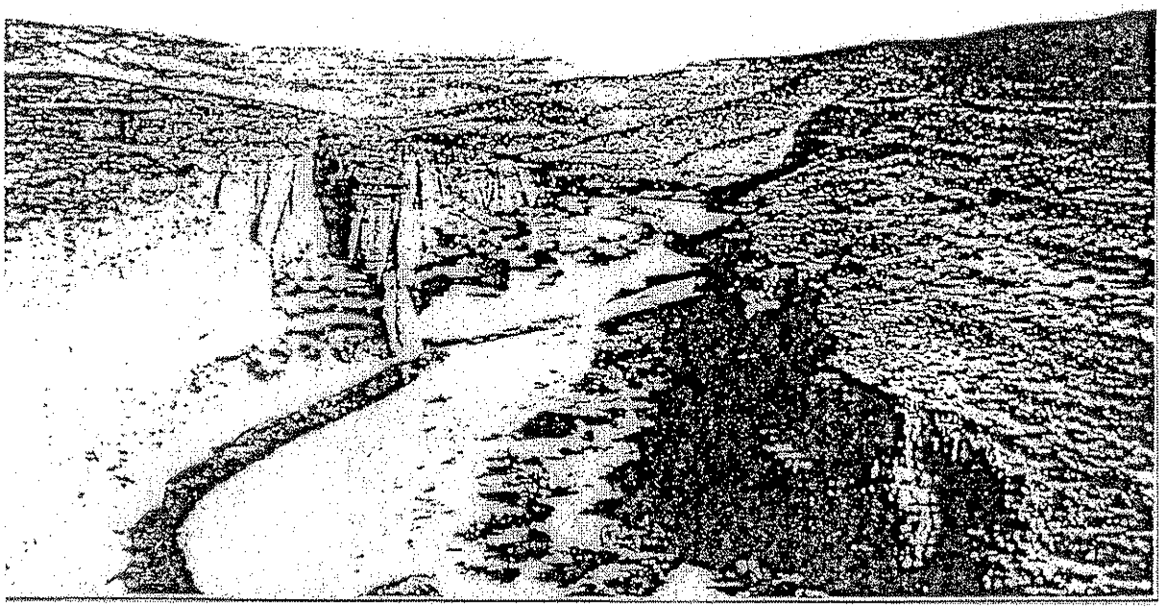
"To the Log Camp" scenery on the 'Frisco, four miles above Clifton. Segal (n.d.)



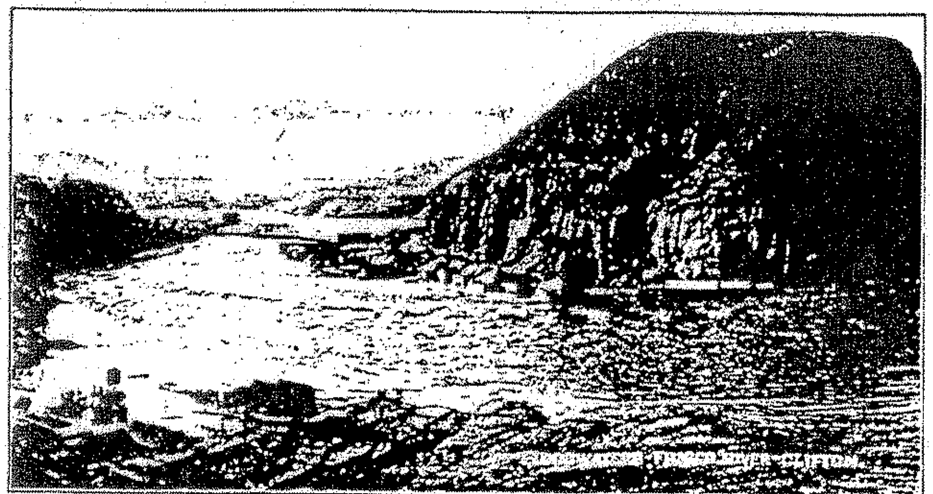
Railroad bridge and hospital at Clifton. Segal (n.d.)

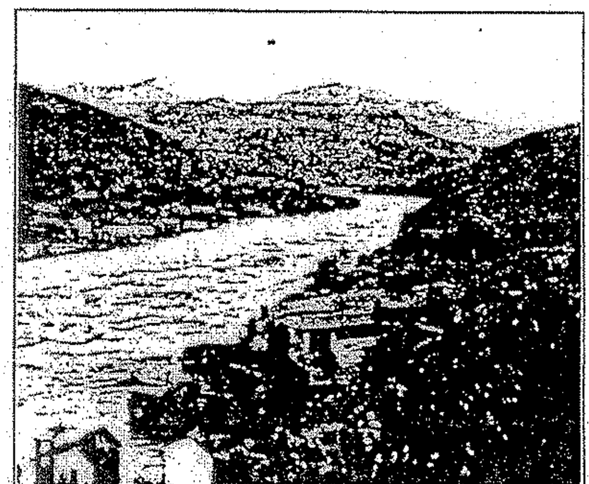


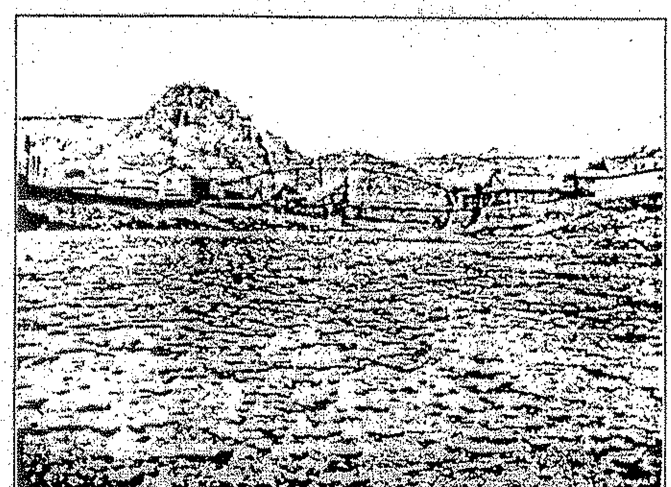
Upper Reaches. Olmstead 1919



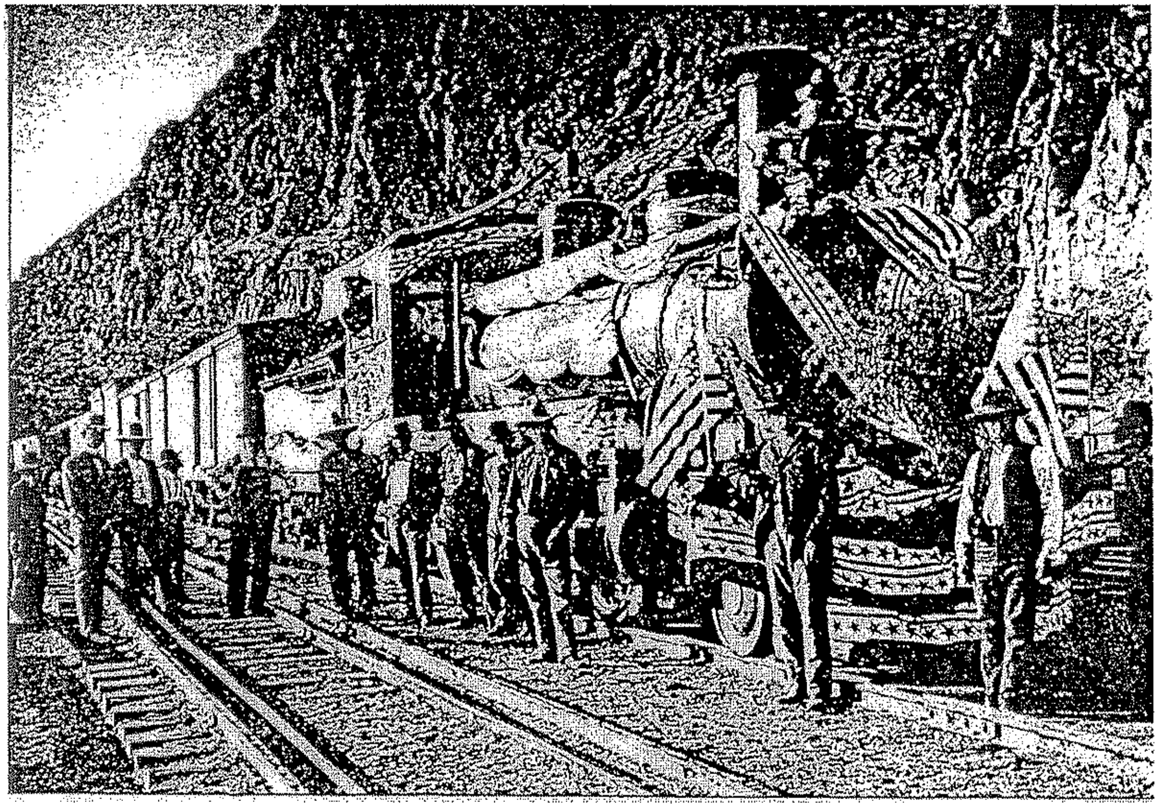
At junction with Gila. Olmstead 1919



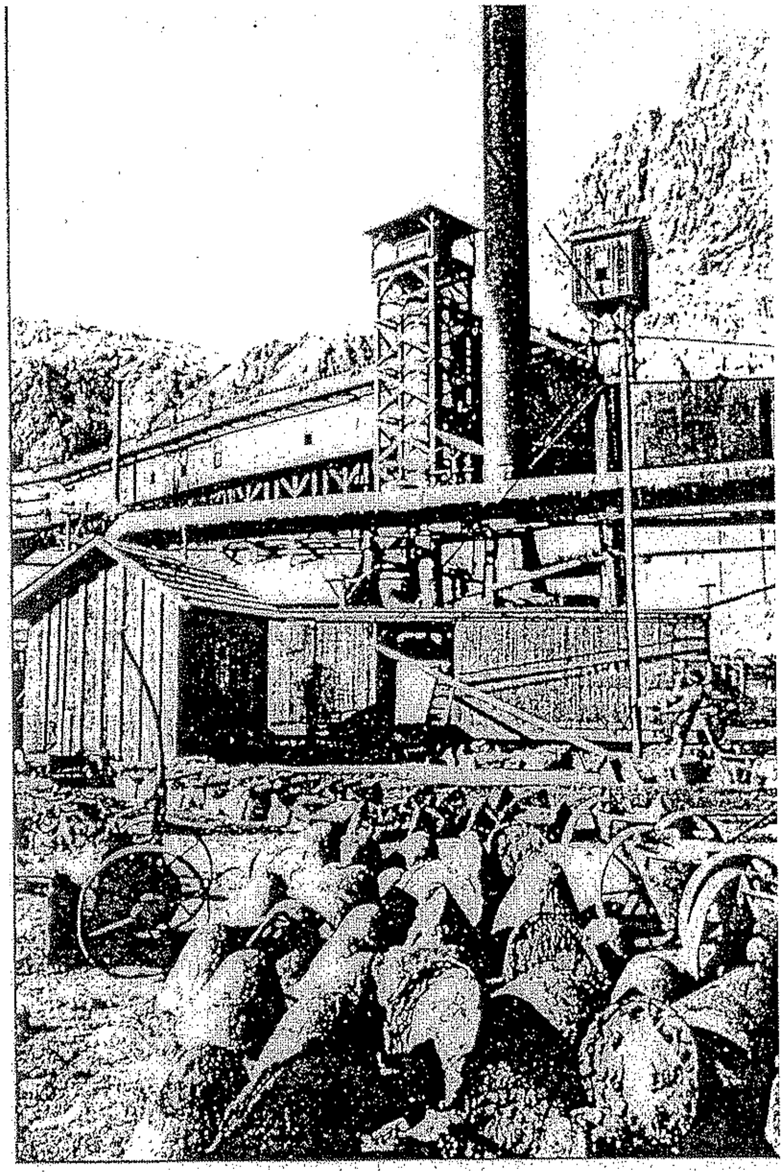




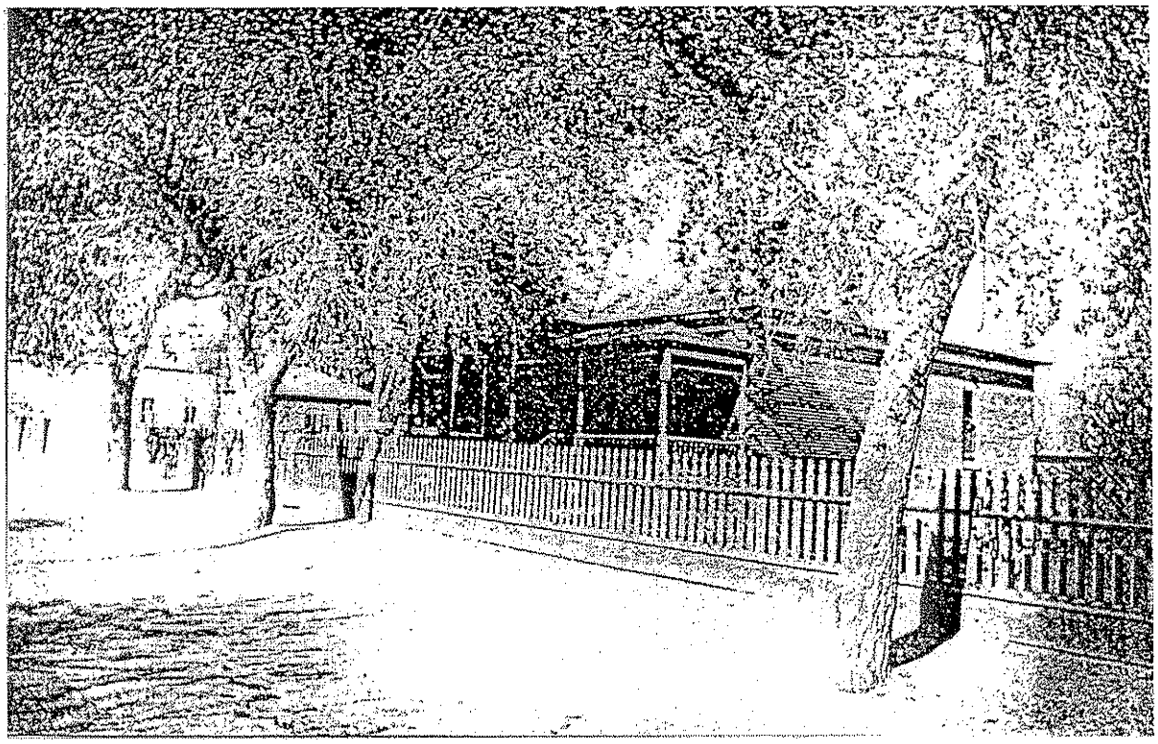
Scenes on San Francisco River at Clifton, Arizona. Olmstead 1919



First standard gauge entering Clifton. Segal (n.d.)



Arizona Copper Co. shipping copper at Clifton. Segal (n.d.)



Residence of Jas. Smith. Esq., Clifton, Arizona. Segal (n.d.)

Arizona Stream Navigability Study
for the
Upper Gila River
Safford to the State Boundary
and
San Francisco River
Gila River Confluence to the State Boundary

Draft Final Report

Prepared for the

Arizona State Land Department

Date of Original Report: June 1997

Prepared by

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In Association with
George V. Sabol Consulting Engineers, Inc.,
JE Fuller/ Hydrology & Geomorphology, Inc.,
and
SWCA, Inc. Environmental Consultants

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

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Section 4

Geomorphology of the Upper Gila and San Francisco Rivers

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APPENDIX

A Aerial Photographs of the Upper Gila and San Francisco Rivers (June, 1997). A-1

Section 4:

Geomorphology of the Upper Gila and San Francisco Rivers

Introduction

This section describes the regional geology and fluvial geomorphology of the Upper Gila and San Francisco Rivers. The objectives of this section are to:

- Describe potential geologic impacts on streamflow and navigability.
- Describe channel changes, if any, which occurred since statehood.
- Provide a geologic context for discussion of historical stream conditions.
- Describe the location of the ordinary high watermark and ordinary low watermark.

Resources used to support this overview of the Upper Gila and San Francisco Rivers geology included summaries of regional geologic history, aerial photographs, field observations, and topographic maps.

Stream Reaches

The Upper Gila River study reach extends from Safford to the Arizona/New Mexico (Figure 1), a distance of approximately 73 miles. The San Francisco River study reach extends from its confluence with the Gila River to the Arizona/New Mexico border, a distance of about 45 miles. For the purposes of the geomorphic investigation, the Upper Gila and San Francisco Rivers will be considered in the following four stream reaches:

- Reach 1 - Gila River - Safford to Gila Box
- Reach 2 - Gila River - Gila Box
- Reach 3 - Gila River - Gila Box to New Mexico Border
- Reach 4 - San Francisco River - Gila River to New Mexico Border

The geomorphology of these four reaches is described in the following sections. Aerial

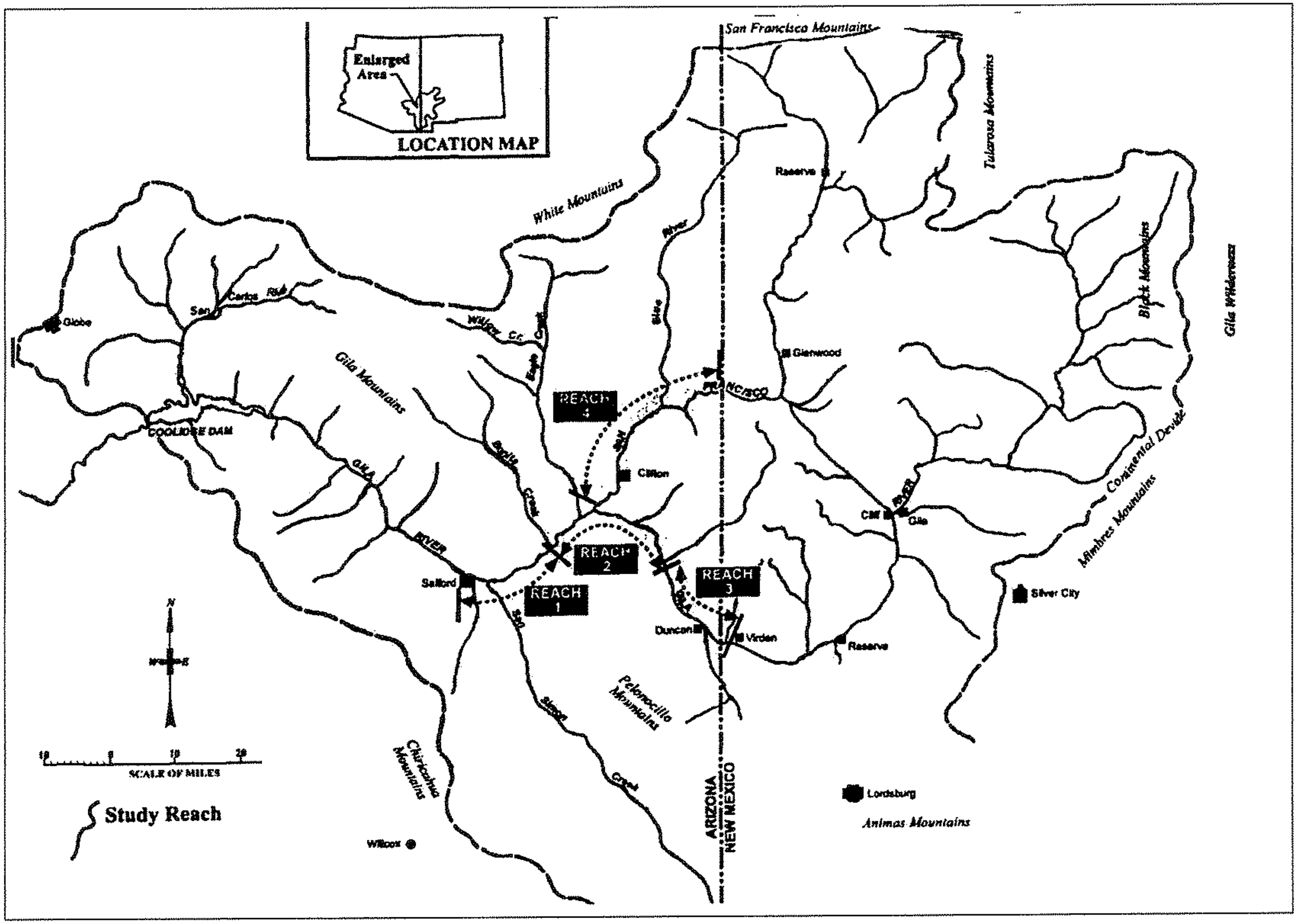


FIGURE 1. Study Reach Location Map

photographs taken in June 1997 of the study reaches are included in Appendix A.

Physiography

The 118-mile Upper Gila and San Francisco Rivers study reach is located within Graham and Greenlee Counties in eastern Arizona, although their watersheds include about 10,459 square miles of eastern Arizona and western New Mexico (Figure 1). The watershed ranges in elevation from about 2,885 feet at Safford to well over 10,000 feet in the peaks of New Mexico's Gila Wilderness and Arizona's White Mountains. The San Francisco River watershed is bounded by the Gila Mountains to the west, the San Francisco and White Mountains to the north, the Tularosa Mountains to the east, and the Gila River watershed to the south. The Upper Gila River watershed is bounded by the San Francisco River watershed and Gila Mountains to the west and north, the Black, Mimbres, and Animas Mountains to the east, and the San Pedro River watershed to the south and west. Major perennial tributaries to the upper watershed include the Blue River (San Francisco River), and Bonita Creek and Eagle Creek (Upper Gila River).

Vegetation in the study area is dominated by Sonoran and Chihuahuan Desert communities which include grasses, low shrubs, and saguaro cacti. Since the 1940's, the dominant riparian vegetation species has become tamarix, although previously some reaches were lined by cottonwood, seepwillow, and mesquite trees. The upper watersheds extend through several climatic-vegetation zones, including areas above the tree line on the highest peaks in the drainage area.

Historically, sources of runoff in the study reach included discharge from springs, snowmelt from higher elevation areas in the upper watershed, and direct runoff from precipitation. Long-term and/or historical streamflow records are available for the entire study reach. Historical and hydrologic data indicate that the Upper Gila and San Francisco Rivers were perennial in their ordinary and natural condition throughout the study area as of the time of statehood, as they are today. Table 1 summarizes some relevant streamflow statistics and flow characteristics for the study reach based on the hydrologic analysis summarized in Section 5 of this report.

Table 1 Upper Gila River and San Francisco River Streamflow Statistics and Flow Characteristics				
Frequency	**Discharge (cfs)**	**Hydraulic Depth (ft)**	**Average Velocity (ft/sec)**	**Top Width (ft)**
Gila River Near Virden, NM - Upstream End of Study Reach (Duncan Valley)				
90 % Flow	21	0.6	1.3	27
Median (50%) Flow	91	0.9	2.2	45
Mean Annual Flow	190	1.2	1.6	100
2-Year Flood	4,980	5.5	8.5	107
5-Year Flood	10,400	7.5	12.6	110
Gila River Nr. Clifton/Guthrie, AZ - Midpoint of Study Reach (Gila Box)				
90 % Flow	18	0.7	1.0	26
Median (50%) Flow	80	1	1.7	47
Mean Annual Flow	206	1.3	2.5	64
2-Year Flood	5,940	3.7	11.5	140
5-Year Flood	11,500	5.5	14	150
Gila River at Safford Valley, Near Solomon, AZ - Downstream End of Study Reach (Safford Valley)				
90 % Flow	62	0.8	0.5	144
Median (50%) Flow	174	1.3	0.9	146
Mean Annual Flow	433	1.9	1.5	150
2-Year Flood	9,400	6.7	8.8	160
5-Year Flood	22,900	11	11.6	180
San Francisco River at Clifton - Entire Study Reach				
90 % Flow	34	0.9	1.4	28
Median (50%) Flow	76	1.0	1.6	49
Mean Annual Flow	215	1.2	2.5	72
2-Year Flood	6,800	4.5	10.1	150
5-Year Flood	17,800	8.5	13.7	153

Geologic Setting

Arizona is comprised of two great geologic regions: the Colorado Plateau Province, and the Basin and Range Province, with a transition zone, or Central Mountain Province, dividing them (Figure 2). The Upper Gila and San Francisco Rivers primarily drain the Central Mountain Region which may be extended eastward to the Continental Divide in New Mexico. The Upper Gila River also drains a portion of the Basin and Range Province in southern Arizona and southwestern New Mexico. The Central Mountain Region is characterized by mountains of Precambrian igneous, metamorphic rocks, capped by remnants

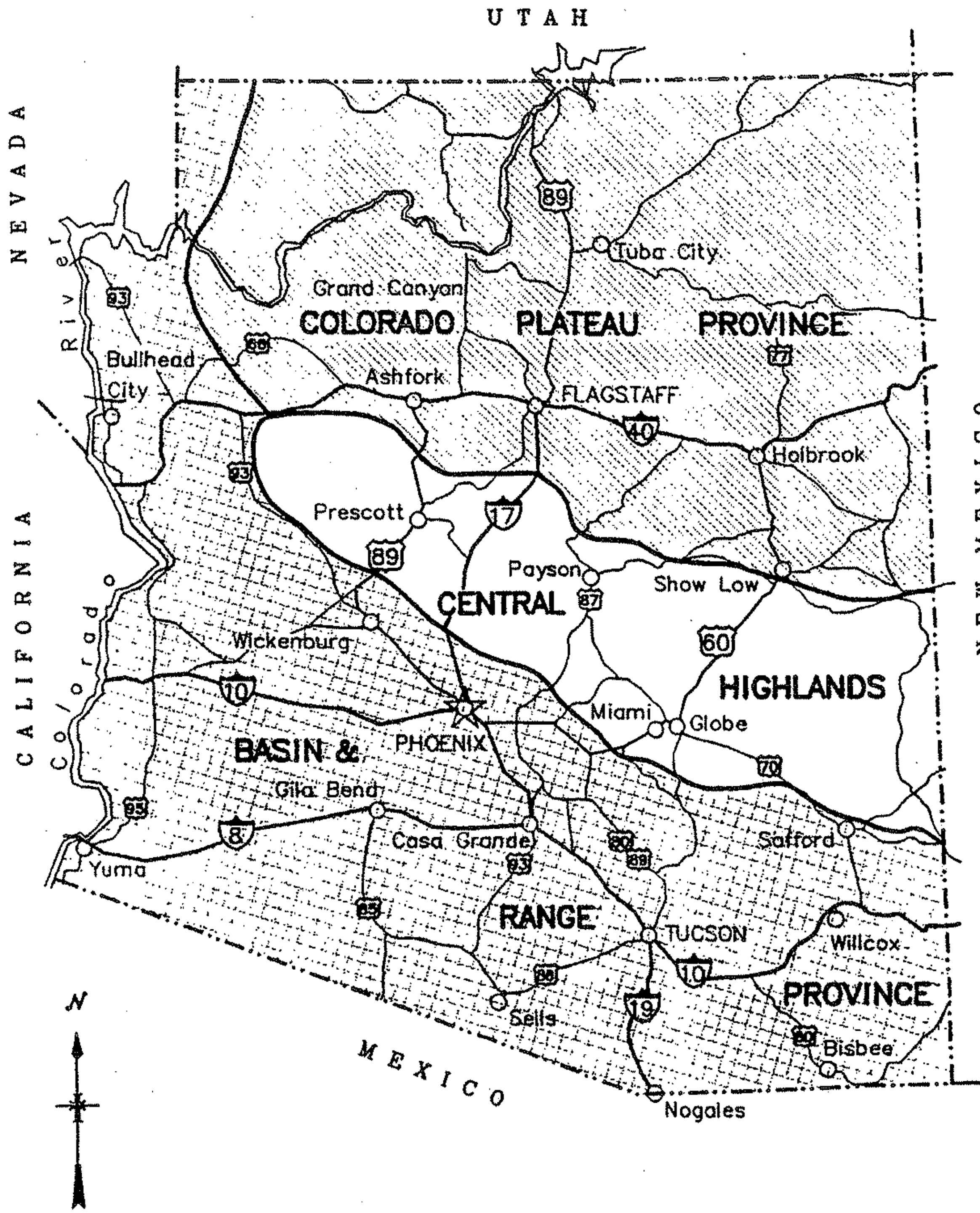


FIGURE 2. Physiographic Province Map

of Quaternary and Late Tertiary volcanics. Regional uplift of the entire state, including the Central Mountains, is thought to have occurred during the Laramide Orogeny in late Cretaceous/early Tertiary time (65 Ma[1]). Volcanic activity in the study area generally occurred about 29 million years before present (b.p.), during the Tertiary Period. The mountains of the transition zone generally experienced longer periods of erosion than the other physiographic provinces in Arizona, resulting in generally lower elevations than the mountains of the two other provinces (Nations and Stump, 1981). Central Mountain Region mountain ranges within Arizona in the Upper Gila and San Francisco Rivers basin include the Gila, White, and Peloncillo Mountains. These ranges consist primarily of Precambrian metamorphic and igneous rock with some more recent volcanics.

The Upper Gila and San Francisco Rivers study area is located mostly within relatively narrow canyons of the Central Mountain Province. Therefore, the geomorphology of most of the Upper Gila and San Francisco Rivers is controlled by bedrock cropping out in the bed or at the margins of these canyons. The average width of the canyons in Reaches 2 and 3 (Gila Box and San Francisco River) is about 500 feet, with very narrow floodplain terraces. In the latter reaches, moderate floods tend to fill the entire canyon bottom. In Reach 3, located between Duncan and Apache Grove, the canyon has an average width of about 2,000 feet, with floodplains that alternate from side to side, as the main channel meanders across the canyon bottom.

Reach 1, downstream of the Gila Box in the Safford Valley, is located within a deep alluvial valley at the margin of the Basin and Range Province. Here, the river flows in a broad valley more than a mile wide, and is subject to rapid shifting of the channel and floodplain geometry in response to floods. During sustained periods of low flow with no large floods, the channel has tended to narrow. The historical channel response to flooding in Reach 1 has been described by Burkham's (1972) classic paper on channel change on the Gila River in the Safford Valley.

[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).

Geologic Impacts on Streamflow

Shallow bedrock is present within Reaches 2, 3, and 4 of the Upper Gila and San Francisco River study reaches. The bedrock geology of the study reach exerts the following controls on river conditions in the study reach in several ways:

- First, bedrock limits the potential for lateral movement of the stream channel and prevents significant modifications of the channel cross sections. The natural erosion rate of bedrock is slow enough to be considered insignificant within the historical period. Within the bedrock-confined canyons of the Gila Box reach and the San Francisco River, no significant changes in channel geomorphology were identified during the period since statehood. In these canyon reaches, the exact locations or geometry of specific pools and riffles may fluctuate in response to large floods, but the overall channel pattern and reach-averaged width/depth/velocity relationships probably remained essentially unchanged.

- Second, narrow bedrock canyons do not provide favorable environments for extensive agricultural operations. Therefore, irrigation diversions as of the time of statehood were typically small, with the total water requirements less than the total average flow of the river.

- Third, discharges from springs in bedrock aquifers constitute a significant source of the ordinary and natural streamflow. Discharge from springs provides a constant base flow, making the Upper Gila and San Francisco Rivers perennial gaining streams, with an average annual discharge ranging from about 190 cfs to 430 cfs on the Upper Gila River, and 215 cfs on the San Francisco River.

- Finally, the rugged terrain and remoteness of the bedrock canyons of the Upper Gila and San Francisco Rivers minimized the potential for human impacts on the watershed and channel as of the time of statehood. Few towns and no large cities were located on the Upper Gila and San Francisco Rivers. Therefore, despite early exploration of the region relative to the rest of Arizona, transportation routes, including ferries, roads and railroads, almost completely avoided the Upper Gila and San Francisco Rivers. The few transportation routes in the study area are described in Section 3 of this report.

Channel Geomorphology

Descriptions of Historical River Conditions. The early explorers and residents of Arizona record river conditions in the Upper Gila and San Francisco Rivers that are similar to the conditions that may be observed today. These historical accounts, provided elsewhere in this report, describe steep, bedrock canyons with broad flat sandy and gravelly channels that filled the canyon bottoms, and perennial flow. Early explorers were able to travel on foot or horseback down the river channels during low flow periods. Historical accounts of boating the Upper Gila and San Francisco Rivers describe easy travel in small, low draft boats, with minor rapids. No physical or anecdotal evidence was identified that suggests that the geomorphology of the Upper Gila and San Francisco Rivers has significantly changed during the period since statehood, except for the few bridge crossings that have been constructed. No detailed maps that had a scale sufficient to facilitate comparison with recent maps were identified during the course of the literature search.

Existing Conditions. In its current condition, the Upper Gila and San Francisco Rivers are slightly sinuous, moderately steep, mountain streams entrenched in moderately deep canyons. The channel bed generally consists of alluvial material with short boulder/cobble riffles that form rapids at low to moderate discharges. Bedrock crops out locally in the bed and banks of Reaches 2, 3, and 4. The channel slope of the Gila River averages about 0.002 ft./ft. (0.2 percent). The channel slope of the San Francisco River averages about 0.004 ft./ft. (0.4 percent). The average sinuosity of both rivers is about 1.1, although the canyons themselves follow a somewhat sinuous path, with the low flow channels meandering within them. The channel margins are composed of bedrock and geologically older alluvial terraces, with inset terraces formed in low energy slackwater zones. A summary of some geomorphic characteristics of the four reaches of the Upper Gila and San Francisco Rivers are provided in Tables 2 to 5. Plots of longitudinal profile and canyon width are shown in Figures 3 and 4. Figures 5 to 8 show portions of current USGS topographic maps for Reaches 1 to 4, respectively, to illustrate typical channel and canyon geometry.

Table 2
Stream Classification Data for Reach 1: Gila River - Safford to Gila Box

Category	Classification/Description
Stream Size	Wide (> 500 ft.)
Flow Habit	Naturally perennial, intermittent due to diversions
Flood Characteristics	Flashy, Short Duration, High Losses
Bed Material	Alluvium (sand & gravel)
Valley Setting	Low Relief (< 100 ft.)
Drainage Network	Dendritic
Floodplains	Wide (> 10x channel width)
Incision	Not Incised
Channel Boundaries	Alluvial (channel abuts older terrace at right near Safford)
Width/Depth Ratio	High (> 100)
Bank Vegetation	Sparse, less than 50% Cover
Channel Slope	Moderately steep (S_o = 0.0025 ft./ft.)
Sinuosity	Sinuous low flow channel (S > 1.1), Straight flood channel (S < 1.06)
Braiding	Generally braided at high flows, locally braided at low flow
Anabranching	Not anabranched
Channel Width	Random Variation

Table modeled after FHWA, 1991.

Table 3 Stream Classification Data for Reach 2: Gila River Box	
Category	**Classification/Description**
Stream Size	Medium (100-500 ft.)
Flow Habit	Perennial
Flood Characteristics	Flashy, Short Duration, High Losses
Bed Material	Alluvium (sand & gravel), with some bedrock outcrop & control
Valley Setting	Moderate Relief (100-1000 ft.)
Drainage Network	Dendritic
Floodplains	Little or none (< 2x channel width)
Incision	Not Incised
Channel Boundaries	Mostly bedrock (low flow channel abuts minor alluvial surfaces)
Width/Depth Ratio	Moderate (10-100)
Bank Vegetation	Moderate, approx. 50% cover
Channel Slope	Moderately steep (S_o = 0.0022 ft./ft.)
Sinuosity	Sinuous low flow channel (S > 1.1), Straighter flood channel
Braiding	Locally braided at low flow, not braided at high flow
Anabranching	Not anabranched
Channel Width	Random variation, some widening at bends
	Table modeled after FHWA, 1991.

Table 4 Stream Classification Data for Reach 3: Gila River - Gila Box to Duncan	
Category	**Classification/Description**
Stream Size	Medium (100-500 ft.)
Flow Habit	Perennial, infrequently dry locally due to irrigation diversions
Flood Characteristics	Flashy, Short Duration, High Losses
Bed Material	Alluvium (sand & gravel), with minor bedrock control
Valley Setting	Low Relief (< 100 ft.)
Drainage Network	Dendritic
Floodplains	Narrow (2-10 x channel width)
Incision	Possible minor incision since statehood
Channel Boundaries	Mostly alluvial (low flow channel abuts bedrock in short canyons)
Width/Depth Ratio	Moderate (10-100)
Bank Vegetation	Moderate (> 50% cover)
Channel Slope	Moderately steep (S_o = 0.0019 ft./ft.)
Sinuosity	Sinuous low flow channel (S > 1.1), Straighter flood channel
Braiding	Moderately braided at low flow, less braided at higher flow
Anabranching	Not anabranched
Channel Width	Random variation, some widening at bends
	Table modeled after FHWA, 1991.

Figure 3. Gila River
Longitudinal Profile & Valley Width

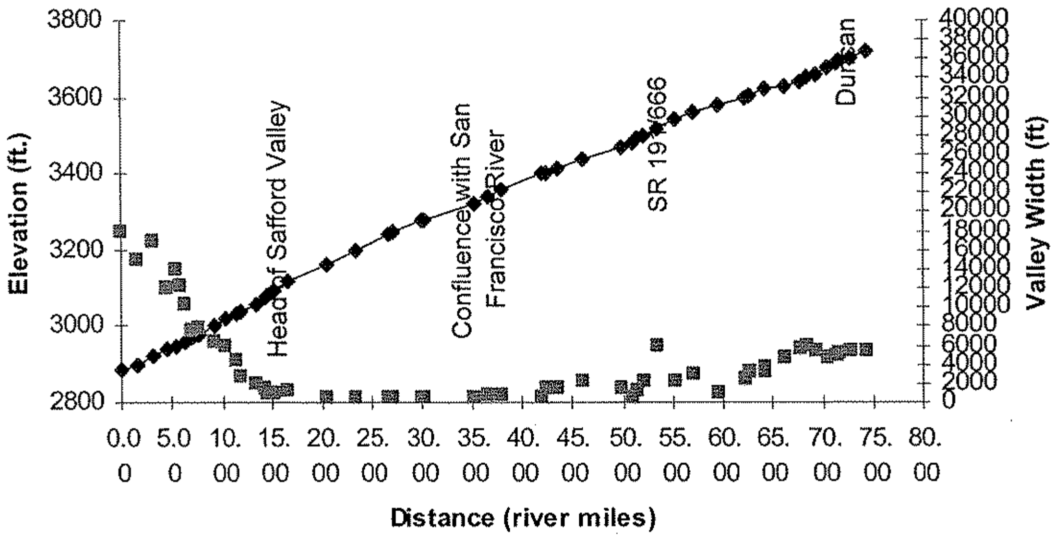
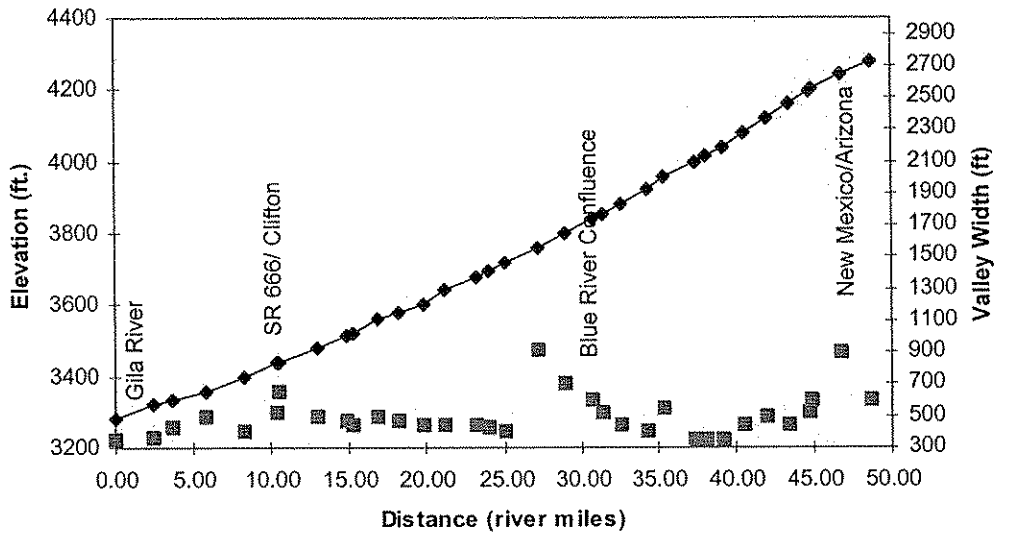


Table 5
Stream Classification Data for Reach 4: San Francisco River

Category	Classification/Description
Stream Size	Medium (100-500 ft.)
Flow Habit	Perennial, may be intermittent in drought years
Flood Characteristics	Flashy, Short Duration, High Losses
Bed Material	Alluvium (sand & gravel), with some bedrock outcrop & control
Valley Setting	Moderate Relief (100-1000 ft.)
Drainage Network	Dendritic
Floodplains	Little or none (< 2x channel width)
Incision	Not Incised
Channel Boundaries	Mostly bedrock (low flow channel abuts minor alluvial surfaces)
Width/Depth Ratio	Moderate (10-100)
Bank Vegetation	Moderate, approx. 50% cover
Channel Slope	Moderately steep (S_o = 0.0022 ft./ft.)
Sinuosity	Sinuous low flow channel (S > 1.1), Straighter flood channel
Braiding	Locally braided at low flow, not braided at high flow
Anabranching	Not anabranched
Channel Width	Random variation, some widening at bends

Table modeled after FHWA, 1991.

Figure 4. San Francisco River
Longitudinal Profile & Valley Width



In general, the geomorphology of the Upper Gila and San Francisco Rivers reflects the bedrock geology of the reach. The minor changes in channel geomorphology that can occur, typically occur during the largest floods. During large floods, there is sufficient energy to erode channel bed sediments, including the boulders that form the riffles, and the vegetated terraces along the margins of the channel. The low flow channel is inset within a wider flow path that includes alternating unvegetated, gravelly point bars. A definitive increase in vegetative density and a slope break generally marks the boundary between the active flood channel and floodplain. Streambank riparian vegetation, if it occurs along the channel, grows predominantly on the margins of the point bars and the floodplain terraces. While the point bars, riffles and terrace margins are subject to erosion during large floods, the net changes in overall channel characteristics typically are minor for an extended river reach. That is, erosion of a bar or riffle in one location generally is balanced by deposition elsewhere in the reach. The overall stream characteristics are preserved, although the exact channel dimensions at any given location may change with time.

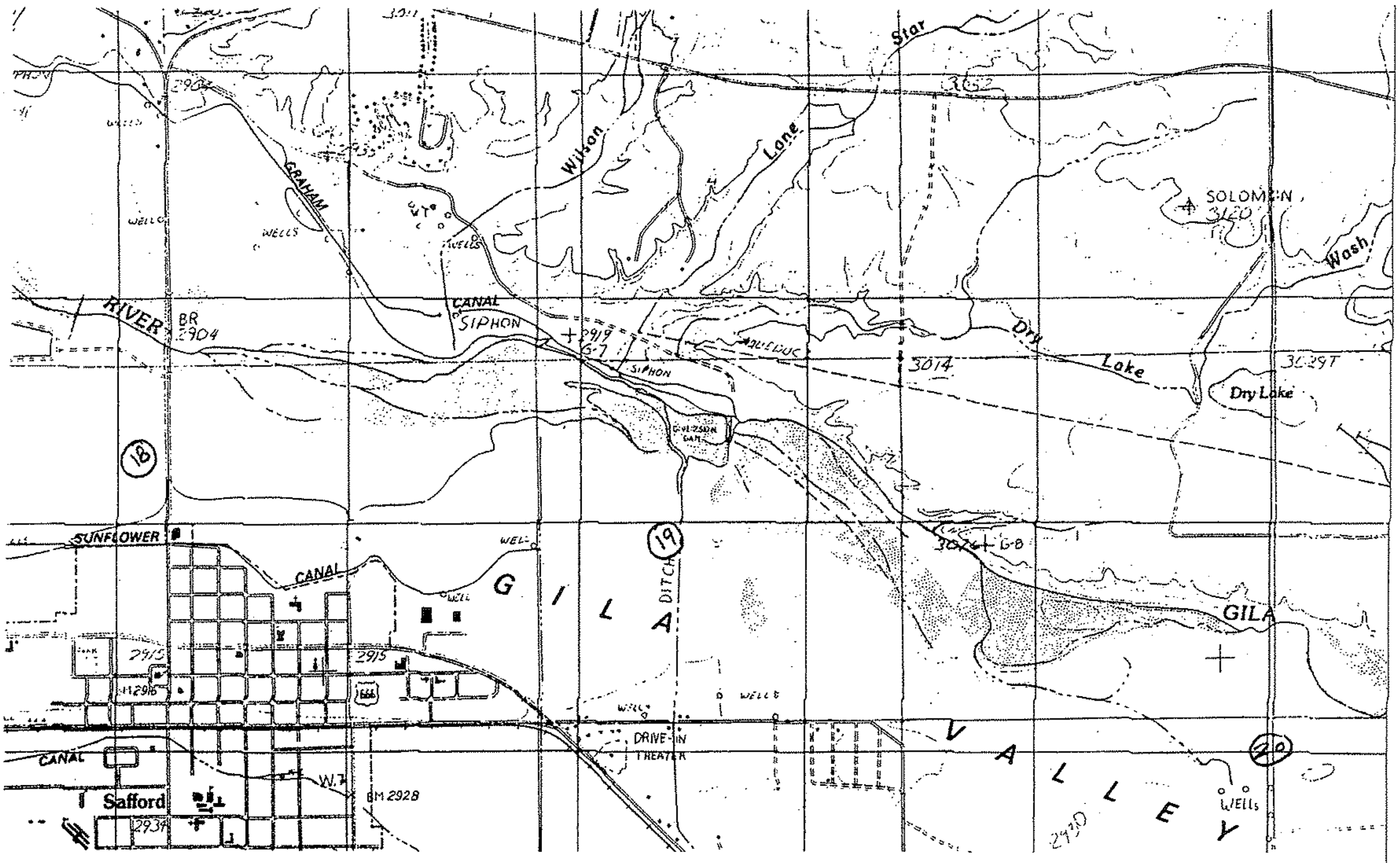


FIGURE 5. Reach 1 topo map

(Source: USGS 7.5' Quad, Safford, AZ, 1985)

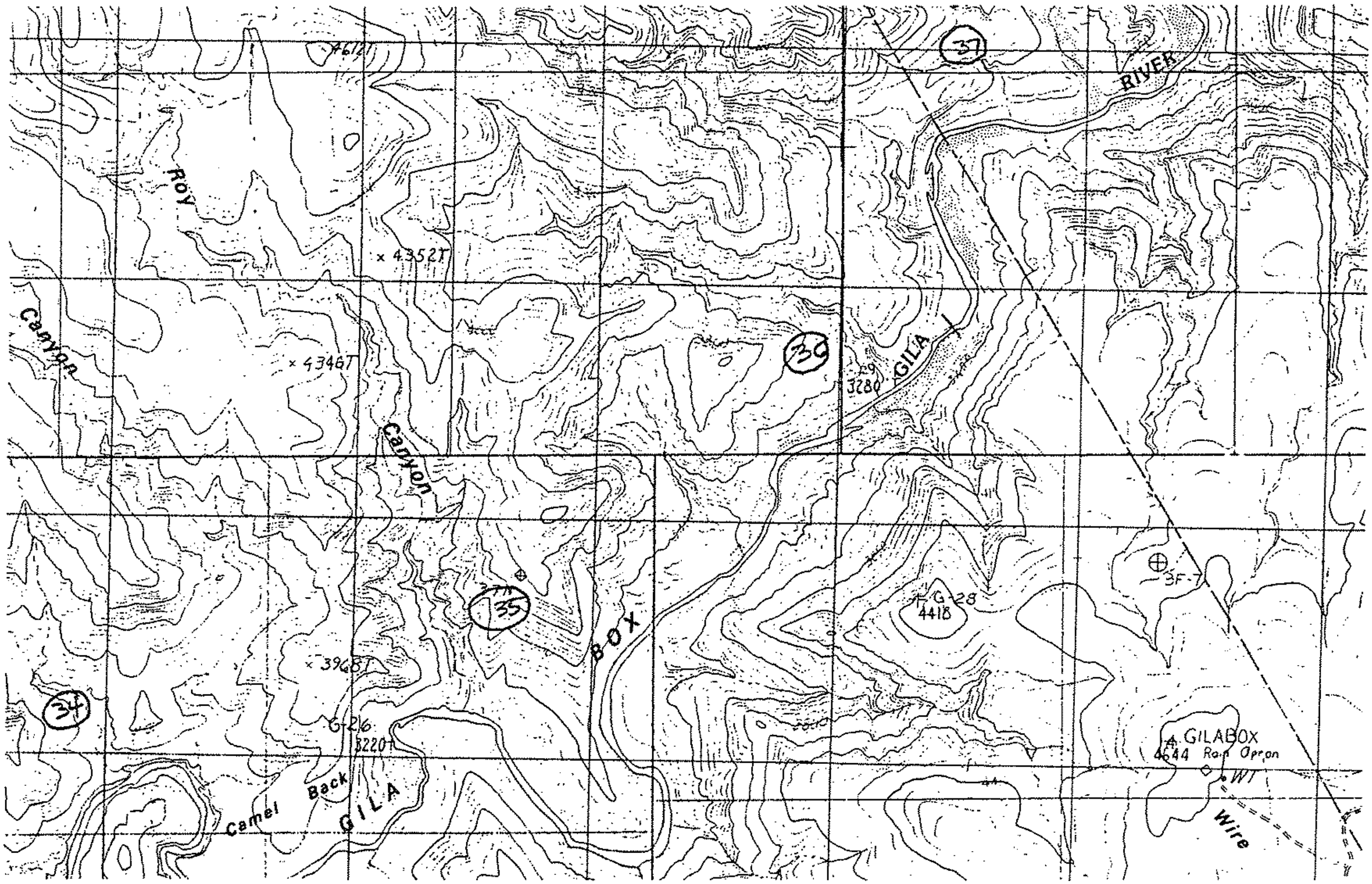


FIGURE 6. Reach 2 topo map

(Source: USGS 7.5' Quad, Safford, AZ, 1985)

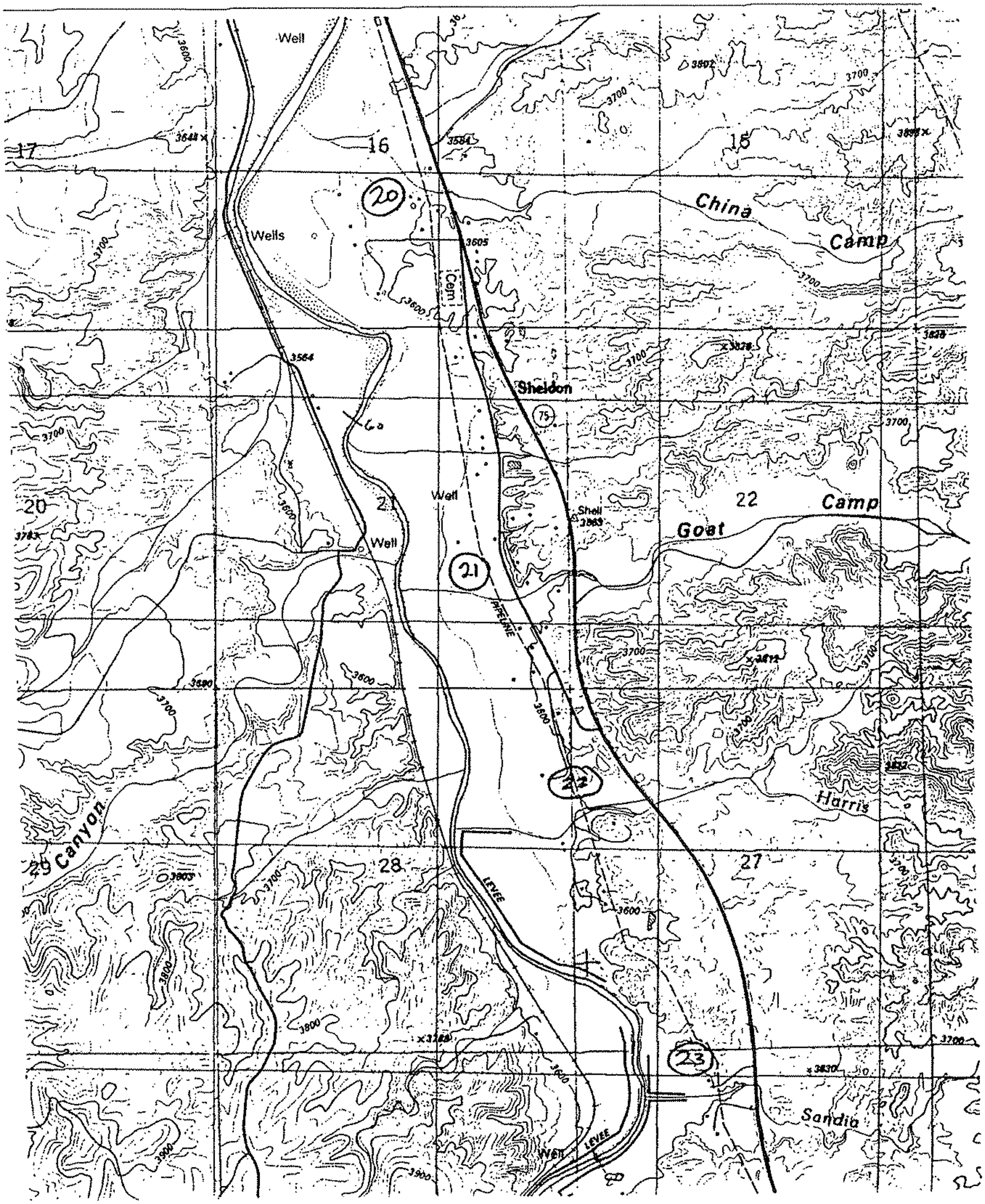


FIGURE 7. Reach 3 topo map

(Source: USGS 7.5' Quad, Sheldon, AZ, 1986)

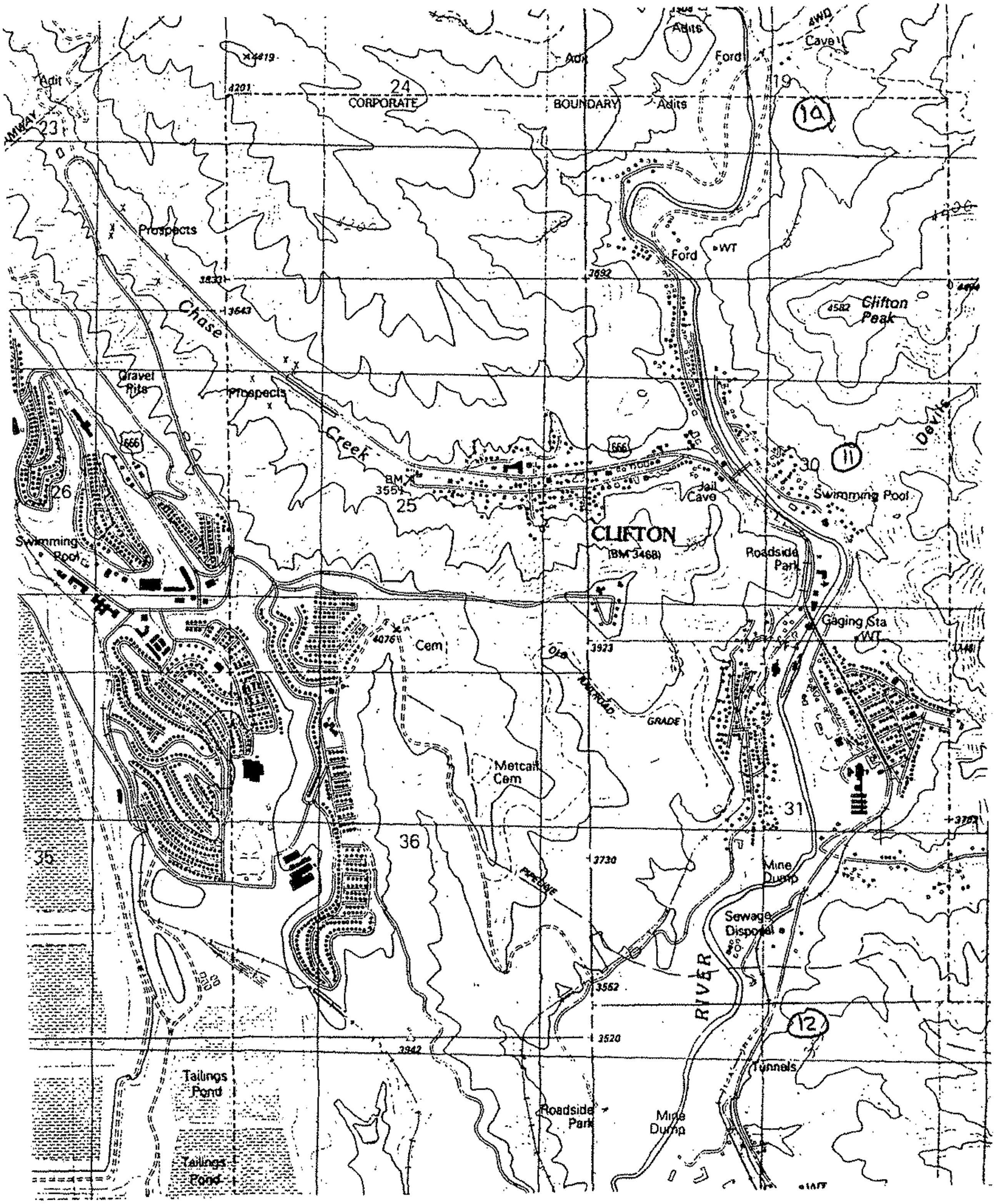


FIGURE 8. Reach 4 topo map

(Source: USGS 7.5' Quad, Clifton, AZ, 1989

In the alluvial portions of Reach 1, large floods flow across the broader geologic floodplain and have the potential to cut new channels within the active channel area. The active channel area is not deeply inset within the geologic floodplain and the banks are poorly defined. However, like the erosion and deposition in the canyon reaches, any local changes in low flow channel geometry are generally balanced when considered from a reach-wide perspective.

Historical evidence of systematic channel change along the Upper Gila and San Francisco Rivers is lacking. Few detailed maps are available for the study area. The oldest historical maps identified during the literature search/agency contact phase of the project were prepared by the USGS during the 1930's. These maps cover the Upper Gila and San Francisco Rivers upstream of the Safford Valley, and have a contour interval of 40 feet. Comparison with the USGS topographic quadrangle maps for the study area, which were based on topographic data obtained from 1950-1960, indicate that only minor changes in channel position occurred during this period. Older USGS topographic maps for the area, dated 1915, have a contour interval of 100 feet, which did not allow detailed evaluation of channel change.

Summary

Review of the geology of the Upper Gila and San Francisco Rivers indicates that the channel geomorphology is substantially unchanged from its condition at or before statehood. Most of the Upper Gila and San Francisco Rivers is formed within bedrock canyons. Bedrock along the channel margins in these canyons precludes significant movement of the river channel or other channel changes. In addition, the bedrock geology of the Upper Gila and San Francisco Rivers area made access to the river difficult during the period around statehood, prevented development of extensive irrigation systems, and prevented the development of large population centers near the river.

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1972 *Channel Changes of the Gila River in Safford Valley, Arizona 1846-1970.* USGS Professional Paper 655-G.

Nations, D., and Stump, E.
1981 *Geology of Arizona*. Kendall/Hunt Publishing Co., Dubuque, IA, 221 p.

APPENDIX A

Aerial Photographs of the Upper Gila and San Francisco Rivers (June, 1997)

Originals on File at Arizona State Land Department, Drainage and Engineering Section

Arizona Stream Navigability Study
for the
Upper Gila River
Safford to the State Boundary
and
San Francisco River
Gila River Confluence to the State Boundary

Draft Final Report

Prepared for the

Arizona State Land Department

Date of Original Report: June 1997

Prepared by

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In Association with
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June 2003: JE Fuller/ Hydrology & Geomorphology, Inc.

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Section 5

Hydrology of the Upper Gila and San Francisco Rivers

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A Arizona Copper Company Diversion Dam on the San Francisco River near Clifton, Arizona
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Section 5:
Hydrology of the Upper Salt River

Introduction

The objective of this section is to document and evaluate the "ordinary and natural discharge" of the Upper Gila and San Francisco Rivers as of the time of statehood. While these rivers do not have major dams within the study reach, there are numerous irrigation diversions and at least one small reservoir near the headwaters. Therefore, the ordinary and natural hydrologic condition depends on if man-made changes are considered. To assure that the range in potentially "natural" conditions is presented, this section of the report summarizes information that describes the hydrology of the Upper Salt River for the following time periods:

- Pre-Settlement - Flow conditions for the period leading up to statehood
- Statehood - Flow conditions in 1912, the year of Arizona statehood
- Post-Statehood - Long-term flow conditions, including the period after 1912

For stream conditions during each of these time periods, estimates of monthly and annual flow rates, anecdotal information regarding the appearance and character of the stream, and flood data will be summarized. Hydraulic rating curves relating discharge to stream depth, width, and velocity for existing and historical river conditions will also be presented.

Stream Reaches

For the purposes of the hydrologic analysis, the Upper Gila River will be considered as a single stream reach. Likewise, the San Francisco River will be considered a single hydrologic stream reach. While the geomorphology and historical use of these streams vary somewhat within the study area, hydrologic conditions vary gradually without well-defined break points, and can therefore be considered as single hydrologic units. Therefore, the stream reaches described in this section include the following:

- Gila River - Safford to Arizona/ New Mexico border near Duncan
- San Francisco River - Gila River confluence to Arizona/ New Mexico border

Data Sources

The records of the U.S. Geological Survey (USGS) are the primary source of hydrologic data for the Upper Gila and San Francisco Rivers study reach summarized in this report. These data include daily discharge values, peak flow values, and some limited irrigation diversion discharge values. Available published USGS water resources data were gathered from the Arizona State Land Department Library in Phoenix, Arizona, from the USGS Water Resources Division Library in Tucson, Arizona, and from the government documents library at Arizona State University. Additional irrigation diversion data were obtained from the Gila Water Commissioner's office in Safford, Arizona. Table 1 below lists the key existing and historical USGS stream gauges along with some basic watershed characteristics for the study reach associated with each gauge location.

The USGS routinely measures discharge values at established stream gauges in order to track shifts in the stage-discharge rating curves attributable to shifting channel geometry. These discharge measurements were performed by hand, by either wading into the stream with a velocity meter or by lowering the velocity meter from a bridge or a cable-car. Early published discharge measurements (usually before 1910) included stream width and flow area along with gauge height and discharge. Although generally unpublished, stream width and flow area data have always been recorded in the notes of the surveyor or gauge operator. Much of these data for the stream gauges located in these study reaches were gathered by accessing the USGS national archives through the USGS Water Resources division in Tucson.

Table 1. Upper Gila River Navigability Study USGS Stream Gauges in the Upper Gila River Watersheds					
Gauge	**USGS ID #**	**Drainage Area (sq. miles)**	**Elevation of Station (ft above MSL)**	**Slope of Reach (ft/ft)**	**Earliest Record**
Gila River					
Gila River Near Red Rock, NM	09431500	2,829	4090	.0015	1904
Gila River Near Virden, NM	09432000	3,203	3,875	.0025	1914
Gila River Near Clifton/Guthrie, AZ	09442000	4,010	3,336	.0019	1910
Gila River at Head of Safford Valley, Near Solomon, AZ	09448500	7,896	3,060	.0031	1914
Gila River at Safford, AZ	09458500	10,459	2,890	.0020	1940
San Francisco River					
San Francisco River at Alma, NM		1,540	4850	.0038	1904
San Francisco River at Glenwood, NM	09444000	1,653	4560	.0038	1927
San Francisco River at Clifton	09444500	2,766*	3,436	.0032	1910**
Notes: * 2 square miles is noncontributing ** some earlier data are available starting 1891					

Hydrologic Setting

Climate

The climate of the Upper Gila River and San Francisco River watersheds varies dramatically with elevation, although the climate along the rivers themselves is relatively uniform over the length of the study reaches. During the dry transition seasons of late spring and early fall, daily temperatures alone can fluctuate as much as 40 degrees (Fahrenheit). The lower regions of the Gila River near Safford experience hot summers with daytime high temperatures in 100's. Winters are generally mild in these areas with occasional lows in the teens (10-20°F) after winter storms. The upper elevations of the Gila and San Francisco River watersheds experience alpine conditions. Summer daytime high temperatures in the higher elevations above 8,000 feet in elevation rarely exceed the 80's. Winter low temperatures can drop below zero during severe winter storms.

Table 2
Climatic Data for the Upper Gila River and San Francisco River Watersheds

Average Annual Statistics	Safford 1900-1973 Elev.=2,934 ft.	Clifton 1906-1988 Elev.=3,468 ft.	Duncan 1901-1982 Elev.=3,650 ft.	Alpine 1904-1982 Elev.=8,020 ft.
Precipitation (in.)	8.82	12.69	9.92	20.61
Max. Temperature	80.8	80.99	77.8	61.6
Min. Temperature	46.8	51.62	40.4	25.5

Source: (Sellers, 1985)

Table 3
Seasonal Variation in Precipitation (Inches) and Temperature (^{o}F) for the Upper Gila River and San Francisco River Watersheds

Average Annual Statistics	Safford 1900-1973 Elev.=2,934 ft.	Clifton 1906-1988 Elev.=3,468 ft.	Duncan 1901-1982 Elev.=3,650 ft.	Alpine 1904-1982 Elev.=8,020 ft.
January	0.58	0.96	0.78	1.48
February	0.57	0.96	0.69	1.29
March	0.67	0.79	0.58	1.38
April	0.23	0.35	0.21	0.75
May	0.08	0.30	0.21	0.56
June	0.20	0.39	0.29	0.73
July	1.91	2.14	1.77	3.72
August	1.57	2.31	1.94	3.77
September	1.05	1.59	1.15	2.27
October	0.67	1.01	0.89	1.99
November	0.51	0.66	0.50	1.16
December	0.77	1.18	0.91	1.51
Annual	8.82	12.63	9.92	20.61

Source: (Sellers, 1985)

Upper Gila River

The Gila River at Safford, Arizona drains an area of approximately 10,459 square miles, not including the Animas River Basin, which is a closed basin. The Gila River headwaters are in the expansive Gila Wilderness in Western New Mexico. The highest point in the basin is Whitewater Baldy, at an elevation of 10,895 feet above mean sea level. Principle tributaries to the Gila River in Arizona include the San Francisco River near Clifton, Eagle Creek near Clifton, Bonita Creek near the head of the Safford Valley, and the San Simon River near Safford. The Gila river flows through Greenlee and Graham Counties on its way to Safford in Graham County. In Greenlee County, the Gila River flows through the agricultural communities of Duncan, York, and Guthrie. In Graham County, the river flows through the Gila Box Riparian National Conservation Area upstream of Solomon and the Safford Valley.

In Arizona, agricultural centers are located along the Gila River near Duncan and in the Safford Valley. In these reaches with agriculture, the river is wider than the canyon reaches and is more prone to channel alignment changes. A number of irrigation canals divert river water to nearby agricultural fields. Of the 64 river miles between the Arizona/New Mexico State line and Safford, approximately 26 river miles are through relatively narrow bedrock canyons, where the channel alignment has been relatively stable compared to the reaches with agricultural uses in the floodplain. Historical stream gauge data for the Upper Gila River are available at stations at Red Rock, New Mexico; near Virden, New Mexico; at Guthrie, Arizona; near Clifton, Arizona; at the Head of the Safford Valley, Arizona; and at Safford, Arizona.

Table 4 Gila River Drainage Area Summary	
River Reach	**Drainage Area (square miles)**
Near Redrock, New Mexico (28 river miles upstream from state line)	2,860
Near Virden, New Mexico (15 river miles upstream from state line)	3,203
To Arizona/ New Mexico State Line	3,363
Above San Francisco River Confluence (34 river miles downstream from state line)	4,046
(San Francisco River total drainage area)	(2,804)
To head of Safford Valley, near Solomon (47 river miles downstream from state	7,896
At Safford (64 miles downstream from state line)	10,459

San Francisco River

The San Francisco River drains an area of approximately 2,804 square miles (see Figure 1). The largest tributary to the San Francisco River is the Blue River, which has for its headwaters the eastern highlands of Arizona, including the Blue Range. The San Francisco River begins in Arizona on the southern flanks of Escudilla Mountain (elevation 10,912 feet) near Alpine, Arizona. The river then flows east into New Mexico where it drains a large portion of that state's western uplands which include several peaks over 9,000 feet in elevation and a few over 10,000 feet in elevation. The San Francisco River joins the Gila River approximately 11 river miles south of the town of Clifton, Arizona.

Two locations on the San Francisco River have reliable recorded historic gauge data: Clifton, Arizona and a reach including Alma and Glenwood, New Mexico. Between Alma/Glenwood, New Mexico and Clifton, Arizona (the only two locations with gauge records on the San Francisco River), the largest tributary to the San Francisco River (and its largest tributary overall) is the Blue River. Therefore, the best representative flow data for the San Francisco River upstream of the Blue River is that data collected at Alma and Glenwood, New Mexico. Likewise, the best available data for the San Francisco River between the Blue River confluence and Clifton are from the Clifton gauge. The following table (Table 5) summarizes drainage area data for the San Francisco River.

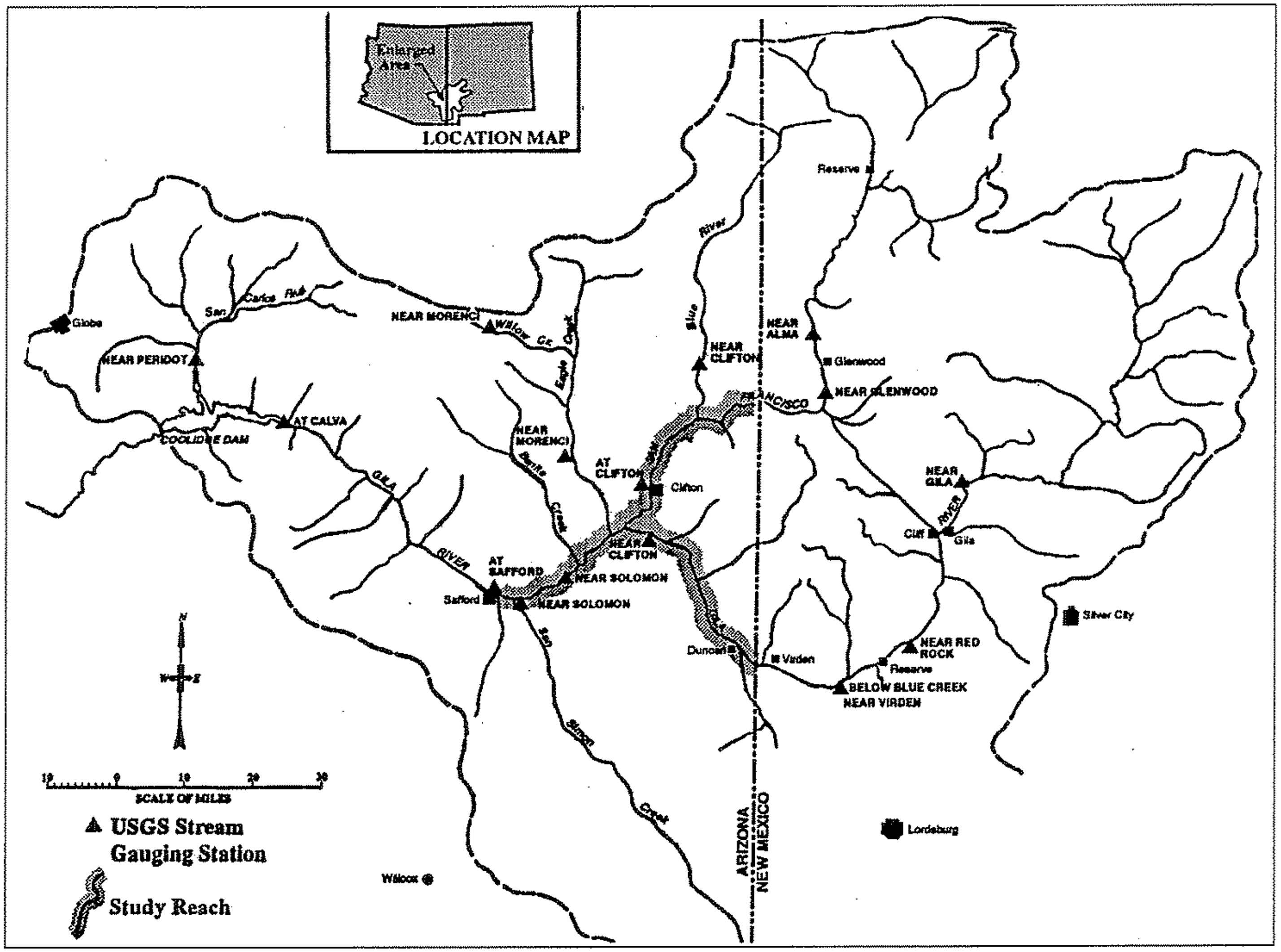


FIGURE 1. Study Reach Location Map

Table 5 San Francisco River Drainage Area Summary	
River Reach	**Drainage Area (square miles)**
To Alma, New Mexico (27 river miles upstream from state line)	1,540
To Arizona/New Mexico State Line	1,917
Above Blue River Confluence (13 river miles downstream from state line)	2,037
(Blue River total drainage area)	(624)
To Clifton (34 river miles downstream from state line)	2,765
Confluence with Gila River (45 miles downstream from state line)	2,804

Diversions

Other than irrigation diversion structures, the Upper Gila River and the San Francisco River are unregulated and free-flowing. However, early records indicate that significant irrigation diversions were in place well before statehood. Early accounts of irrigation diversions indicate that as early as 1899 there were 17 diversions from the Gila River in the Duncan Valley (i.e., a 10 mile reach of the Gila River extending upstream from Duncan, Arizona) and 28 diversions in the Solomonsville Valley (Safford Valley) (USGS, 1901).

The Montezuma Ditch, the earliest constructed canal in the Safford Valley (according to USGS records), was built in 1874. It is interesting to note that discharge measurements taken April 15, 1899 in the Safford Valley indicate that the Gila River was flowing at 237 cfs near the head of the valley, 0.0 cfs was measured that same day downstream of several of the diversions, and only 32.8 cfs was flowing below Ft. Thomas downstream from all diversions at the western end of the valley. Also, on that day, the Montezuma Ditch was carrying 101 cfs (USGS, 1901). Therefore, it may be assumed that it was not unusual for irrigation diversions to completely drain the river during some months of low flow.

Early accounts of irrigation diversions on the San Francisco River note diversions at Luna, New Mexico (one diversion), and a few miles above Frisco, New Mexico (two diversions) as early as April, 1899. Two diversions from the San Francisco River near Clifton are also described; one for the purpose of irrigation is described as "a small ditch 1¾ miles above the bridge" (the gauge location), and a second diversion located 1½ miles above Clifton diverts "about 14 second-feet (cfs)" for power development for the Arizona Copper Company. This later diversion is returned to the San Francisco River above the gauging station. A USGS gauge description sketch dated only as 1911, notes the presence of a "series of small reservoirs" in the overbank areas of the San Francisco River downstream of the Clifton railroad bridge (USGS, 1901).

A sketch by the USGS, dated April 13, 1911, of the Arizona Copper Company's diversion dam located just upstream of Clifton on the San Francisco River shows the crest of the diversion dam to be 118.5 feet wide, with a concrete apron which measures 22 feet parallel to the direction of flow, and intake works which account for another 44.6 feet, including an eight-foot wide crib screen (USGS, 1911). Notes on the sketch indicate that there is "no free overfall" below the apron of the dam and that the crest is constructed of a "4"x 4" plank". The early sketch also shows the depth of flow over the diversion dam to be 0.6 feet above the crest on April 13, 1911, with a published discharge measurement at the dam on this date of 225 cfs. No other descriptions of other canal head works were found for the canals located in other reaches of the San Francisco River and the Upper Gila River. However, the details discussed above for a canal which is reported to have flowed fairly constantly at 14 cfs, provides a glimpse of what one head works looked like near the turn of the century, and perhaps an idea of what other head works may have been like for the larger canals located elsewhere on the Gila River. A copy of the head works sketch is provided in the Appendix A.

Accurate historic diversion data prior to 1936 is not readily available in part because there was no mandate for such data to be recorded. The Gila Water Commissioner started recording accurate records in 1936. An annual summary of diversions starting in 1936 for the Upper Gila River is shown in Table 6.

Table 6				
Year	**River Flow:**	**Diversion**	**River Flow:**	**Diversion**
1936	90	39	217	132
1937	206	40	418	161
1938	87	23	164	98
1939	94	34	172	79
1940	146	40	303	100
1941	435	34	915	151
1942	111	36	222	172
1943	71	32	151	122
1944	80	27	151	128
1945	109	28	220	149
1946	53	14	116	70
1947	45	10	100	52
1948	86	9	148	40
1949	303	25	569	168
1950	49	18	87	69
1951	33	3	79	26
1952	140	20	324	129
1953	46	8	83	39
1954	89	13	190	80
1955	67	13	170	86
1956	24	8	49	43
1957	121	11	225	70
1958	205	19	473	147
1959	74	11	179	80
1960	138	15	285	111
1961	73	8	159	36
1962	211	21	410	135
1963	130	20	273	101
1964	69	12	142	70
1965	161	18	395	93
1966	209	23	433	133
1967	115	16	259	90
1968	314	26	656	152
1969	62	15	122	89
1970	53	15	110	96
1971	89	5	181	39
1972	255	12	506	67
1973	314	20	671	125
1974	59	13	115	80
1975	220	16	342	109
1976	88	18	147	94
1977	66	9	132	31
1978	330	13	848	75
1979	287	16	750	106
1980	135	23	445	122
1981	62	18	150	110
1982	131	24	270	118
1983	374	22	1149	127

Table 6				
Year	River Flow:	Diversion	River Flow:	Diversion
1984	198	24	460	135
1985	370	21	740	134
1986	186	24	324	149
1987	121	26	334	138
1988	257	23	445	138
1989	68	18	120	94
1990	78	10	170	69
1991	340	20	681	126
1992	377	20	801	124
1993	518	22	1558	119
1994	230	23	345	108
1995	262	22	506	109
1996	117	16	194	95
Average	161	19	350	102
Source: Gila Water Commissioner				

The Gila River Decree (Globe Equity No. 59), the first formal water adjudication decree for this study reach, was entered in the U.S. District Court on June 29, 1935 (BuRec, 1974). The Gila River Decree governs the use of the Gila River from the head of the Duncan-Virden Valley to San Carlos Reservoir. Under the decree, the discharge of the Gila River in the governed reach is fully appropriated. It is the job of the Gila Water Commissioner to apportion flow to water users in the Safford and Duncan-Virden Valleys when there is flow in the Gila River. When river flows are insufficient to meet the entire demand, water rights are exercised by senior priority.

The Gila River Decree limits the rate of diversion to one cubic foot per second for each 80 acres. The decree also limits the total diversion to 6 acre feet per acre per irrigation season (January 1 to December 31). Overall, water is distributed according to arable acreage as follows:

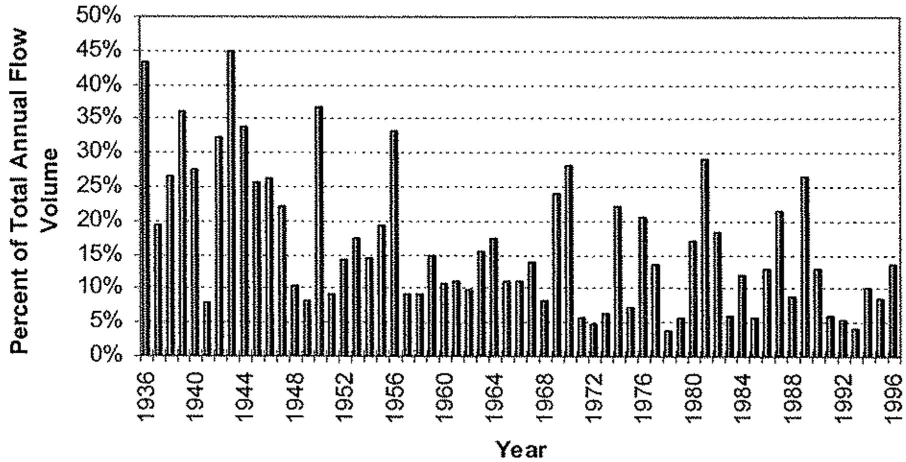
Duncan-Virden Valley

	New Mexico	2860.10 acres	
	Arizona	5201.25 acres	
	Subtotal	8061.35 acres	
Safford Valley		32512.40 acres	
Total		40573.75 acres	Source: (BuRec, 1974)

Applying the six acre-feet-per-acre rule to the total allowable acreage yields 243,443 acre feet annually, almost twice the average combined diversions from the Upper Gila River as shown in Table 6, but less than the long-term average flow volume of the Gila River at Safford.

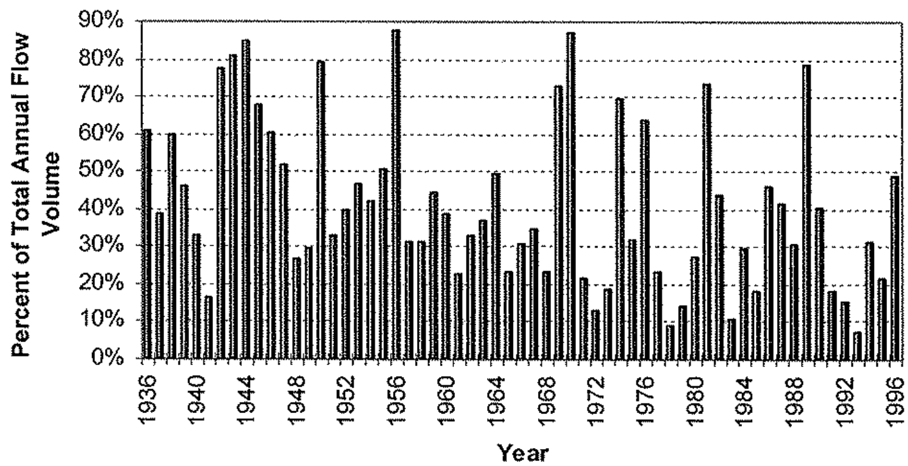
An indication of the long-term trend of irrigation use is the percentage of Gila River flow used for irrigation. The following two charts show the long-term trend of irrigation diversions as a percentage of the annual discharge of the Upper Gila River in two locations: (1) the Duncan Valley, and (2) the Safford Valley.

Figure 2. Duncan Valley Diversions as a Percent of Annual Discharge at Gila River near Virden



Basic Data Source: (Gila Water Commissioner, 1996)

Figure 3. Safford Valley Diversions as a Percent of Annual Discharge at Gila River near Solomon



Basic Data Source: (Gila Water Commissioner, 1996)

Both Figure 2 and 3 indicate a general trend of decreased volume of irrigation diversions from the Upper Gila River over the last 60 years. This trend could be attributable to several factors including:

- More efficient diversion, distribution, and irrigation practices
- Later decrees changing the allowable total diversions
- Decreasing arable acreage
- Changing crop types
- Increased use of groundwater supplies.

A later court decision, the Arizona v. California, et. al. Decree, was entered by the United States Supreme Court on March 9, 1964 (BuRec, 1974). This decree set allowable water uses for, among other areas in the Upper Gila River Basin, land along the San Francisco River in New Mexico. Under the decree, the total consumptive use for the San Francisco River in New Mexico (i.e., from Luna to the Glenwood area) is set at 31,870 acre feet during any period of 10 consecutive years, or 4,112 acre-feet during any one year. These limits included both irrigation diversions and groundwater pumping.

<u>Summary</u>

Since well before statehood, large scale irrigation diversions from the Gila River were taking place in the Duncan-Virden Valley and the Safford Valley. The combined capacity of all these early diversion canals and ditches was enough to divert all the flow from the Gila River during the peak irrigation season (which coincides with seasonal low river flow rates) in reaches with irrigated agriculture. The Montezuma Canal, located in the Safford Valley, could divert at least 101 cfs, or about 50 percent of the long-term average annual flow. Long-term records kept continuously since 1936 indicate a general decrease in the total annual diversion volumes taken from the Gila River. This information suggests that diversions from the Gila River as of the time of statehood were probably on the same order of magnitude, but slightly greater than today, since there were no formal court decrees limiting use.

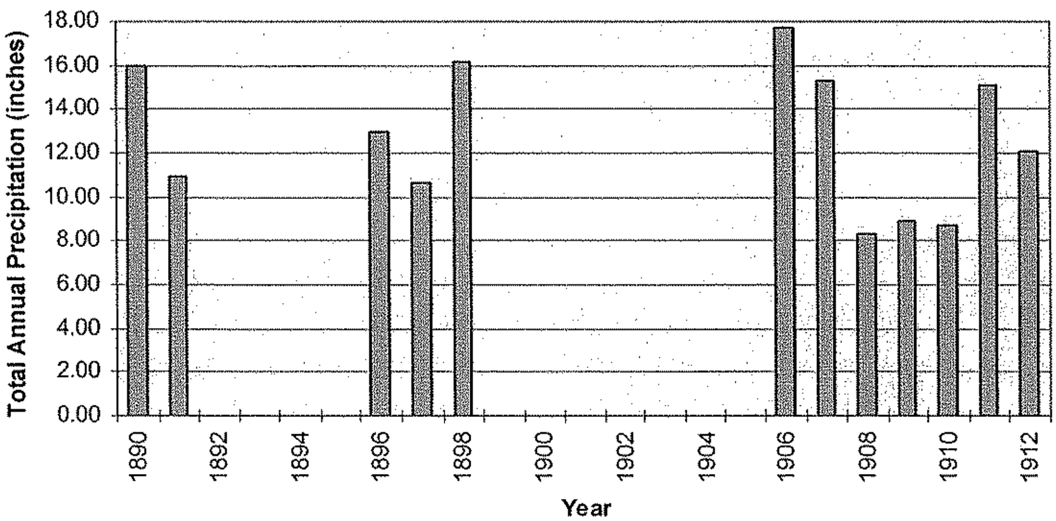
Available diversion data for the San Francisco River are sparse, consisting of a few spot measurements recorded in early Bureau of Reclamation/USGS reconnaissance reports published in USGS Water Supply Papers. It may be assumed that irrigation diversions (i.e., water rights) were most likely not substantial, given the limits placed on consumptive use on lands adjacent to the San Francisco River in New Mexico in the Arizona v. California Decree. However, even small diversions from the San Francisco River could have had a measurable impact, given the typical low average flow rates during seasons when high irrigation demand coincides with seasonal low flow.

Pre-Statehood Hydrology

Hydrologic data for the period prior to Arizona statehood are available from direct measurements made by the USGS and the Bureau of Reclamation, which were published in annual summaries of stream gauging records. In addition, comparison of pre-statehood and long-term precipitation records at Clifton indicate that modern streamflow records presented later in this report are probably representative of conditions as of the time of statehood, if an adjustment for irrigation diversions can be made.

Available pre-statehood precipitation records for Clifton, Arizona starting in 1890 are shown in Figure 4 below (USGS, 1900, Sellers, 1985). The long-term annual average precipitation at Clifton is 12.63 inches (Sellers, 1985). From 1906 to 1912 the annual precipitation totals at Clifton varied greatly, like most stations in the arid west, from a high of 17.73 in 1906 to a low of 8.67 in 1910 (the record for 1908 is missing five months worth of data). Note that the precipitation total during 1912 (12.13 inches) falls near the long-term average of 12.63 inches. The average annual precipitation at Clifton for the period from 1906 through 1912 was 12.32 inches.

Figure 4. Annual Precipitation at Clifton, Arizona
1890-1912



No other annual precipitation data were readily available for the years immediately preceding the year of statehood (1912) in and around the upper Gila River basin for which meaningful data could be compared for long-term trends.

Upper Gila River

Early Gauge Measurements. The first discharge measurements on the Upper Gila River were recorded by the USGS on March 22, 1899, during a reconnaissance trip through the Upper Gila River basin by Cyrus C. Babb (USGS, 1901). On that day, according to Babb's report, the discharge was measured on 17 canals in the Duncan Valley as well as on the main channel of the river itself. It is noted that the Upper Gila River was flowing at 160 cfs above the head of the Telles, or uppermost, canal located in the Duncan Valley. Also noted in this report was that the total diversion rate into the ditches was 86 cfs on that day, and that the discharge in the river in Duncan below all of the diversions was 104 cfs "showing a gain of 30 second-feet [cfs] in a distance of about 15 miles." In addition, Babb was able to determine from local records or some other source that:

Gila River at Duncan has been dry on two occasions within the last twenty-five years. These droughts occurred, one in June, 1896, and the other in June, 1897. During August, 1897, occurred the greatest flood within the same period. The water flooded the town of Duncan, rising 8 feet above the river bed.

On a return trip, Babb notes:

On May 15, 1899, at the time of a second visit to Duncan, the river was discharging only 10 second-feet, having dropped from 104 second feet since April 30 [March 30?].

During the same reconnaissance trip in the spring of 1899, Babb recorded discharge measurements and some background information for 28 canals in the vicinity of Solomonsville in the present day Safford Valley. The earliest constructed canal, as noted by Babb, was the Central ditch, reportedly constructed in 1874. Thirteen large ditches are noted together with their lengths and associated irrigated land. These thirteen ditches have a combined length of 81 miles, and carry water to an estimated 41,000 acres.

Pre-statehood records from individual stream gauges on the Upper Gila River are described in the following paragraphs.

Gila River near Virden New Mexico. No data are available for the Gila River near Virden prior to statehood.

Gila River at Redrock, New Mexico. The gauge near Redrock, New Mexico "was originally established May 14, 1908, at the mouth of the Middle Box Canyon of the Gila, about 2 miles east of the Redrock post office, New Mexico. On July 16, 1909, it was moved about one-eighth mile upstream in the canyon." (USGS, 1910). The gauge was located about 20 river miles upstream of the Arizona border. From 1908 through 1910, 22 discharge measurements were taken which included flow width and area data. Since no rating curves were readily available for this gauge site, the width/area data were used to estimate hydraulic depth and average velocity for the purpose of determining the low flow stream channel characteristics for the period prior to statehood.

Discharge measurements were made during low flows between 29 cfs and 398 cfs. The hydraulic depths range from 0.7 feet to 1.6 feet, the average velocity ranges from 0.7 feet per second (fps) to 3.1 fps, and flow widths varied from 22 feet to 154 feet. Note that the greatest hydraulic depth for a discharge measurement occurred at a discharge of only 91 cfs, the lowest hydraulic depth occurred at a discharge of 101 cfs. The smallest width and greatest average velocity occurred at a discharge of 84 cfs, and the greatest width occurred at a discharge of 398 cfs. These data suggest that the channel at the Redrock gauge site was mobile, prone to horizontal and vertical shifting even at low flows.

Table 7
Month Streamflow Statistics for Gila River near Red Rock, New Mexico
November 1908-December 1910 (all data prior to statehood)

Month	Average Monthly Discharge (cfs)	Average Monthly Min. Discharge (cfs)	Average Monthly Max. Discharge (cfs)
January	106	74	151
February	143	78	247
March	387	135	675
April	214	126	424
May	134	114	180
June	46	24	111
July	79	26	199
August	176	90	238
September	150	54	597
October	74	59	86
November	98	68	197
December	122	74	133
Annual	144	77	270

The average monthly discharge data for the Red Rock gauge shown in Table 7 fall within the range of the low-flow discharge measurements discussed above. Therefore, it can be concluded that the average monthly hydraulic depth and the average flow width for all months during the period of record prior to statehood at this gauge site falls between 0.7 foot deep and 1.6 feet deep and between 22 feet wide and 154 feet wide.

Gila River near Guthrie, Arizona. This gauge station was officially established on November 6, 1910. The gauge is located approximately 500 feet upstream from the Guthrie railroad bridge in Section 3, Township 6 south, Range 30 east (USGS, 1911). For the period prior to statehood, only three discharge measurements are recorded which include flow width and area data, from which channel characteristics can be estimated for this reach of the river. These measurements were taken between October and December 1910, and range in discharge from 63 cfs to 92 cfs. The flow depths varied from 2.0 to 2.9 feet deep, and the widths varied from 31 feet to 32 feet wide (see Table 8 below). Flow measurements for the remaining months during the pre-statehood period were made, although no width/depth data are preserved in the published USGS records.

Table 8
Month Streamflow Statistics for Gila River near Guthrie, Arizona
November 1910-December 1912 (all data including the year of statehood)

Month	Average Monthly Discharge (cfs)	Average Monthly Min. Discharge (cfs)	Average Monthly Max. Discharge (cfs)
January	143	63	450
February	103	50	150
March	580	88	1160*
April	238	95	445
May	55	29	101
June	37	5	134
July	447	7	3260*
August	162	47	365
September	223	49	1193
October	240	64	1023
November	114	79	183
December	94	74	113
Annual	203	54	715

Notes: * One month of one year only

No other pre-statehood data are recorded for the Upper Gila River in, or reasonably close to, the study reach.

Summary. No pre-statehood flow data are available for the lower portion of the study reach near Safford. The limited amount of pre-statehood flow data available indicate that the average discharge for the years immediately prior to statehood at approximately the middle of the study reach at Guthrie was 203 cfs, and probably was between 203 cfs and 144 cfs at the upper portion of the study reach near Duncan (see Table 9 below).

Table 9 Annual Streamflow Statistics for the Upper Gila River Pre-Statehood			
Location	**Average Annual Discharge (cfs)**	**Average Annual Min. Discharge (cfs)**	**Average Annual Max. Discharge (cfs)**
Red Rock, NM	144	77	270
Guthrie, AZ	203	54	715

At Guthrie, monthly average and monthly average minimum discharges typically were lowest during the month of June with 37 cfs and 5 cfs respectively. Likewise, at Red Rock the monthly average and monthly average minimum discharges for the month of June prior to statehood were 46 cfs and 24 cfs respectively. June 1896 and 1897 were reportedly the only two occasions when the Gila River near Duncan went dry for the period of 25 years prior to 1899 (USGS, 1901). A discharge of 0.0 cfs was also noted to have taken place on the Upper Gila River at least once during April 1899 as a result of irrigation diversions in the Safford Valley.

The greatest flood of memory on the Upper Gila River in the Duncan area for the period 25 years prior to 1899 occurred August, 1897. No flow rate was recorded for the pre-1899 event, but the town of Duncan was flooded and the flow depth was reported to be eight feet (USGS, 1901). Annual average maximum flow rates prior to statehood were about 715 cfs at Guthrie, and probably between 270 and 715 cfs in the Duncan area at the upstream end of the study reach. The largest recorded pre-statehood monthly maximum discharge of 3,260 cfs at Guthrie, Arizona was during July 1911. The month with the greatest monthly average maximum discharge at Red Rock, New Mexico was March (675 cfs).

San Francisco River

Early Gauge Measurements. The first discharge measurement on the San Francisco River recorded by the USGS was taken on April 5, 1899 during a reconnaissance trip through the upper Gila River basin by Cyrus C. Babb (USGS, 1901). On that day, 94 cfs was measured approximately 7 miles upstream of Clifton. The first regular measurements of the San

Francisco River occurred at a station officially established near Alma, New Mexico, approximately 27 miles upstream of the Arizona/ New Mexico border, on October 18, 1904. Some limited data are available for this gauge site starting in August, 1904. This gauge was discontinued February 24, 1914. The gauge consisted of a vertical staff gauge which was read daily by a local resident. The gauge site was moved approximately one mile downstream during August 1912 (USGS, 1905-1914).

The drainage area at Alma is 1540 square miles, approximately 55 percent of the San Francisco River Basin. For the period between 1904 and 1912, the longest period with no flow was from May 1st through July 22nd 1910 (83 consecutive days), and a total of 130 non-consecutive days of no recorded flow from April 25th through September 16th of that year. The year 1910 was the driest year on record between 1890 and 1912, with a total annual flow volume of about 10 percent of the long-term average.

Some irrigation diversions from the San Francisco River were noted during the Babb reconnaissance trip (USGS, 1901). The following is recorded in the 21st Annual Report of the USGS, 1899-1900:

> *At Luna, New Mexico, the valley is about 5 miles long, and has been occupied within the last few years by a Mormon colony, which diverts water by means of a canal heading in Arizona, 12 miles above the town. In April, 1899, this canal was carrying 8 second-feet, which was all the water in the river at the point of diversion.*
>
> *In Luna Valley there are about 1,000 acres under cultivation.*
>
> *A few miles above Frisco the canyon again opens into a narrow valley which is somewhat settled. A certain amount of water is collected in the canyon, but is diverted again, by means of two canals, for the irrigation of this section.*

Luna is located approximately 77 river miles upstream of the Arizona/New Mexico State line, and Frisco is located upstream of the Arizona/New Mexico State line near the entrance to the San Francisco River canyon.

San Francisco River at Alma. The Alma stream gauge was maintained by the USGS until January 1914, with gaps in the data occurring December, 1904, the entire year of 1908 and April, 1911 - July 1912. Data available includes daily gauge heights and the corresponding daily discharge values based on periodic discharge measurements. Some of the published discharge measurements recorded for this gauge include the cross-sectional area and the flow width (see USGS, 1910). The average monthly discharges for this gauge for the period before statehood (February 14, 1912) are shown in Table 10 below. Also shown in Table 10 are estimates of the maximum flow depth for each month's mean flow value.

Table 10
Month Streamflow Statistics for San Francisco River near Alma, New Mexico
1904-1911 (all data prior to statehood)

Month	Average	Average	Average	Estimated
January	245	43	2001	0.8
February	339	110	1498	0.8
March	508	103	1430	1.1
April	393	171	719	1.2
May	84	45	187	0.6
June	13	2.4	31	1.7
July	40	2	502	0.5
August	125	15	931	0.7
September	86	17	712	0.7
October	35	19	132	0.5
November	68	27	201	0.7
December	158	31	942	0.8
Annual	175	45	774	0.8

Estimating the maximum channel depths was possible for this gauge site due to the frequency of days with no flow (usually between May and August), and because the records clearly indicate at what gauge height zero flow occurs. For periods experiencing no channel bed elevation changes, the zero-flow height was subtracted from the total recorded gauge height to estimate the maximum stream flow depth (i.e., the deepest portion of the stream). To avoid errors due to channel bed elevation changes resulting from high flows, the zero-flow gauge height was only applied to data bracketed on both sides by zero or near-zero gauge height readings, and for periods with an absence of large flow events which are likely to contribute to a bed elevation shift.

The maximum stream depth estimates were compared to estimates based on extrapolation of rating curves based on discharge measurements (see section on rating curves), and to discharge measurements which included hydraulic geometry data (i.e., flow area and width). The average hydraulic depth based on the hydraulic geometry data usually fell just below the maximum depth estimate, showing that the maximum depth estimate is in the expected range (i.e., greater than the hydraulic depth), and showing that the deepest part of the low-flow channel may not have been significantly deeper than the rest of the low-flow channel during periods of low flow.

San Francisco River at Clifton. The San Francisco River at Clifton gauge site was established by the USGS October 23, 1910 (USGS 1910). For the period of record before statehood, the gauge was alternately operated at two locations in Clifton due to the reported shifting nature of the channel. The main location (i.e., the location used most during the entire gauging record), is "at the highway bridge at Clifton ....about 5 miles above the mouth of the river". At the time the gauge was established, it is reported that "water is diverted for irrigation by a small ditch 1¾ miles above the bridge." Additionally, it was noted along with the 1910 data, that "about 14 second-feet is diverted for power development, but the water used at the power plant is returned to the river above the [gauge] station." The latter diversion takes place at the dam.

When accurate measurements could not be taken at the bridge, measurements were taken at a gauge at the dam. The gauge at the dam was established January 16, 1911 (USGS, 1911), and was used as necessary until June 30, 1912. After that time, the gauge site was maintained at the highway bridge and alternately at the railroad bridge in Clifton. Until May 15, 1914, the gauge consisted of a vertical staff gauge or a chain gauge attached to either the highway bridge or the railroad bridge. Usually, a common vertical reference mark was used to keep the datum of the gauges consistent. Because of the frequent gauge location changes, however, and since there are some inconsistent datum shifts, the record is difficult to decipher with respect to absolute flow depth. The average monthly discharges for this gauge for the period before statehood are shown in Table 11 below.

Table 11
Monthly Streamflow Statistics for San Francisco River at Clifton, Arizona
October 1910-February 1912 (all data prior to statehood)

Month	Average Monthly Discharge (cfs)	Average Monthly Min. Discharge (cfs)	Average Monthly Max. Discharge (cfs)
January	223*	100*	470*
February	115	82	168
March	1130*	145*	6200*
April			
May			
June			
July	269*	56*	1120*
August	87*	50*	145*
September	185*	50*	1060*
October	289	84	1888
November	102	75	155
December	79	58	103
Annual	275	78	1257

Notes: * Record is for one month of one year only. Other averages are based on two year record. No data available for some months.

Table 12 below presents estimated maximum flow depths based on the monthly average flow for the three months which had sufficient detail in the data record.

Table 12
Discharge Data for San Francisco River at Clifton, Arizona
October 1910-December 1910

	Average	Minimum	Maximum	Estimated
October	109	175	68	0.7-1.3
November	99	200	45	0.7-1.3
December	54	100	25	1.2

Summary. Pre-statehood hydrologic data for the San Francisco River indicate that the average annual flow rate increased from about 175 cfs to 275 cfs within the study reach. The average flow depth in the river was probably about one foot, with flow widths averaging about 20 to 30 feet. Annual high flows over 500 cfs typically occurred during late winter to early spring months, with occasional summer floods.

Statehood Hydrology

The Upper Gila and San Francisco Rivers experienced slightly below-average flow rates during 1912, the year of statehood, both compared to the pre-statehood record and the long-term record based on the entire period of record (1899-1989). The month of February 1912 also experienced flow rates that were well below average for the month. Table 13 below shows the monthly average discharge data for the year 1912 at USGS gauging stations which were recording data that year. Table 14 shows flow data from the day of Arizona statehood, February 14, 1912.

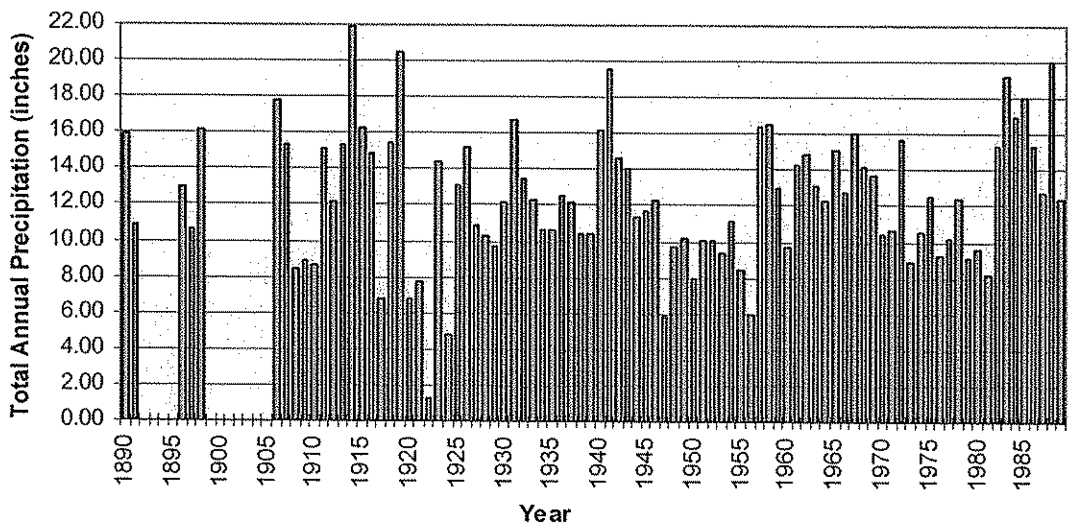
Table 13 Monthly Average Discharge (cfs) for Gila and San Francisco Rivers 1912				
Month	**Gila River near Redrock**	**Gila River near Guthrie**	**San Francisco near Alma**	**San Francisco at Clifton**
January		101		74
February		60		63
March		601		948
April		328		341
May		99		216
June		26		278
July		315		
August	99	173	48	
September	93	178	37	
October	87	145	36	143
November	86	115	15	55
December	82	97	18	118
Annual	-	182	-	-

Table 14 1912 Flow Measurements - Gila and San Francisco Rivers February 14, 1912		
Period	**Gila River near Guthrie**	**San Francisco at Clifton**
February 14, 1912	65 cfs	70 cfs
February, 1912 Average Flow	60 cfs	63 cfs
February, 1912 Range of Flow	35-75 cfs	40-70 cfs
Long-term Average Flow for February	324 cfs	314 cfs

Compared to pre-statehood data, the average discharge rate during February, 1912 for both the Gila River at Guthrie, Arizona, and the San Francisco River at Clifton were in the range of approximately 56% of normal. Compared to the entire record, the February, 1912 averages for these two stations are a mere 20% of normal. Therefore, flow conditions on the day of Statehood are not representative of the ordinary and natural flow conditions of the Upper Gila and San Francisco Rivers.

Precipitation records from 1912 support the trend identified by flow measurements on the Upper Gila and San Francisco Rivers. During February, 1912, 0.38 inch of precipitation was recorded at Clifton, Arizona. The average precipitation for February at Clifton for the period 1906 through 1988 was 0.92 inch. The total annual precipitation of 12.13 inches measured at the Clifton station during 1912 falls below, but near, the long-term average of 12.39 inches. Figure 5 shows long-term precipitation trends at the Clifton, Arizona station.

Figure 5. Annual Precipitation at Clifton, Arizona 1890-1988



Source: (USDA, Weather Bureau, 1906-1988, and USGS, 1900)

Post Statehood Hydrology

Long-term stream gauging records and data summaries have been assembled by the USGS for several stations along the Upper Gila and San Francisco Rivers. These long-term records include data for the entire period of record for each station, which in some cases includes data from the pre-statehood period in addition to more recent data. The following paragraphs summarize average monthly and annual statistics for the stream gauges located on the Upper Gila and San Francisco Rivers in the study area and within a reasonable distance outside the study area boundaries or the study reach for the period following statehood.

<u>Upper Gila River</u>

Gila River below Blue Creek, near Virden, New Mexico. USGS gauging records from the general reach of the Gila river surrounding this gauge are available beginning January 1923 under the name "Gila River at Virden Bridge, Near Duncan, Arizona," and beginning May, 1914 under the name "Gila River near Duncan, Arizona." Supplemental information to the station description at this location are included in Appendix B. Because the records are not continuous, only the more recent data from the gauge titled "Gila River below Blue Creek, near Virden, New Mexico" were used to evaluate the long-term record for this location within the study reach. Following is a monthly summary of the data from this gauge site. The statistics shown here are based on data gathered from USGS Water Supply Papers published from 1927 through 1989:

Table 15
Monthly Streamflow Statistics for Gila River below Blue Creek, near Virden, New Mexico
1928-1978, 1981-89

Month	Average Monthly Discharge (cfs)	Average Monthly Min. Discharge (cfs)	Average Monthly Max. Discharge (cfs)
January	209	64	1390
February	293	61	1280
March	387	45	1460
April	255	28	1140
May	141	14	907
June	45	4.4	183
July	81	4.9	366
August	221	9.4	1160
September	194	4.9	1510
October	170	5.4	1670
November	107	35	520
December	186	48	1800
Annual	190	43	640

Gila River Near Clifton, Arizona. USGS gauge measurements in this reach of the Gila River were initially recorded under the name "Gila River near Guthrie" from November 6, 1910 through July 11, 1918, and were cited as such in earlier in Section 4. This gauge site is approximately 4 miles farther upstream than the gauge location known as "Gila River Near Clifton, Arizona," which is approximately 6 miles upstream from the confluence with the San Francisco River. Data presented in the USGS Water-Resources Investigations Report 91-4041 titled "Basin characteristics and Streamflow Statistics in Arizona as of 1989" (USGS, 1991) combines the data from the Guthrie gauge with that of the Clifton gauge to form an equivalent gauge record.

Table 16
Monthly Streamflow Statistics for Gila River near Clifton, Arizona (Guthrie)
1912-1917, 1929-33, 1949-89

Month	Average Monthly Discharge (cfs)	Average Monthly Min. Discharge (cfs)	Average Monthly Max. Discharge (cfs)
January	258	43	1360
February	324	24	1670
March	396	21	1770
April	249	12	1690
May	121	12	874
June	41	9.4	171
July	121	13	934
August	234	17	898
September	191	8.2	1210
October	194	8.7	1750
November	111	11	564
December	237	17	2390
Annual	206	43	930

Gila River at Head of Safford Valley, Near Solomon, Arizona. This USGS gauge site was established April 21, 1914 in nearly the same location as exists today. The gauge site is located below the intake to the Brown Canal, so discharge in the canal is added to the gauge site discharge value (the maximum discharge of the Brown Canal is reported to be approximately 25 cfs). The statistical results presented in the following table do not include data recorded from 1914 through 1920. No explanation for this omission was apparent, nor is one given in the USGS documentation (UGSG, 1991).

Table 17 Monthly Streamflow Statistics for Gila River at Head of Safford Valley, Near Solomon 1921-1933, 1936-1989			
Month	**Average Monthly Discharge (cfs)**	**Average Monthly Min. Discharge (cfs)**	**Average Monthly Max. Discharge (cfs)**
January	490	93	3370
February	680	103	3870
March	801	82	3380
April	568	64	2780
May	291	38	2040
June	100	20	388
July	218	44	735
August	528	66	2500
September	392	36	2080
October	403	40	7450
November	240	49	2230
December	494	60	5800
Annual	433	101	1680

Gila River at Safford, Arizona. The Gila River at Safford gauge site was operated from 1941 through 1946, and then from 1957 through 1965. This site in located at the downstream end of the Upper Gila River study reach.

Table 18 Monthly Streamflow Statistics for Gila River at Safford 1941-1946, 1957-1965			
Month	**Average Monthly Discharge (cfs)**	**Average Monthly Min. Discharge (cfs)**	**Average Monthly Max. Discharge (cfs)**
January	445	74	2040
February	458	27	2170
March	491	13	2660
April	337	4.7	1680
May	154	0.13	1560
June	15	0.00	130
July	94	5.6	442
August	428	11	1660
September	380	16	1180
October	194	0.16	1180
November	139	0.28	403
December	288	1.3	1400
Annual	284	87	1120

San Francisco River

San Francisco at Alma, New Mexico. This USGS gauge site is located upstream of the Arizona/ New Mexico border and is representative of flow at the upper end of the San Francisco River study reach. The history, and other information for this station were provided in the "Pre-Statehood Hydrology" and "Statehood Hydrology" sections of this chapter.

Table 19
Monthly Streamflow Statistics for San Francisco River near Alma, New Mexico
1904-1907, 1909-1912

Month	Average Monthly Discharge (cfs)	Average Monthly Min. Discharge (cfs)	Average Monthly Max. Discharge (cfs)	Estimated Maximum Flow Depth (Feet)
January	245	43	2001	0.8
February	339	110	1498	0.8
March	508	103	1430	1.1
April	393	171	719	1.2
May	84	45	187	0.6
June	13	2.4	31	1.7
July	40	2.0	502	0.5
August	89	14	931	0.7
September	76	15	712	0.7
October	34	19	132	0.5
November	59	16	201	0.7
December	134	28	942	0.8
Annual	168	44	774	0.8

San Francisco River at Clifton, Arizona. This USGS gauge site is located near the midpoint of the San Francisco River study reach, downstream of the confluence with the Blue River. The history, and other information for this station are provided in the "Pre-Statehood Hydrology" and "Statehood Hydrology" sections of this chapter.

Month	Average Monthly Discharge (cfs)	Average Monthly Min. Discharge (cfs)	Average Monthly Max. Discharge (cfs)
January	240	37	1590
February	314	39	1630
March	418	44	2140
April	328	36	2250
May	155	24	1240
June	53	11	178
July	107	29	657
August	204	41	1360
September	149	22	816
October	246	23	4290
November	116	28	1450
December	255	34	2450
Annual	215	42	937

Table 20
Monthly Streamflow Statistics for San Francisco River at Clifton, Arizona
1914-1915, 1917, 1928-1933, 1936-1989

Summary

Streamflow data gathered for the Upper Gila and San Francisco River study reaches, summarized in the previous paragraphs indicate the following:

- The Upper Gila River is a naturally perennial stream. The average annual discharge for the Upper Gila River varies from about 200 cfs to 430 cfs in the study reach.

- The San Francisco River is a naturally perennial stream. The average annual discharge for the San Francisco River varies from about 90 cfs to 215 cfs.

- The minimum monthly average flow (range: 15 to 100 cfs) for the Upper Gila River study reach occurs in June, as does the average minimum flow (0.0 cfs to 20 cfs).

- The minimum monthly average flow (range: 13 cfs to 53 cfs) for the San Francisco River study reach occurs in June. The average minimum flow (2.0 cfs to 11 cfs) occurs in June and July.

Flow duration data represent the percent of time a given flow rate was equaled or exceeded. For example, a 90% flow rate of 200 cfs indicates that 90 percent of the time, the flow rate will be greater than 200 cfs; a 50% flow rate of 500 cfs means that more than half of the time the flow rate exceeds 500 cfs (a.k.a., the median discharge). Table 21 presents flow duration estimates reported by the USGS (1991) at gauge stations near the Upper Gila and San Francisco River study reaches.

Table 21
Duration Table of Daily Mean Flow for Period of Record

Gauge	1%	10%	20%	50%	80%	90%	99%
Gila River near Virden, NM	1,760	404	214	91	43	21	3.3
Gila River near Clifton, AZ	2,010	455	230	80	28	18	9
Gila River at Head of Safford Valley, Near Solomon, AZ	3,970	932	456	174	91	62	29
Gila River at Safford, AZ	3,480	694	322	66	7.9	0.52	0.00
San Francisco River at Clifton, AZ	2,120	417	208	76	45	34	18

Source: (Garret & Gellenbeck, 1991)

Average flow statistics are required to estimate the average flow depth, velocity, and width for the study reaches. The long-term average flow rates for the Upper Gila River and the San Francisco River are shown in Table 22.

Table 22
Long-Term Flow Statistics for the Upper Gila River and the San Francisco River

Reach	Median (50%) Flow (cfs)	Average Annual Flow (cfs)	Average Annual Minimum Flow (cfs)
Upper Gila River	66-174	190-433	43-101
San Francisco River	32-76	90-215	42-44

It is noted that both the San Francisco River, and the Upper Gila River between Duncan and the Head of Safford Valley, experience increasing average annual discharges in the downstream direction (a "gaining stream"). Records indicate that the Gila River in the reach between the Head of Safford Valley and Safford experiences decreasing average annual discharges (a "losing stream"). This could be attributable to several factors or a combination of factors, including the following:

- Shorter period of record for the Gila River at Safford station (25 years).
- Large irrigation diversions in the Safford Valley.
- Increased natural stream channel losses downstream from where the river emerges from the relatively narrow canyon with shallow bedrock near the head of the Safford Valley.

In addition, it is noted that the average annual discharge rates at all gauge locations are equaled or exceeded only approximately 20% of the time (Compare Tables 15-20 with Table 21). This is due to a wide gap between base flow conditions and the annual peak floods. That is, floods account for a significant portion of the average annual runoff volume. For example, the 90% flow rate which is considered by some agencies to represent the base flow rate, varies from 0.52 cfs to 62 cfs on the Upper Gila River (average annual flow = 190-433 cfs), and is approximately 34 cfs on the San Francisco River at Clifton (average annual flow = 90-215 cfs). Similarly, the median flow rate (50%) is measurably smaller than the average annual flow rate for both rivers (Table 22). Therefore, it may be prudent to base decisions regarding susceptibility to year-round (vs. seasonal) navigation on the median or base flow rates, rather than the average annual flow rates.

Hydraulic Rating Curves

A collection of hydraulic rating curves were assembled for both pre-statehood (or near statehood) conditions and current conditions. Except for the hydraulic rating curves for the "Gila River near Virden" site for 1927-1930, and the "San Francisco River at Clifton" site for 1946-1948, all historic rating curves shown below were developed from the actual USGS gauge records (including discharge measurements), and not from historic hydraulic rating curves found during the data collection effort. The current hydraulic rating curves dated 1997 for all gauges were obtained from the USGS Water Resources Division in Tucson, Arizona. No historic hydraulic rating curves were available for the Gila River at Safford gauge site, nor were any published or unpublished stage discharge data available for this site from which an accurate hydraulic rating could be developed.

Gila River near Virden

Figure 6. Rating Curve for Gila River near Virden 1914

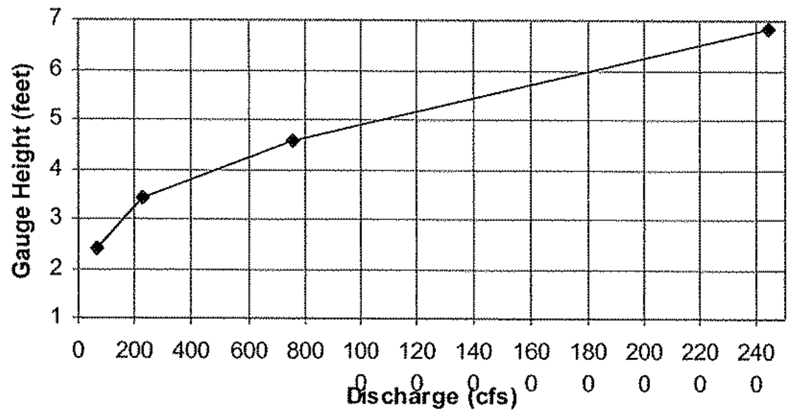
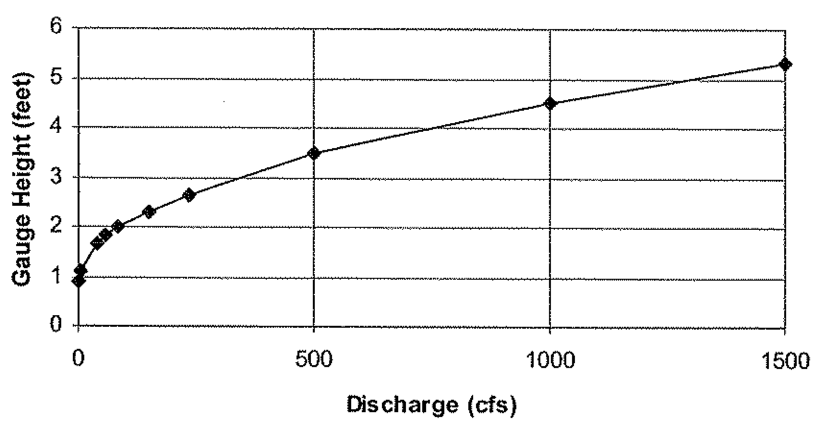
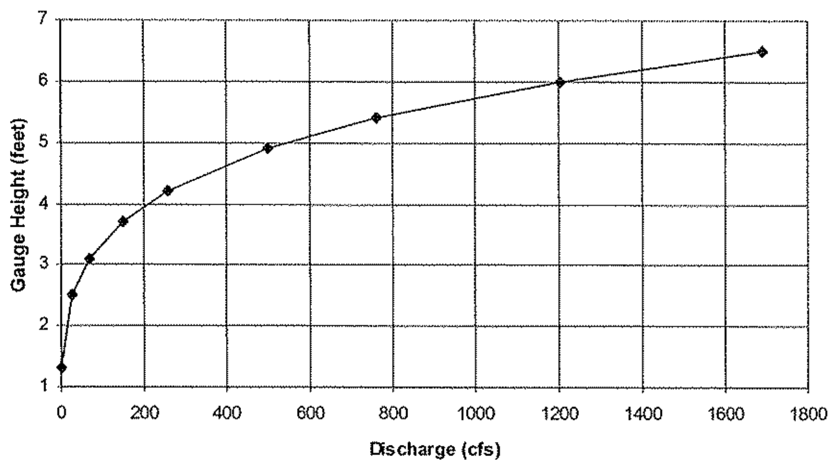


Figure 7. Rating Curve for Gila River near Virden 1927-1930



Source: (USGS, 1930)

Figure 8. Rating Curve for Gila River near Virden 1997



Source: (USGS, 1997)

The rating curve shown in Figure 6 for the Gila River near Virden is actually for a historic station located nearer to Duncan, but the published gauge record calls it "near Virden," using the same name as the existing USGS gauge. In general, however, in comparing the 1927-1930 rating curve to the 1997 rating curve, it appears that the channel may have become somewhat deeper between 1930 and 1997. For example, a discharge of 600 cfs on the 1927-1930 rating curve corresponds to a flow depth of approximately 2.7 feet deep, whereas the same discharge on the 1997 rating curve corresponds to a flow depth of approximately 3.8 feet deep, a difference of about one foot at 1000 cfs. This difference could be result of a system-wide adjustment, or a local short-term fluctuation in the elevation of the sand-bed channel.

Gila River near Clifton

Figure 9. Rating Curve for Gila River near Clifton
1912

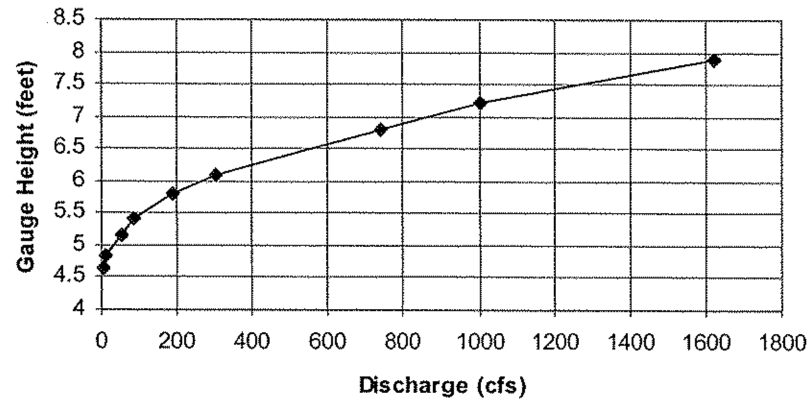
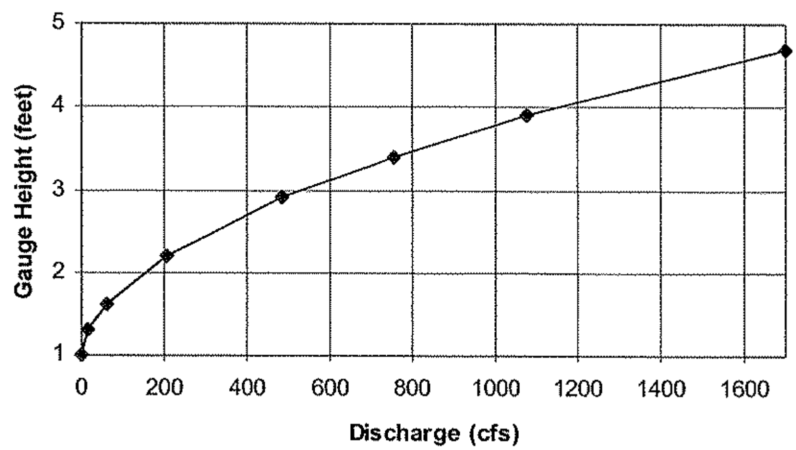


Figure 10. Rating Curve for Gila River near Clifton
1997



Source: (USGS, 1997)

Comparing the rating curves in Figures 9 and 10 for the Gila River near Clifton shows that at 600 cfs and 1000 cfs, the depths do not vary by more than about 0.2 foot. Therefore, it may be assumed that the low-flow channel geometry has not changed significantly since the time of statehood for the reach of the Upper Gila River near Clifton.

Gila River at Head of Safford Valley, Near Solomon

Figure 11. Rating Curve for Gila River at Head of Safford Valley, 1914

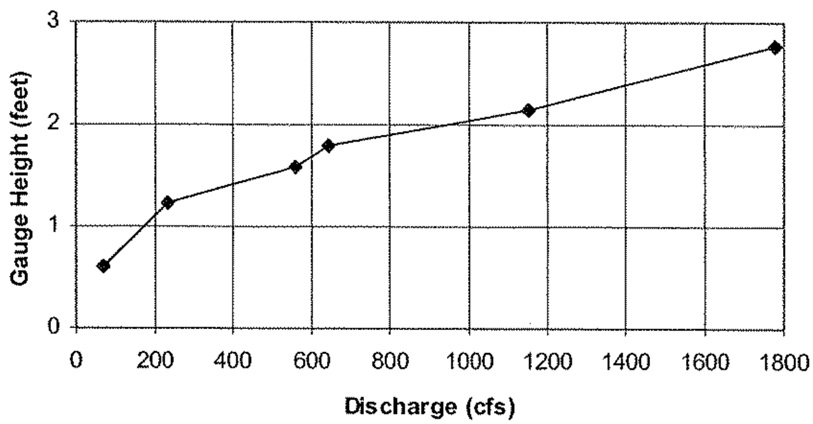


Figure 12. Rating Curve for Gila River at Head of Safford Valley, 1925

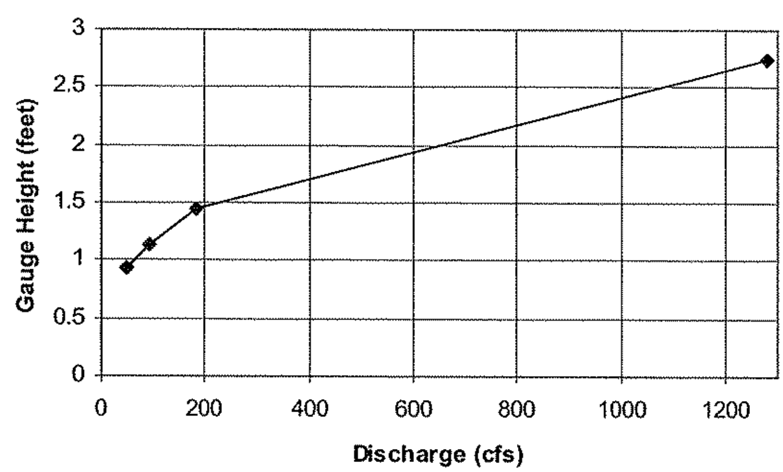
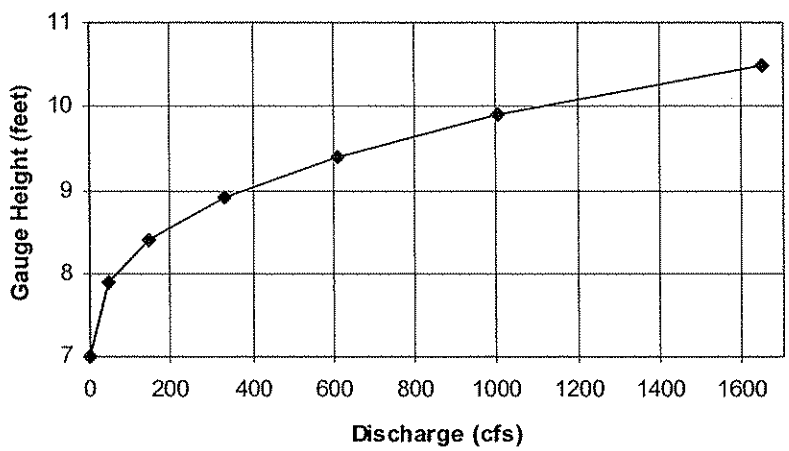


Figure 13. Rating Curve for Gila River at Head of Safford Valley, 1997



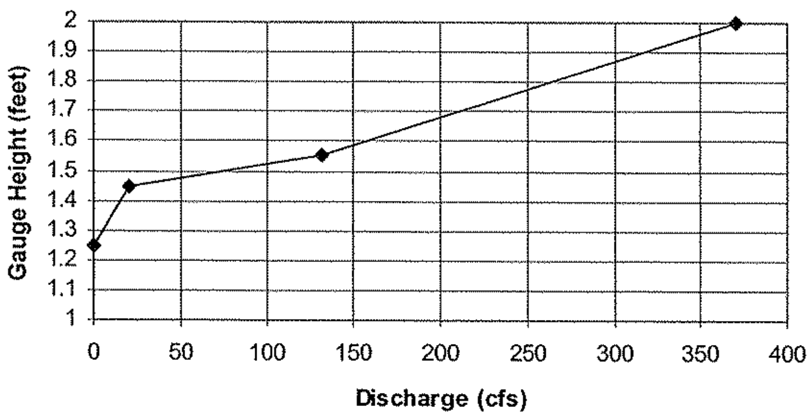
Source: (USGS, 1997)

The earliest rating curve for the Gila River at Head of Safford Valley stream gauge (i.e., 1914) corresponds to a gauge location which is approximately 0.4 mile farther downstream from where the existing gauge is located. The channel widens considerably in the 0.4 mile reach between the current gauge location and the 1914 gauge location. A comparison of a 1925 rating curve to the current rating curve reveals little difference in the flow depths at the same discharges. In 1925, the gauge location was the same as for 1914. This rating curve shift could be evidence of channel incision related to a local short-term perturbation or a long-term trend; the gauge data alone is not sufficient to draw conclusions regarding historical channel adjustments.

San Francisco River near Alma

Other than the published gauge record itself, no other notes or documentation were found which record historic channel geometry at the Alma, New Mexico gauge location. The rating curve shown in Figure 14 is based on assumptions made from an assortment of USGS discharge measurements.

Figure 14. Rating Curve for San Francisco River near Alma, 1910



San Francisco River near Clifton

Figure 15. Rating Curve for San Francisco River at Clifton, 1911

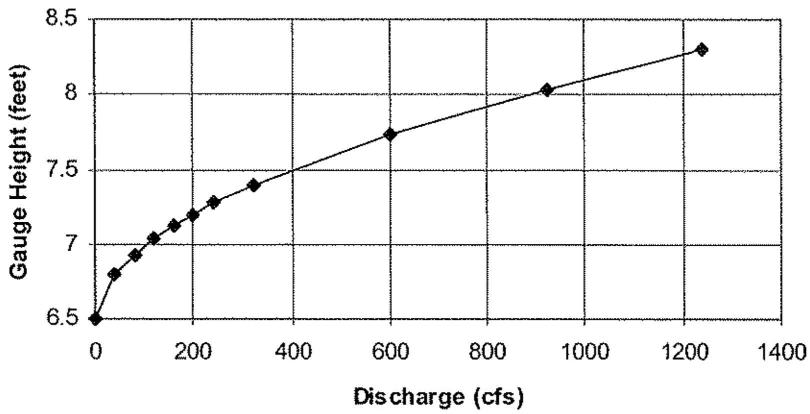
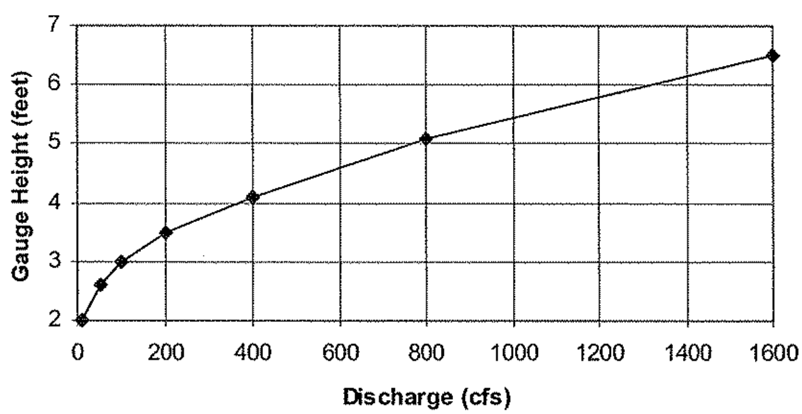
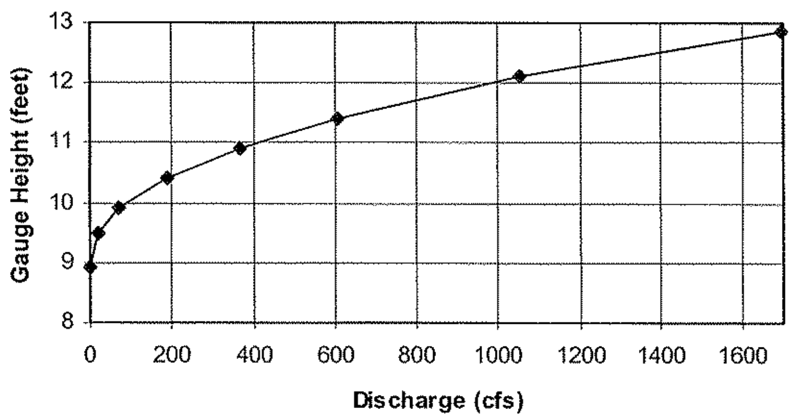


Figure 16. Rating Curve for San Francisco River at Clifton, 1946-1948



Source: (USGS, 1948)

Figure 17. Rating Curve for San Francisco River at Clifton, 1997



Source: (USGS, 1997)

A comparison of the three rating curves for the San Francisco River at Clifton (Figure 15-17) reveals that at 600 cfs and 1000 cfs, the earlier channel flowed at about half the depth of the 1946-1948 and the current channel, indicating that some degree of channel incision may have occurred.

Average Flow Characteristics

Table 23 summarizes flow characteristics estimated from the published streamflow data, USGS discharge measurement notes, and the hydraulic rating curves shown in Figures 6-17. In almost every case, low flow characteristics were calculated using unpublished USGS discharge notes which include flow width, area and velocity data. Usually, in these cases, there were a large number of data points at low flow rates, and fewer discharge measurements which fell within 10 percent of the average annual discharge. As a result, low-flow characteristics are considered the most accurate of those contained in Table 23.

To determine the flow characteristics at the 2-year flood and at the 5-year flood, the most recent USGS rating curve for each gauge location was used for maximum depth. The average depth was then estimated using historic cross-sections where available, and the velocity was determined by dividing the discharge by the cross-sectional flow area.

Table 23
Upper Gila River and San Francisco River Flow Characteristics

Recurrence Interval	Discharge (cfs)	Hydraulic Depth (ft)	Average Velocity (ft/sec)	Top Width (ft)
Gila River Near Virden, NM (Source data: Cross Section, USGS, 1931)				
90 % Flow	21	0.6	1.3	27
Median (50%) Flow	91	0.9	2.2	45
Mean Annual Flow	190	1.2	1.6	100
2-Year Flood	4,980	5.5	8.5	107
5-Year Flood	10,400	7.5	12.6	110
Gila River Nr. Clifton/Guthrie, AZ (Source data: USGS Discharge Measurements, 1930, 1939, 1940, 1950)				
90 % Flow	18	0.7	1.0	26
Median (50%) Flow	80	1	1.7	47
Mean Annual Flow	206	1.3	2.5	64
2-Year Flood	5,940	3.7	11.5	140
5-Year Flood	11,500	5.5	14	150
Gila River at Head of Safford Valley, Near Solomon, AZ (Source Data: Cross Section, USGS, 1941)				
90 % Flow	62	0.8	0.5	144
Median (50%) Flow	174	1.3	0.9	146
Mean Annual Flow	433	1.9	1.5	150
2-Year Flood	9,400	6.7	8.8	160
5-Year Flood	22,900	11	11.6	180
Gila River at Safford, AZ (Source Data: Cross Section, USGS, 1942)				
90 % Flow	.52	0.1	0.4	12
Median (50%) Flow	66	1.3	0.9	55
Mean Annual Flow	284	2.6	1.5	75
2-Year Flood	8,230	4.0	5.1	400
5-Year Flood	13,500	5.0	5.4	500
San Francisco River at Clifton (Cross Section, USGS, 1931, and Discharge Measurements, USGS, 1910, 1913-14, 1915, 1917, 1918, 1928, 1929, 1940, 1950, 1960)				
90 % Flow	34	0.9	1.4	28
Median (50%) Flow	76	1.0	1.6	49
Mean Annual Flow	215	1.2	2.5	72
2-Year Flood	6,800	4.5	10.1	150
5-Year Flood	17,800	8.5	13.7	153

Federal criteria of minimum flow conditions necessary for navigation of various recreational craft (ASLD, 1997) are presented in Tables 24 and 25. Minimum stream conditions determined by the U.S. Fish and Wildlife Service are summarized in Table 24. Minimum and maximum conditions are summarized in Table 25.

Table 24
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 25
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

From the data summarized in Tables 24 and 25 and flow characteristics of the Upper Gila and San Francisco Rivers shown in Table 23, the following conclusions can be drawn:

- Fifty percent of the time, the hydraulic characteristics in the reaches represented by the USGS gauge locations (except for Gila River near Virden) have sufficient average width and depth characteristics to accommodate all forms of recreational water craft listed in Tables 24 and 25 except for power boats.

- Ninety percent of the time there would be sufficient width and depth at all USGS gauging stations, except for the Safford gauge, to accommodate use of a kayak or canoe.

- None of the reaches represented by the USGS gauge locations exhibited sufficient average velocities to be considered dangerous or impracticable for recreational boating until the 2-year flood flow is reached. Modern boating records indicate that these reaches are currently boated at these flow rates.

It is important to note that the flow characteristics presented in Table 23 represent average conditions at discrete points along the study reaches. There is no doubt that there will be reaches which have obstacles such as broad shallow areas, sand bars, rapids and irrigation diversions which, at certain discharges, will have significantly different flow characteristics. These conditions may, in some cases, preclude or at least hinder use by any boat, especially for travel in the upstream direction.

Summary

The rating curves presented in this section reveal little conclusive evidence regarding long-term low-flow channel characteristics, other than that no large-scale changes or trends are apparent. The rating curves do vary over time, however, and reveal that the low-flow channel is prone to shifting. This is confirmed by numerous published USGS gauge descriptions which include references to shifting low-flow channel conditions at most of the gauge locations. This condition is also revealed in numerous unpublished USGS rating curves, where the curves vary significantly at the lower discharges (i.e., less than 1000 cfs) over two and three year periods as a response to shifting low-flow channel conditions.

The depth of flow associated with the long-term average annual flow rate on the Upper Gila River at the gauge stations listed in Table 23 is estimated to vary from approximately 1 foot to 2.5 feet deep. Similarly, the associated velocities are estimated to vary between approximately 1.5 feet per second and approximately 2.5 feet per second, and the top widths are estimated to vary between approximately 64 feet and 140 feet. On the San Francisco River at Clifton, the flow conditions for the average annual flow rate are estimated to be approximately 1.2 feet deep with an estimated velocity of approximately 2.5 feet per second and a top width of approximately 72 feet.

Since the average annual discharge rates are only equaled or exceeded 20% of the time on the Upper Gila River and the San Francisco River, the average annual discharge rate may not be a representative of "typical" flow conditions as the median (50%) flow rate and the 90% flow rate. The latter flow rates give a truer indication of how often the Upper Gila and the San Francisco rivers are susceptible to certain types of navigation. Based on the long-term gauge record, which demonstrates highly variable flow rates on an annual basis, the Upper Gila River and the San Francisco River would have been susceptible to navigation by low-draft floating boats such as canoes, rafts, kayaks, flatboats, or inflatables, on a seasonal basis or opportunistically in response to brief periods of higher flow, as of the time of statehood.

Floods

The Upper Gila and the San Francisco Rivers, like most rivers in Arizona, experience a wide range of discharge rates, from seasonal dry or near-dry conditions to floods with peak discharges greater than 100,000 cubic feet per second (cfs). Flood discharge rates based on long-term records are listed for various recurrence intervals at various key concentration points in Table 26.

Table 26
Peak Discharge Estimates at USGS Gauges (cfs)

Gauge	2-Year 50%	5-Year 20%	10-Year 10%	25-Year 4%	50-Year 2%	100-Year 1%
Gila River near Virden	4,980	10,400	15,200	22,900	29,900	37,900
Gila River near Clifton	5,940	11,500	16,800	26,100	35,400	47,000
Gila River at Head of Safford Valley, near Solomon	9,400	22,900	38,000	66,900	98,000	140,000
Gila River at Safford	8,230	13,500	17,700	24,100	29,700	35,900
San Francisco River at Clifton	6,800	17,800	30,000	53,100	77,200	109,000

Source: (USGS, 1991)

Table 27 summarizes some of the largest historic floods recorded at various gauging locations in and near the study reaches of the Upper Gila River and the San Francisco River.

Table 27
Historical Flood Peak Discharge Estimates at USGS Gauges (cfs)

Gauge	Discharge	Date
Gila River near Virden	58,700 41,700	December 19, 1978 September 29, 1941
Gila River near Clifton	57,000 48,800	December 19, 1978 December 29, 1984
Gila River at head of Safford Valley, near Solomon	132,000 100,000 100,000	October 2, 1983 December 19, 1978 January 19, 1916
Gila River at Safford (1940-1965)	33,000 23,900	September 30,'1941 January 14, 1949
San Francisco River near Glenwood	37,100	October 2, 1983
San Francisco River at Clifton	90,900 70,000* 65,000* 60,000* 65,000*	October 2, 1983 December 3, 1906 November 27, 1905 January 10, 1905 February 21, 1891

* Discharge is an isolated historic peak, not part of the systematic record.
Data Source: (USGS, 1991)

Table 26 indicates that the San Francisco River experienced a series of large floods prior to statehood at a frequency that has not been seen since statehood, three separate flood events greater than 60,000 cfs in a two year period, and four separate flood events greater than 60,000 cfs in a 15 year period. Since statehood, however, the San Francisco River at Clifton has experienced five floods with discharges greater than 55,000 cfs.

The greatest recorded peak discharges on the Upper Gila River between Safford and the state line near Duncan occur at the point where the river emerges from a relatively narrow canyon at the head of the Safford valley. It should be noted that the flood peaks listed for Safford on Table 26 do not give a complete flood history, compared to the other gauge locations because of the relatively shorter flow record at Safford. A quick comparison between the annual peak discharges at Safford and those at the head of the Safford Valley reveals that there is little flood peak attenuation in the 15 miles between the two gauge locations. On average, for years in which both gauges have their annual peak discharges recorded on the same day (12 years total), the discharge was approximately six percent less at Safford than at the head of the Safford Valley.

Summary

The Upper Gila and San Francisco Rivers are perennial streams which, except for numerous irrigation diversions, have remained free-flowing since they were first settled in the 1870's. Flow rates within the study reaches probably have not changed significantly since the time of statehood. River flows have been reliable enough over the past 120 years to support irrigation-based agriculture in the Duncan Valley at the upstream end of the Upper Gila River reach, as well as a more extensive irrigation-based farm economy in the Safford Valley downstream of the study area.

Long-term median (50%) flow rates for the Upper Gila River vary from about 66 cfs to 174 cfs between the Arizona/ New Mexico border and Safford. The long-term median flow rate for the San Francisco River varies from about 32 cfs to 76 cfs between the Arizona/ New Mexico border and the Gila River confluence. The long-term flow record demonstrates that the Upper Gila River and the San Francisco Rivers are susceptible to wide seasonal and annual variations in discharge rates.

Typical lowest seasonal flows on the Upper Gila River vary from 0.0 cfs to approximately 20 cfs. The average low flow discharge rates correspond to average flow depths of about 0.5 foot and flow widths less than 40 feet. On the San Francisco River, the lowest seasonal flow, which averages 11 cfs during the month of June, would correspond to an average depth of less than 0.4 foot, and a typical channel width less than about 20 feet. Portions of both the Upper Gila River and the San Francisco River are known to have become dry periodically in certain reaches, although a dry riverbed occurs more frequently on the San Francisco River. It is difficult to determine if these rivers would have experienced no-flow days prior to the advent of large-scale irrigation diversions, due to the lack of flow records that pre-date the irrigation diversions, and the fact that all of the flow in the Gila

River is fully appropriated. Furthermore, the combined pre-statehood irrigation diversion capacity was greater than the average annual flow rate of the Upper Gila River during the peak irrigation, which corresponds to the seasonal low flow period.

It is likely that the San Francisco River at and near Clifton may have experienced periods of no flow even without irrigation diversions. The early records for this gauge indicate that the diversions that occurred took place far upstream (in New Mexico), and probably had little effect on discharges recorded at Clifton. Based on the currently available information, it is likely that under natural conditions the upper Gila River would have rarely had no-flow days, but it most certainly would have experienced prolonged periods of low flow in certain reaches during June and July.

According to various federal agency criteria for recreational use of water crafts, and according to long-term gauge records, which demonstrate highly variable flow rates on an annual basis, the Upper Gila River and the San Francisco River would have been susceptible to navigation by low-draft boats on a seasonal basis. Nevertheless, kayaks and canoes could have navigated some portions of the Upper Gila River and the San Francisco River during the lowest flow months, as well as during flows up to approximately the 5-year discharge event. Neither the Upper Gila River nor the San Francisco River would have been susceptible to reliable navigation by larger boats such as powered barges, steamboats, or keel boats, due to the occurrence of rapids, high velocities, long narrow canyons with no access to safe landings, and natural and man-made obstructions such as riffles, waterfalls, and irrigation diversion structures.

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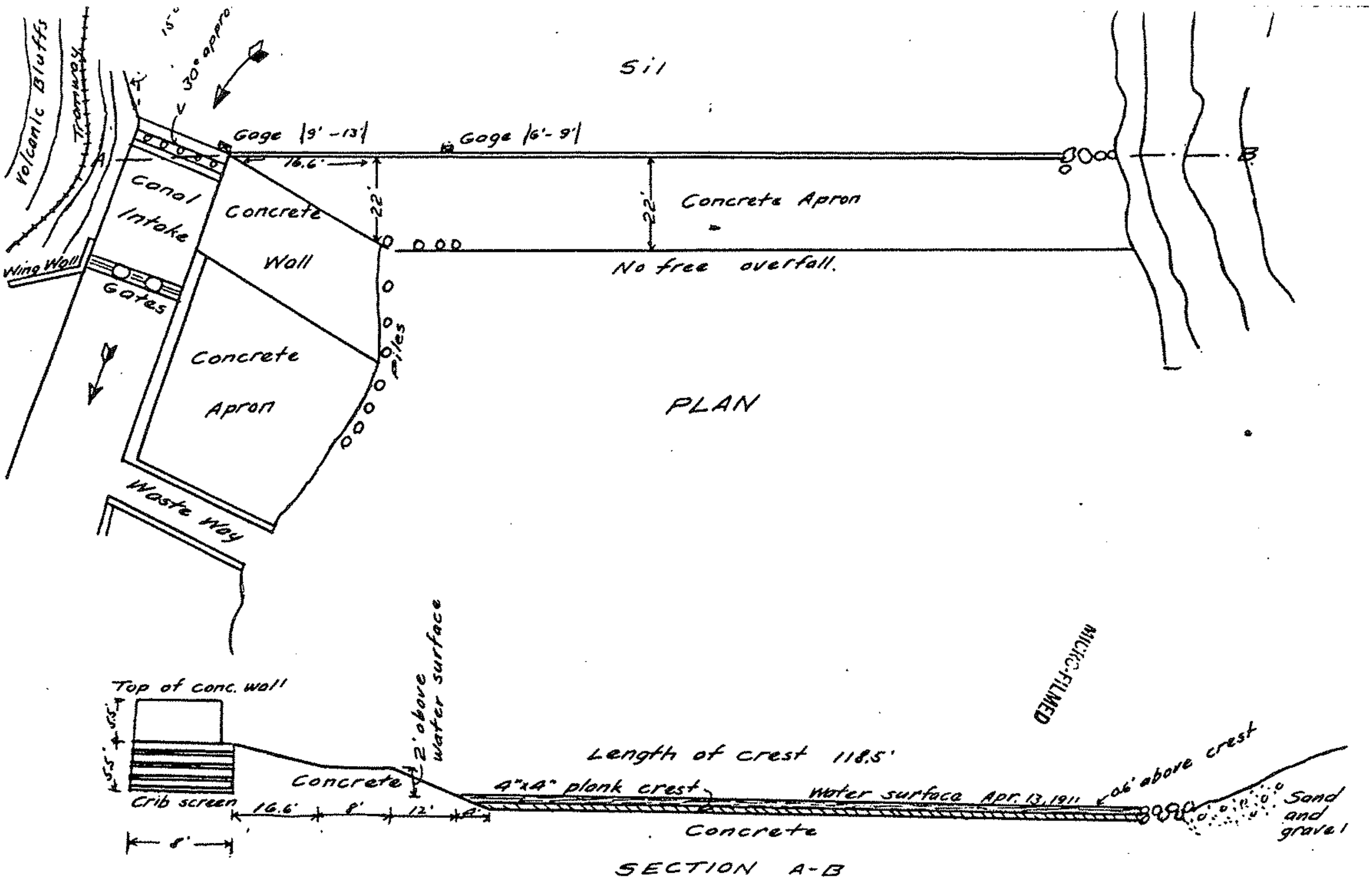
APPENDIX A

Arizona Copper Company Diversion Dam on the San Francisco River near Clifton, Arizona



MICRO-FILMED

133

SKETCH OF A.C.CO. DAM, CLIFTON, ARIZ.

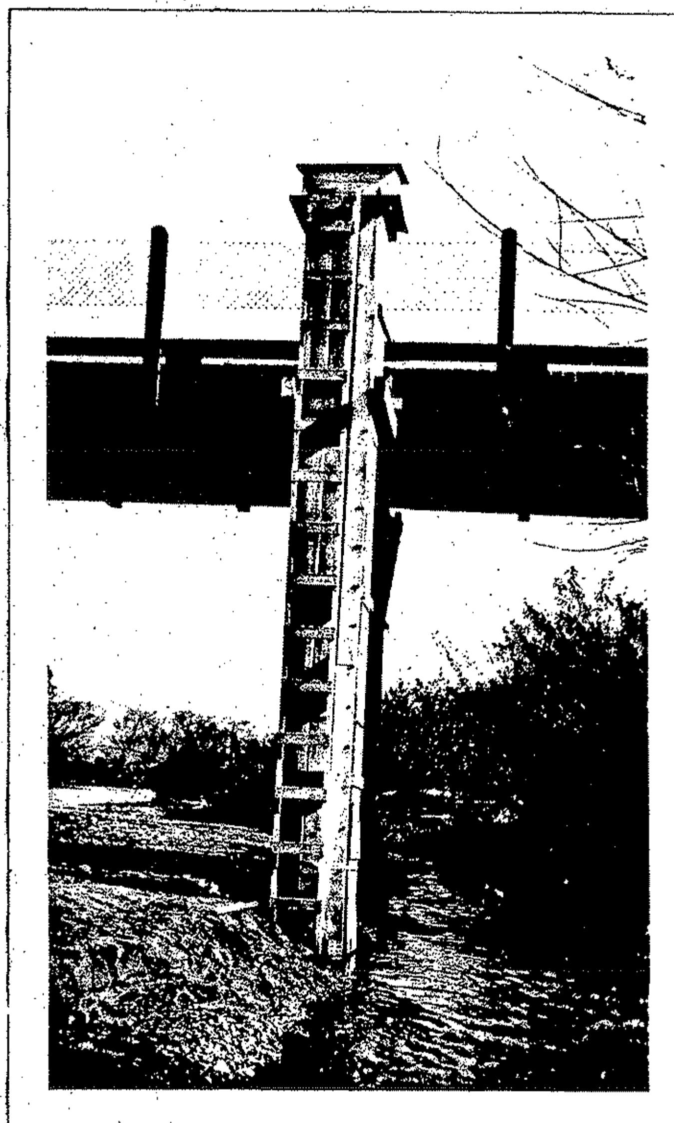
APPENDIX B

Gila River at Virden Bridge near Duncan, Arizona
Supplement to Station Description

Discontinued

MICRO-FILMED

Gila River at Virden Bridge near Duncan, Arizona.
Supplement to Station Description. June 3, 1931.



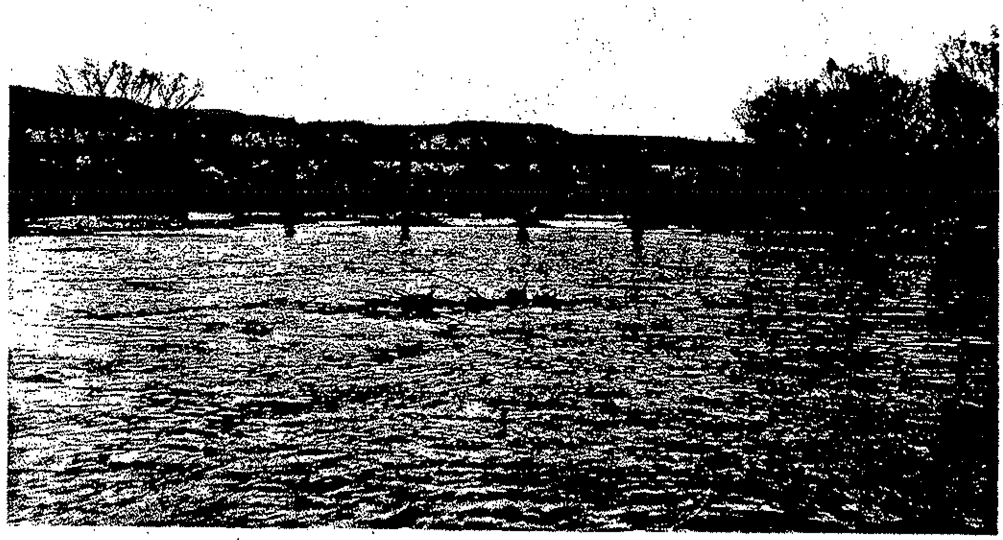
Close-up of gage well showing main details
and small channel past gage. December 2, 1930.

Gila River at Virden Bridge near Duncan, Arizona.

Supplement to Station Description, continued.

MICRO-FILMED

View looking upstream showing channel past gage and bridge from which measurements are made. Only a small stream flows past the gage at present. December 2, 1930.

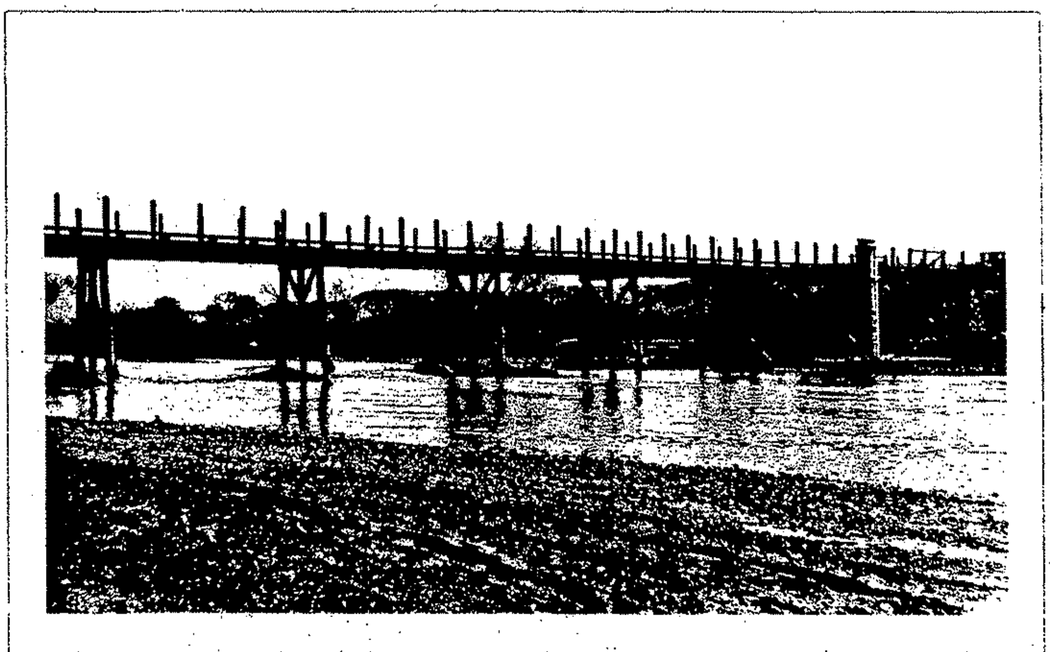


View looking downstream showing channel past gage, which can be seen at left of picture. December 2, 1930.

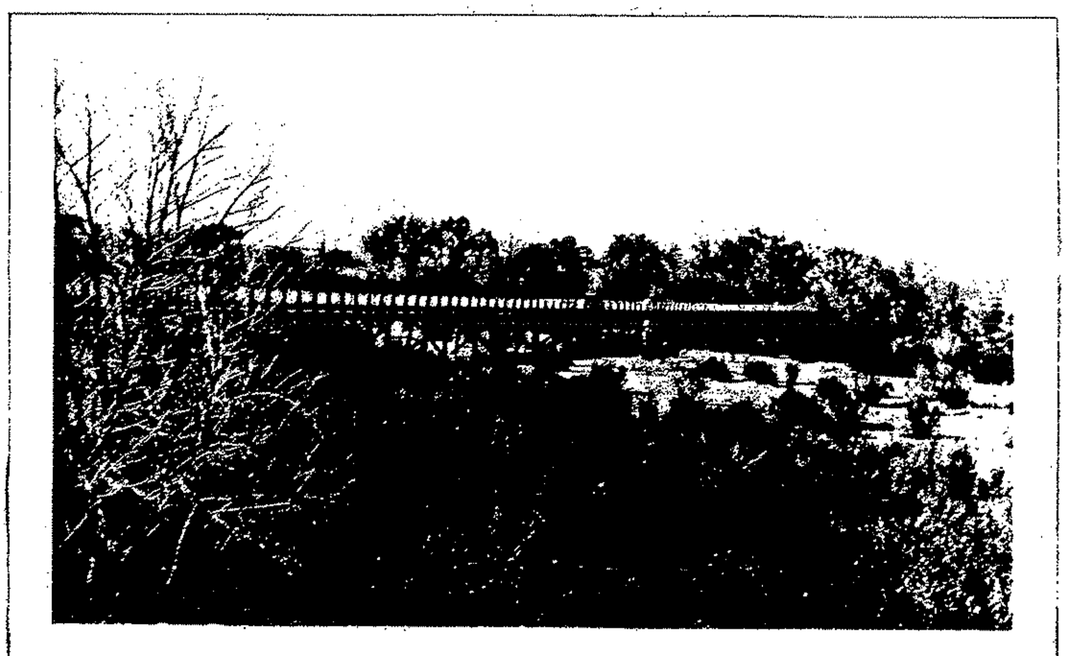
MICRO-FILMED

Gila River at Virden Bridge near Duncan, Arizona.

Supplement to Station Description, continued.



View from right side looking upstream and across towards gage. A small channel flows past the gage. December 2, 1930.

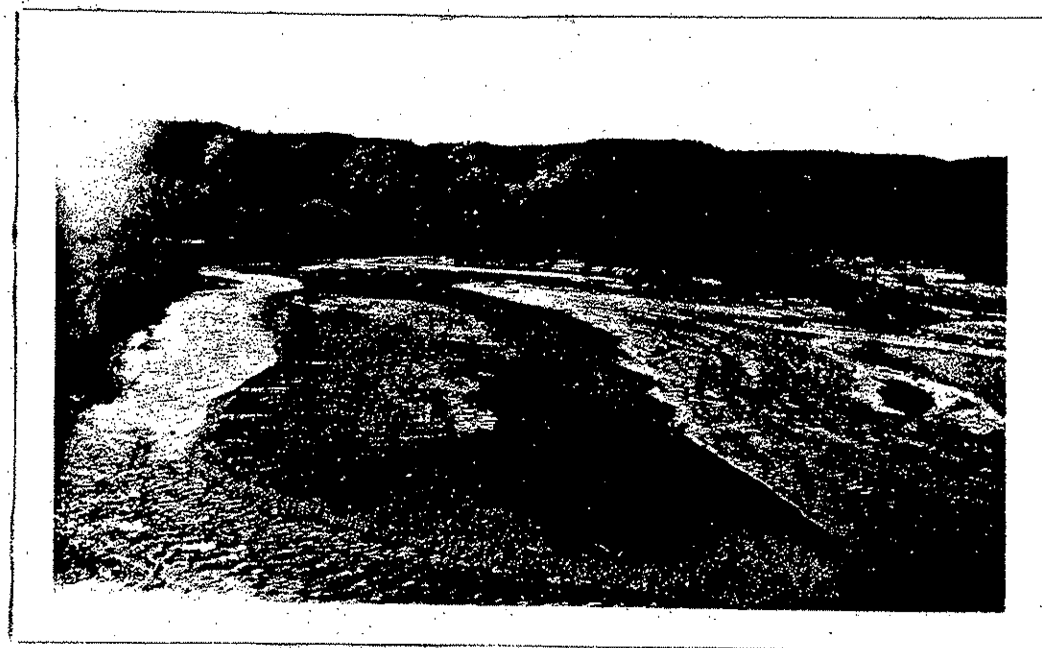


General view of Virden Bridge from left side. Gage can be seen at right of middle part of picture. Main channel is beyond gage. December 20, 1930.

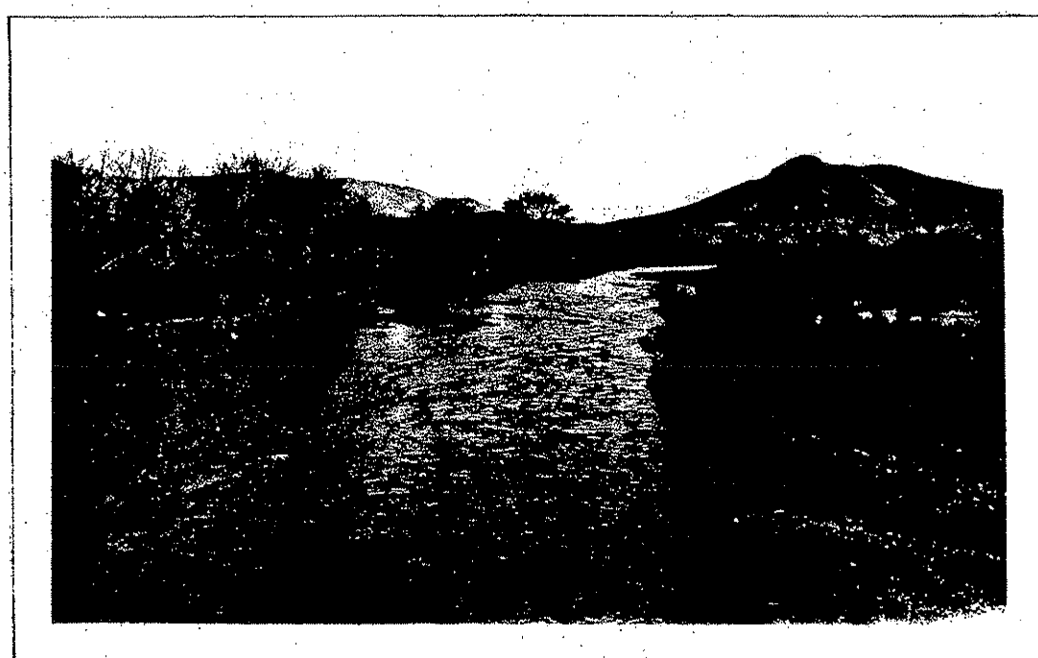
MICRO-FILMED

Gila River at Virden Bridge near Duncan, Arizona.

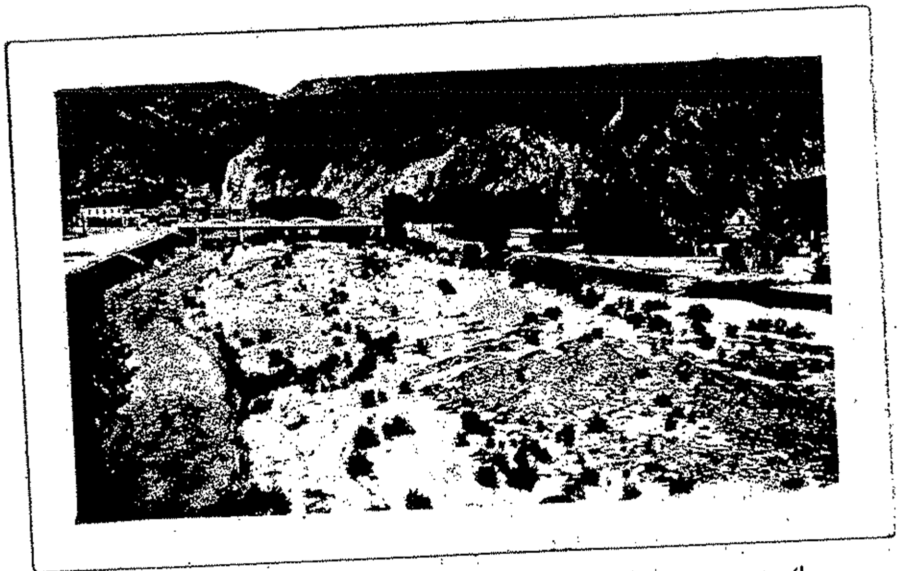
Supplement to Station Description, continued.



View looking downstream from bridge showing channel below gage. December 20, 1930.



View looking upstream from bridge showing channel above gage. Small side channel at extreme right of picture flows past gage. December 20, 1930.

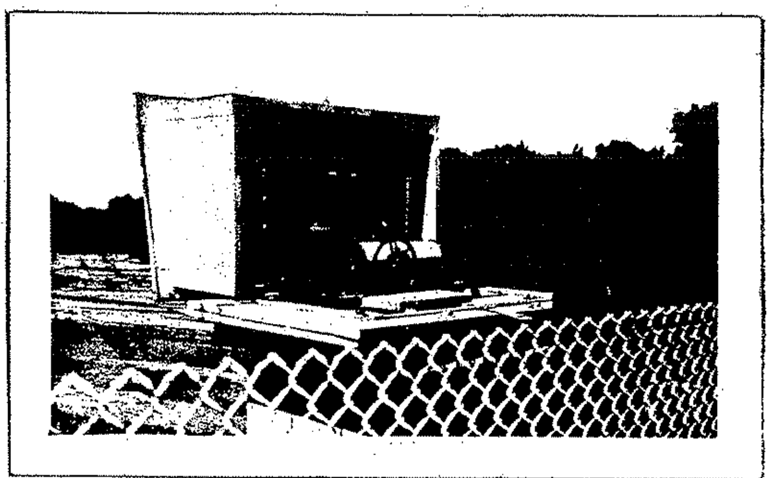


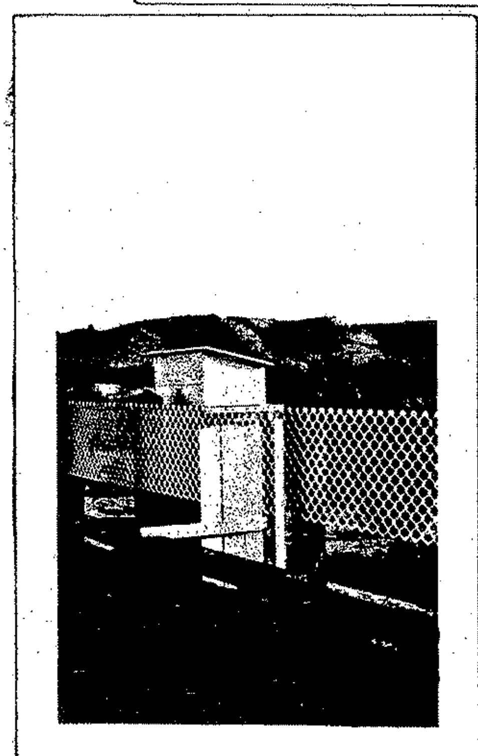
Looking upstream towards gaging station
1927 — 48 and after

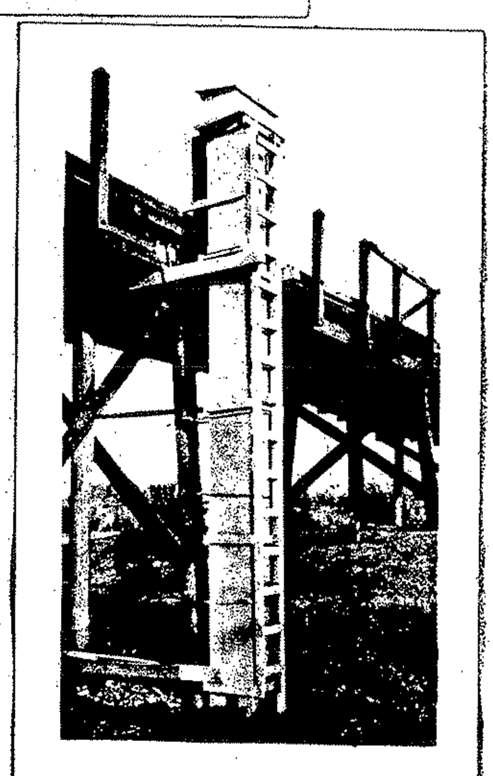
MICRO FILMED

Looking downstream
shows high water measuring section
1927 — 48 and after

MICRO-FILMED







Arizona Stream Navigability Study
for the
Upper Gila River
Safford to the State Boundary
and
San Francisco River
Gila River Confluence to the State Boundary

Draft Final Report

Prepared for the

Arizona State Land Department

Date of Original Report: June 1997

Prepared by

SFC Engineering Company
In Association with
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JE Fuller/ Hydrology & Geomorphology, Inc.,
and
SWCA, Inc. Environmental Consultants

Revised:

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

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Section 6

Boating on the Upper Gila and San Francisco Rivers

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Section 6:

Boating on the Upper Gila and San Francisco Rivers

Introduction

The objective of this section of the report is to provide information on the types of boating which have occurred historically and in modern times on the Upper Gila and San Francisco Rivers. Several types of information are presented including the following:

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

Historical and modern accounts of boating on the Upper Gila and San Francisco Rivers are presented in this section. Historical boating on the river includes use of unspecified boats (presumably low-draft, non-powered boats), canoes, and rafts. Modern boating on the river primarily includes the use of canoes, rafts, and kayaks. Other information on historical boating on the Upper Gila and San Francisco Rivers was presented in Section 3. Hydraulic rating curves and hydrologic data for the Upper Gila and San Francisco Rivers were presented in Section 5.

Federal Agency Boating Criteria

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 its own boating standards (Cortell and Associates, 1977). These federal criteria, summarized in Tables 1 and 2, were developed primarily for recreational boating, not necessarily for commercial boating. Minimum stream conditions required are summarized in Table 1. Minimum and maximum conditions are summarized in Table 2.

Table 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 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 previous navigability studies did not agree with the minimum velocity criteria given in Table 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. Therefore, it is assumed that the minimum velocities in Table 2 are probably intended to indicate what stream conditions are most typically considered "fun."

The Bureau of Land Management (BLM) apparently has adopted a more 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 during seasonal floods.

- Inaccessible streams are not navigable.
- Long obstructions such as bars make upstream segments non-navigable.

The BLM navigability criteria do not necessarily conform to the federal test of navigability established in ARS §37-1101. No specific, documented decisions by federal agencies for the Upper Gila and San Francisco Rivers were identified during the course of this study. However, testimony at the June 10, 1997 ANSAC hearing in Globe, Arizona indicated that the BLM has determined an unspecified portion of the Gila River to be navigable. The BLM Safford office currently monitors and permits recreational and commercial boating activities in the Gila Box Riparian National Conservation Area portion of the Upper Gila River.

Historical Accounts of Boating

There were at least three historical accounts of boating on the Upper Gila and San Francisco Rivers around the time of Arizona statehood, as described in Section 3 of this report. Newspaper stories were the primary source of historical boating accounts in this sparsely populated area. All of the documented accounts of boat use on the Upper Gila and San Francisco Rivers indicate that boat use was recreational. Of the three documented historical accounts of boating on the Upper Gila and San Francisco Rivers, exact dates can be assigned to only one. In January and February, 1895 two men boated without difficulty from Clifton down the San Francisco River to well past Safford on Gila River. Although this episode occurred prior to the advent of recorded stream gauging on the Upper Gila and San Francisco Rivers, the long-term average flow rates for the months of January/February were estimated at about 258/324 cfs and 240/315 cfs, respectively (Tables 16 & 20, Section 5).

It is noted that for all of the instances of boat use on the Upper Gila and San Francisco Rivers, the boaters floated in the downstream direction. No evidence of boating in the upstream direction was found. The type of boats typically used were flat-bottomed boats, canoes, and rafts. Stanley Sykes of Flagstaff reportedly canoed the entire Gila River in Arizona at some time during 1909. Information presented in Table 3 summarizes probable stream characteristics required to support use of the types of canoes available at statehood.

The criteria for canoes are not substantially different from criteria for canoes available today.

Table 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

Modern Accounts of Boating

Today, the Upper Gila and San Francisco Rivers are popular recreational boating streams, with some commercially-operated boating expeditions occurring during optimum flow conditions in the late spring. Given that the hydrologic analysis (Section 5) concluded that flow conditions at statehood were not significantly different from existing flow conditions, and the geomorphic investigation (Section 4) concluded that channel conditions were similarly unchanged, modern boat use may provide evidence of susceptibility to navigation by some types of boats as of the time of statehood. Although boat-making technology has improved since the time of statehood, with the use of inflatable rafts, inflatable and hard-shell kayaks becoming some of the preferred modes of recreational travel, these improvements generally have only made the boats more durable. The depth or width of water required has not substantially changed.

Modern boating accounts of the Upper Gila and San Francisco Rivers include the following:

1. 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 Upper Gila and San Francisco Rivers study reach has been boated in recent years (Central Arizona Paddlers Club, 1992).

2. Arizona State Parks (1978) lists the following Upper Gila and San Francisco River reaches in its outdoor recreation and boating guide:

- Gila River - Virden, New Mexico to State Route 191 (formerly known as SR 666)
- Gila River - State Route 191 to Bonita Creek (Head of Safford Valley)
- San Francisco River - Clifton to Gila River

3. A boating guide to the Southwest lists both the Upper Gila and San Francisco Rivers as boatable streams (Anderson, 1982).

   - San Francisco River. The San Francisco River from Alma, New Mexico to Clifton, Arizona is described as a Class I and II river suitable for kayaks, canoes, and small rafts. However, the guide notes that the San Francisco River is currently (ca. 1982) closed to all types of boating from March 15 to July 15 to preserve nesting habitat for the Black Hawk and other sensitive birds. The guide also notes that this time period corresponds to the optimum boating period for the San Francisco River.

   - Gila River - Alma, New Mexico to Three Way, Arizona. This reach of the Gila River is described as boatable by canoes and kayaks, with little detailed information available on conditions.

   - Gila River - Lower Gila Box. This reach of the Upper Gila River is described as a Class II and III river suitable for kayaks, canoes and small rafts. The BLM manages this reach, and recommends use by canoes or rafts.

   - Gila River - Downstream of Solomonville, Arizona. This reach is described as boatable, but not recommended due to numerous obstructions in the form of barbed wire fences.

4. Testimony at a recent ANSAC hearing on June 10, 1997 in Globe, Arizona by commercial river running operations referenced their use of the Upper Gila River for rafting.

5. Several books and magazines describe boating trips on the Upper Gila River. The July, 1997 issue of *Arizona Highways* includes an article describing a September trip through the Gila Box at about 150 cfs in inflatable boats, with a notation that BLM staff have boated the Gila Box during every month of the year. The book, *Gila Descending,* by M.H. Salmon describes a May, 1983 canoe trip down the entire Upper Gila River at a flow rate ranging from more than 1,000 cfs to about 260 cfs. With regard to the degree of boating expertise required, Salmon states that canoeing the river was "a piece of cake…most anyone could have done it, had he or she the interest and the time."

6. A world wide web site[1] describes recommended boating conditions for raft,

[1] located at http//:www.gorp.com/gorp/resource/us_river/az_gila.htm

canoe and kayak use in the Gila Box reach. The site claims that the river can be floated all year long, by different types of boats according to the flow rate and season, and states that the Gila Box can be canoed between flow rates of 150 cfs to 1,500 cfs. The text of the web site is reproduced in the Appendix.

Summary

The Upper Gila and San Francisco Rivers were used for recreational boating as of the time of statehood (Section 3). Historical hydrologic conditions in the Upper Gila and San Francisco Rivers probably would have met current federal criteria for some types of recreational boating, for most of the year. No evidence of boating in the upstream direction along the Upper Gila and San Francisco Rivers, or use of large machine-powered boats was found. No evidence of significant commercial boating industries developed on the Upper Gila and San Francisco Rivers as of 1912 was uncovered. Both rivers are currently boated for recreational purposes, primarily during the winter and spring months, with limited commercial river running operations in the Gila Box Reach.

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Appendix: Floating the Gila[1]

Generally the Gila River can be floated year long, depending on the flow and type of raft used. This 23 mile float takes you through a spectacular unroaded canyon with 500 foot sheer cliff walls and dramatic geologic features. Bird watching is popular with over 150 species of birds making their home in the canyon at some time of the year. Raptors such as the uncommon zoned tailed hawk, black hawk, and peregrine falcon can be seen, along with many of the colorful neotropical birds that migrate to this area in the spring and summer. Most of all, this river is known for its solitude and primitive nature.

Put in: South of the town of Clifton on State route 191 turn onto the Black Hills Back Country Byway and travel south four miles until you reach the Gila River and the Old Safford Bridge. The best place to put in is on the south side of the river.

Take out: From Safford cross the Gila River north on Eighth Avenue and turn right at the "Y" onto Airport Road. Travel six miles to a stop sign and turn left onto Sanchez Road. From there travel six more miles until you reach a Bonita Creek BLM sign and turn left onto that dirt road. Once on the dirt road continue traveling approximately 2.5 miles to the West Entry Sign of the Gila Box Riparian National Conservation Area. From the Entry sign travel .5 miles to Dry Canyon parking area on the right side of the road. Dry Canyon parking area can be used for overnight parking while on the river.

Flow Guidelines

Since the water flow in the Gila River varies dramatically from year to year it is difficult to state average flows by month. One should always obtain the water flow in cubic feet per second (cfs) prior to planning to float the Gila River. The months January through April experience the highest flows from snowmelt and rain. These flows can range between 100,000 cfs to only 250 cfs with extremely cold water temperatures. Flows generally are much lower during the months of May and June and rise some during the monsoon rainy season of July, August and September. The following flow level guidelines are offered as a safety measure in determining what water craft the river should be floated with:

CFS Level: 10,000 and above
Not Recommended
CFS Level: 6,000 to 10 000
Type of Water Craft: 14 ft. river raft and larger.
Difficulties: Very swift cold water with class III rapids. Logs and debris probable in water. Advanced and very experienced rafters only.
CFS Level: 3,500 to 6,000
Type of Water Craft: 12 ft. river raft and larger. Advanced and very experienced hard shell kayakers.
Difficulties: Swift current with class II and III rapids. Experienced rafters only. At upper level debris and some logs could be in the water.

[1] From Web site at www.gorp.com/gorp/resource/us_river/az_gila.htm

CFS Level: 1,500 to 3,500

Type of Water Craft: 12 ft. river raft and larger. Advanced kayakers (inflatable and hard shell).

- Difficulties: Probably the best time to float the river for novice crafters. Challenging float for kayakers.

CFS Level: 500 to 1,500

Type of Water Craft: 14 ft. river raft and smaller. Inflatable and hard shell kayaks. Experienced canoeists.

Difficulties: Larger river rafts will have to maneuver frequently to find deep water to float, but good for beginners. Excellent for novice inflatable kayakers and canoeists.

CFS Level: 150 to 500

Type of Water Craft: Canoes, and inflatable kayaks.

Difficulties: Excellent for beginners. River narrows considerably with nice chutes with some white water. Floaters may have to pull their boats through short shallow stretches. Warm weather and drifting solitude.

Arizona Stream Navigability Study

for the

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SWCA, Inc. Environmental Consultants

Revised:

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

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Section 7

Navigable Rivers Land Use GIS

I. Methodology

A Geographic Information System (GIS) was developed depicting the 100-year floodplain and land ownership/use within the floodplain (see Appendix A for data organization). The GIS was designed not to aid in the determination of navigability but to help study the impacts should the river be declared navigable. Information regarding the ownership and use of land in the vicinity of the river may be depicted as maps or as statistics. The GIS was not updated as part of the 2003 revisions to this report.

The general land ownership categories depicted by the GIS are as follows:

Ownership Categories
Private
State of Arizona
Bureau of Land Management (BLM)
U.S. Forest Service
National Wildlife Refuge
National Park Service
Indian Reservation
U.S. Farm Service Administration
Other / No Data

The general land use categories depicted by the GIS are as follows:

Land Use Categories
Vacant Land
Residential - Single Family
Residential - Multiple Family
Hotel - Motel - Resorts
Condominiums
Commercial Property
Industrial Property
Farm/Ranch Property
Public Utilities
Natural Resources
Special Use Property
General Service Use

Additional data, such as county, township, range, section, book, map, parcel, source, legal parcel area, state land use code, and owner descriptions, are also contained in the GIS.

A. Base Data

The base layers for the GIS, including rivers, counties, and public land survey system, were obtained from the Arizona Land Resources Information System (ALRIS) maintained by the Arizona State Land Department (ASLD). Additional river data were obtained from 1:100,000 scale Digital Line Graph (DLG) files maintained by the United States Geological Survey (USGS).

B. Floodplain

The 100-year floodplain was digitized from Federal Emergency Management Agency (FEMA) maps of varying scales. Georeferencing (i.e. registration of map data to real world coordinates) was accomplished via section corners and, in a few circumstances, street intersections. Arbitrary lines were digitized at junctions with tributary floodplains. Adjacent maps were edgematched; significant mismatches were not adjusted but were closed using straight line segments.

C. Land Ownership/Use

Parcels were digitized from paper County Assessor maps. Georeferencing was accomplished using the following:

1. Section corners or subdivisions (e.g. quarter-quarter-section corners),

2. Legal descriptions using a section corner or subdivision as a reference point,

3. Distances, based on map scale, from a section corner or subdivision,

4. Corresponding features in a smaller scale map (e.g. a map of a housing development might be registered via its corresponding outline depicted in a section map), and/or

5. Adjacent features.

Digitizing was accomplished as follows:

1. Clearly delineated parcel boundaries were digitized as depicted. Lines in large scale maps generally took precedence over corresponding lines in small scale maps.

2. Areas of parcel overlap were assigned to one parcel or the other as deemed best. Unclear boundaries between two parcels were digitized according to best judgement.

3. Parcels of vague or undepicted location were not digitized unless an outline could be obtained from an alternate source (e.g. ALRIS data or USGS 1:100,000 DLG files).

4. Linear (non-polygonal) parcels, depicting railroad right-of-way (ROW), were not digitized. An exception was made if adjacent parcels clearly depended on a ROW edge, in which case a 200' wide corridor was applied.

When necessary, adjacent maps were edgematched. Small scale features were adjusted to large scale features. Attributes were assigned in a fashion consistent with ASLD's Gila River coverage:

1. Parcel numbers were assigned where clearly designated, unless the parcel clearly was non-private (State, BLM, etc.), in which case a "non-private" parcel code (AZ, BLM, etc.) was assigned.

2. Parcels which were not numbered, but were clearly labeled (Arizona, U.S.A., etc.) were assigned non-private codes as appropriate. Where a conflict existed between assessor maps and ALRIS data over USA vs. State ownership, the ownership reflected in the ALRIS data was assigned.

3. Unlabeled or questionable parcels, uncoded road and rail ROW parcels, parcels outside the floodplain, and undigitized regions were assigned a zero parcel number.

4. Sections outside the study area were assigned "background" (BACK) parcel codes.

Relate files, containing land ownership and use data, were generated from State Revenue data. A list of parcel values was generated from the digitized parcels and submitted to the State Revenue office. Data received from the State Revenue office were converted to a table and reprocessed. If, after a quality check, the ID of a digitized parcel was not listed in the State Revenue data (e.g., if a parcel split or merge had not yet been depicted on the County Assessor map), it was assigned "Other / No Data" ownership.

D. Plots

Once all datasets were assembled, checked, and finalized, they were transported to the State Land Dept. building in Phoenix. Annotation coverages were created for the final plots, and existing scripts and tables adapted to production of the final plots. One complete series was created for each river reach.

II. Results and Discussion

The study area was divided into three map sheets for plotting purposes. Floodplain maps were available for the entire study area.

All private parcels were digitized from paper maps. The boundary of the White Mountain Apache reservation was obtained from USGS 1:100,000 DLG files.

Ownership Category	Percent
Private	19.8
State	10.4
BLM	36.3
U.S. Forest Service	21.0
U.S. Farm Service	1.1
Other / No Data	11.4

Land Use Category	Percent
Vacant Land	2.9
Residential - Single Family	0.9
Residential - Multiple Family	< 0.1
Hotel - Motel - Resorts	< 0.1
Commercial Property	0.5
Industrial Property	< 0.1
Farm/Ranch Property	13.4
Natural Resources	2.3
Special Use Property	0.8
General Service Use	67.8
Other / No Data	11.4

Appendix A: GIS Data Organization

A. Base and Reference Layers from ALRIS

Name	Contents
AZTRS	Public Land Survey System of Arizona
COUNTIES	County Boundaries
HYDRO	Hydrology
LAND	Surface Management
RAILS	Railroads
TRANS123	Major Roads

B. Data Organization

A separate workspace is created for each river reach. The principal ARC/INFO coverages contained in each workspace are FLOOD, depicting the 100 year floodplain, PARCELS, containing digitized parcels, RIVER, depicting the river itself, and SHEETS, depicting the mapsheets.

1. FLOOD

The FLOOD coverage has polygon topology. The PAT contains the following items:

ITEM NAME	WIDTH	TYPE	N.DEC
IN_OUT	3	C	0
SOURCE	20	C	0
SC	1	N	0

IN_OUT Values:
in = Part of floodplain
out = Not part of floodplain

SOURCE	SC
FEMA (Detailed Study)	1
FEMA (Approximate)	2
Non-FEMA	3

2. PARCELS

The PARCELS coverage has polygon topology. The PAT contains the following items:

ITEM NAME	WIDTH	TYPE	N.DEC
TOWNSHIP	4	C	0
RANGE	4	C	0
SECTION	2	C	0
COUNTY	2	N	0
BOOK	3	C	0
MAP	3	C	0
PARCEL	4	C	0
CODEDATE	8	D	0
OWN_CODE	12	C	0
SOURCE	20	C	0
CATEGORY	10	C	0

Items TOWNSHIP, RANGE, SECTION, and COUNTY conform to the data dictionary of the ALRIS LAND layer.

Parcels which have a book, map, and parcel number, are coded as follows:

ITEM	Example
COUNTY	9
BOOK	103
MAP	043
PARCEL	1A
OWN_CODE	091030431A

Other parcels are coded as follows:

STANDARD CODES FOR NON-PRIVATE PARCELS

ITEM	Example
BOOK	101
MAP	040
PARCEL	0
OWN_CODE	0

PARCEL Values:

0	= No data or "other" (e.g. Right-of-Way)
AKCH	= Ak-Chin (Maricopa) I.R.
ASNF	= Apache-Sitgreaves NF
AZ	= State of AZ
BLM	= BLM
BWR	= Bill Williams N.W.R.
CONF	= Coronado National Forest
GILA	= Gila River I.R.
NAV	= Navajo I.R.
PFNP	= Petrified Forest NP
SANC	= San Carlos I.R.
SANX	= San Xavier I.R.
SALT	= Salt River I.R.
SRWR	= Salt River N.W.R.
TOHO	= Tohono O' Odham (Papago) I.R.
TONF	= Tonto National Forest
TONM	= Tonto National Monument
WMA	= White Mountain Apache I.R.

"Background" parcels, i.e., sections outside the study area, are coded as follows:

ITEM	**Example**
BOOK	999
MAP	999
PARCEL	BACK
OWN_CODE	BACK

The CODEDATE item contains the date of completion of the coverage. The principal source used to determine the geometry of a particular parcel is documented via the SOURCE item.

SOURCE Values:

ASLD Base	= Base data from AZ State Land Dept. (AZTRS)
County/Paper	= County Assessor paper maps
County/Digital	= County Assessor digital maps
County/GIS	= County GIS
USGS 100K DLG	= USGS 1:100,000 DLG files
ALRIS LAND	= ALRIS LAND coverage
Various	= Various Sources

The CATEGORY item is a temporary item used in the generation of status maps.

Each PARCEL coverage has a relate file, OWNDATA, with the following structure:

ITEM NAME	WIDTH	TYPE	N.DEC
OWN_CODE	12	C	0
OWNER	2	N	0
LC	2	C	0
DEL_FLAG	1	C	0
STATUS_DAT	8	D	0
LAND_USE	4	C	0
AREA	8	C	0
UNITS	1	C	0
OWNER1	40	C	0
OWNER2	40	C	0
OWNER3	40	C	0

OWN_CODE is the relate item to the PARCELS coverage. OWNER is the ownership lookup code and LC the use lookup code, used for querying and plotting. DEL_FLAG is a State Revenue record code, probably indicating a record slated for future deletion. STATUS_DAT is the date of the record. LAND_USE is the four-digit State land use code. AREA is the legal area of the entire parcel. UNITS is the units of the legal area (acres or square feet). OWNER1 through OWNER3 are the first three fields of the taxpayer name and address section.

3. RIVER

The RIVER coverage has line topology. There are no additional attribute items.

4. SHEETS

The SHEETS coverage has line topology. The AAT contains the following item:

ITEM NAME	WIDTH	TYPE	N.DEC
SHEET	2	N	0

Values correspond to the mapsheet number.

APPENDIX B

Land Ownership and Land Use Maps on File at Arizona State Land Department, Drainage and Engineering Section

Arizona Stream Navigability Study
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Section 8

Summary for the Upper Gila and San Francisco Rivers

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Section 8

Summary

The Upper Gila and San Francisco Rivers are perennial streams that have provided reliable sources of water for sustenance, agriculture and recreation throughout Arizona's recorded history, as well as during the prehistoric period. Despite the long history of perennial river discharges, there are only a few recorded instances of use of the rivers for boating around the time of Arizona Statehood in 1912. Not until recently, when recreational boating became popular, have these rivers been extensively used for navigation. Recent recreational boating of both rivers consists primarily of downstream floating in rubber rafts, canoes, kayaks, and other inflatable boats during seasonal periods of above-average flow.

Archaeological studies of the Upper Gila and San Francisco Rivers in Arizona have been fairly limited, although it is known that the Gila River played a major role in the human settlement patterns and occupational success of prehistoric development within the study area. The rivers provided a permanent water source, fish that were used as a protein source, and a riparian corridor that was rich in building materials, wildlife and vegetation. Therefore, most prehistoric habitations in the study area were close to the rivers. Although archaeologists have documented some 11,000 years of human use in southeastern Arizona, most of the archaeological sites in the study area date to the period from about 50 BC to AD 1200 when farmers of the Mogollon archaeological culture lived in the area. The Mogollon farmers lived in farmsteads and hamlets of as many as 20 rooms scattered along the Gila River and in the vicinity of Clifton, on the San Francisco River. In addition to the riverside farming communities, campsites and specialized activity sites have been identified throughout the uplands adjacent to the rivers. In the early historic period (circa AD 1540-1870) the area was occupied by the Yavapai and Apache, who lived primarily by hunting wild animals and gathering wild plants. Their sites consist primarily of rock overhangs, agave-roasting features, and campsites.

Except for the lower portion of the Upper Gila River near Safford, there is no evidence of extensive prehistoric irrigation agriculture on the Upper Gila and San Francisco Rivers, as was documented for the Lower Gila River, probably due to the lack of a wide floodplain and arable land area along the rivers. Given that the water supply in the Upper Gila and San Francisco River study area was sufficient to support an extensive canal system and agricultural economy near, and downstream of, Safford, lack of water probably cannot explain the lack of archaeological evidence of prehistoric irrigation agriculture. Archaeological reconstructions suggest that streamflow rates changed little from the AD 740 -1370 period to the AD 1800-1979 period. Archaeological research has not documented any use of the river for commercial trade and travel or any regular flotation of logs.

Historical records of the Upper Gila and San Francisco Rivers extend back to the Spanish explorations of the Southwest during the 1500's. The Spanish are thought to have named the Gila River the "Rio de Los Balsas" (River of Rafts), either because their army was forced to cross the river in rafts, or because of the Indians' use of wicker baskets to cross the river. By the 1820's, Mexico had won its independence from Spain, and American fur trappers such as James Ohio Pattie, Ewing Young, and Kit Carson explored the Upper Gila and San Francisco Rivers, trapping beaver along the rivers, and establishing a travel route into Arizona. These early trappers traveled primarily on horseback or on foot in the study area, although their records indicate that they built and used canoes and rafts when they reached the Colorado River downstream of the study area. The American military expedition of Stephen Watts Kearny and William Emory in 1846 and Bartlett's boundary survey of 1850-1853 of the Gadsden Purchase, included explorations of the Upper Gila and San Francisco Rivers. Later expeditions through Arizona abandoned the Gila River route of the trappers and the military for Cooke's less difficult route located to the south of the study area.

Discovery of copper deposits by Cavalry troops along the San Francisco River during the Apache wars of the 1870's led to establishment of the Clifton-Morenci mining district. With the Apache threat subdued, and the economic incentive for development provided by copper mining, Euro-American settlement of the Upper Gila River occurred, and with it development of farms and ranches to supply the mines, roads and railroads, and a number of small towns. A Bureau of Census map from 1901 shows most of the Gila Valley was irrigated above the confluence with the San Francisco River, but only a small portion of the San Francisco River near Potter's Ranch above Clifton was irrigated. By 1922, there were about 54 miles of main irrigation canals watering about 4,500 acres of farmland along the Upper Gila River.

Although there is some historical evidence that small boats were used on both the Upper Gila and San Francisco Rivers, transportation in the region was typically by horse, mule, wagon, stagecoach, or rail. A railroad spur was constructed to Clifton by 1883 to transport copper ore, which had previously been shipped by oxen and mule teams. A cattle trail from New Mexico followed the channel of the San Francisco River to the Gila River, and then downstream along the Gila River to other parts of Arizona. This trail remained a popular jeep and four-wheel drive route during low flow months, until the route was recently closed by the U.S. Forest Service to protect the habitat of the endangered Loach Minnow. During the period around statehood, river crossings near Clifton were accomplished by means of swinging bridges (foot bridges) or railroad. Horses, wagons and others had to ford the river.

Several episodes of boating the Upper Gila and San Francisco Rivers were documented during the historical period, in additional to the possible Indian boating noted by the Spanish explorers. The Chiricahua Apaches of the region were known to construct boats made of bull hides stretched over wooden frames for crossing streams, although no instances are specifically recorded for the Upper Gila and San Francisco Rivers. Several persons used canoes or unspecified small boats to float down the entire length of both rivers around the time of statehood. G.W. Evans and Amos Adams floated from Clifton to Riverside (near Florence) in January-February of 1895 in an unspecified type of small boat, and did not report any difficulties until well downstream of Safford. Stanley Sykes used a canoe to float the entire length of the Gila River in Arizona in 1909. Early residents of Clifton reported that building rafts for use on the San Francisco River was a popular pastime for children during the period immediately following Arizona statehood. During recent years, recreational boating has become a popular pastime on both the Upper Gila and San Francisco Rivers, especially during the winter and late spring. No evidence of boating in the upstream direction, sustained commercial boating operations, ferries, or use of keel boats or other powered boats was identified.

Early descriptions of the Upper Gila and San Francisco Rivers do not differ significantly from contemporary descriptions of the rivers. Bartlett (1854) believed that Gila River was not navigable, except during irregular floods. During these "floods" Bartlett felt that flat bottom boats could pass to the Salt River confluence near Phoenix. Whipple (part of the Bartlett survey) felt that the Gila River was an impracticable route for a wagon or railroad route due to its narrow canyons in some reaches. The San Francisco River was described as usually "relatively shallow" flowing over a wide expanse of white sand and reeds. It has steep-walled canyons with a relatively flat floodplain averaging 300-600 feet wide. The permanent stream width was generally less than 30 feet, which meanders across the floodplain. The low flow channel position changes during each flood, creating cut banks and leaving gravel bars. Floods fill the canyon from wall to wall. The Upper Gila was described as a perennial stream, often narrow and shallow enough to travel down the riverbed, except in the impassable (to vehicles) canyons. The river corridor supported a variety of species including beaver, quail, geese, ducks, deer, wolves, coyotes, and fish.

The study area was sparsely populated throughout the historical period, much as it is today. Clifton, at its peak of mining activity in 1910, had a population of about 5,000 (1993 pop. = 3,000). Several small farming and ranching communities grew up along the Upper Gila River to serve the mining community at Clifton. Much of the study is now located within the Apache-Sitgreaves National Forest or is managed by the Bureau of Land Management. Historical uses of the Upper Gila and San Francisco Rivers included limited agriculture supported by irrigation diversions from the rivers, municipal and industrial consumptive uses, recreation, and hunting, gathering, and fishing by Indians prior to the Apache wars.

The geomorphology of the Upper Gila and San Francisco Rivers is substantially unchanged from its condition at or before statehood in most of the study area upstream of the Safford Valley. Most of the Upper Gila and San Francisco Rivers are formed within bedrock canyons. Bedrock along the channel margins in these canyons precludes significant movement of the river channel or other channel changes. In addition, the bedrock geology of the Upper Gila and San Francisco Rivers area made access to the river difficult during the period around statehood, prevented development of extensive irrigation systems, and prevented the development of large population centers near the river. The reach of the Gila River located downstream of the Gila Box widened significantly around the time of statehood in response to large floods, and changed from a narrower, tree-lined river to a wide braided floodplain. Ordinary high and low watermarks may be defined based on existing topographic, vegetative, and soil characteristics.

The Upper Gila and San Francisco Rivers are perennial streams which, except for numerous irrigation diversions, have remained free-flowing since they were first settled in the 1870's. Flow rates within the study reaches probably have not changed significantly since the time of statehood. River flows have been reliable enough over the past 120 years to support irrigation-based agriculture in the Duncan Valley at the upstream end of the Upper Gila River reach, as well as a more extensive irrigation-based farm economy in the Safford Valley downstream of the study area.

As early as 1899, there were 45 diversions in the Duncan and Safford Valleys. The combined capacity of the early diversion canals and ditches was enough to divert all the flow from the Gila River during the peak irrigation season in reaches with irrigated agriculture. Available diversion data for the San Francisco River are sparse; however, even small diversions from the San Francisco River could have had a measurable impact, given the typical low average flow rates during seasons when high irrigation demand coincides with seasonal low flow. Under natural conditions, the Upper Gila River would rarely have had no-flow days, but could have experienced annual periods of low flow during June and July.

Streamflow data gathered for the Upper Gila and San Francisco River study indicate that:

- The Upper Gila River is a naturally perennial stream. The average annual discharge for the Upper Gila River varies from about 200 cfs to 430 cfs in the study reach. The minimum monthly average flow ranges from about 15 cfs to 100 cfs within the study reach, and typically occurs during the month of June.
- The San Francisco River is a naturally perennial stream. The average annual discharge for the San Francisco River varies from about 90 cfs to 215 cfs. The minimum monthly average flow ranges from about 13 cfs to 53 cfs, and typically occurs in the month of June.
- The long-term flow record demonstrates that the Upper Gila River and the San Francisco Rivers are susceptible to wide seasonal and annual variations in discharge rates.

The average annual discharge rates are only equaled or exceeded 20% of the time on the Upper Gila and the San Francisco Rivers. Therefore, the average annual discharge rate may not be as representative of "typical" flow conditions as the median (50%) flow rate or the 90% flow rate, which may give a better indication of their susceptibility to navigation. Long-term median flow rates for the Upper Gila River vary from about 66 cfs to 174 cfs between the Arizona/ New Mexico border and Safford. The long-term median flow rate for the San Francisco River varies from about 32 cfs to 76 cfs between the Arizona/ New Mexico border and the Gila River confluence. Flow depths and widths for the Upper Gila and San Francisco Rivers are shown in Table 1.

Table 1 Upper Gila River and San Francisco River Flow Characteristics				
Frequency	**Discharge (cfs)**	**Hydraulic Depth (ft)**	**Average Velocity (ft/sec)**	**Top Width (ft)**
Gila River Near Virden, NM - Upstream End of Study Reach (Duncan Valley)				
90 % Flow	21	0.6	1.3	27
Median (50%) Flow	91	0.9	2.2	45
Mean Annual Flow	190	1.2	1.6	100
2-Year Flood	4,980	5.5	8.5	107
5-Year Flood	10,400	7.5	12.6	110
Gila River Near Clifton/Guthrie, AZ - Midpoint of Study Reach (Gila Box)				
90 % Flow	18	0.7	1.0	26
Median (50%) Flow	80	1	1.7	47
Mean Annual Flow	206	1.3	2.5	64
2-Year Flood	5,940	3.7	11.5	140
5-Year Flood	11,500	5.5	14	150
Gila River at Safford Valley, Near Solomon, AZ - Downstream End of Study Reach (Safford Valley)				
90 % Flow	62	0.8	0.5	144
Median (50%) Flow	174	1.3	0.9	146
Mean Annual Flow	433	1.9	1.5	150
2-Year Flood	9,400	6.7	8.8	160
5-Year Flood	22,900	11	11.6	180
San Francisco River at Clifton - Entire Study Reach				
90 % Flow	34	0.9	1.4	28
Median (50%) Flow	76	1.0	1.6	49
Mean Annual Flow	215	1.2	2.5	72
2-Year Flood	6,800	4.5	10.1	150
5-Year Flood	17,800	8.5	13.7	153

According to various federal agency criteria for recreational use of water crafts, and according to long-term gauge records, which demonstrate highly variable flow rates on an annual basis, the Upper Gila River and the San Francisco River would have been susceptible to navigation by low-draft boats on an annual and seasonal basis, respectively. Nevertheless, canoes, small rafts, and kayaks could have navigated some portions of the Upper Gila River and the San Francisco River during the lowest flow months, as well as during flows up to and exceeding the 5-year recurrence interval. Neither the Upper Gila River, nor the San Francisco River would have been susceptible to reliable navigation by larger boats such as powered barges, steamboats, keel boats, etc., due to the occurrence of rapids, high velocities, low flow depths, long narrow canyons with no access to safe landings, natural and man-made obstructions such as riffles and irrigation diversion structures.

The Upper Gila and San Francisco Rivers were used for recreational boating as of the time of statehood. Historical hydrologic conditions in the Upper Gila and San Francisco Rivers probably would have met current federal criteria for some types of recreational boating, for most of the year. No evidence of boating in the upstream direction along the Upper Gila and San Francisco Rivers, or use of large machine-powered boats was found. No evidence of any commercial boating industries developed on the Upper Gila and San Francisco Rivers as of 1912 was uncovered. Both rivers are currently boated for recreational purposes, primarily during the winter and spring months, with limited commercial river running operations in the Gila Box Reach. Current river running guidebooks describe the Upper Gila and San Francisco Rivers as boatable at flow rates from 150 cfs (canoes and inflatables) to 10,000 cfs (large rafts).

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Glossary

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 ones 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 Acurviness@ 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.

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Acronyms

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