EVIDENCE

ARIZONA
NAVIGABLE STREAM
ADJUDICATION COMMISSION

EVIDENCE ON HAND PRIOR TO
AUGUST 9, 2002
FOR
SAN PEDRO RIVER

COCHISE, PIMA & PINAL COUNTIES

VOLUME I OF I

006

CONTENTS

TAB 1

ORIGINAL RECEIVED 2-18-97

TESTIMONY RELEVANT TO ALL WATERCOURSES

Presented by Arizona Center for Law in the Public Interest

to the

Arizona Navigable Stream Adjudication Commission

February 18, 1997

The Arizona Center for Law in the Public Interest offers the following testimony relevant to all findings and recommendations of the Commission on whether watercourses were navigable as of statehood. We made many of these points in preliminary testimony to the Commission on February 6, 1996.

As amended, the state statute governing Commission proceedings contains grossly illegal and inaccurate standards for the determination of navigability and non-navigability. Federal law, as developed by the federal courts, sets the test for determining title to the beds of watercourses. Arizona Center for Law v. Hassell, 837 P.2d 158, 164-65 (Ariz. App. 1991). That test is a liberal one: Whether the waterway was at statehood susceptible for use as a highway for transporting people or goods. Utah v. United States, 403 U.S. 9, 11 (1971). A river may be found navigable for title purposes despite occasional impediments such as sand or gravel bars, and despite the fact that it is only navigable a few months out of the year. State of Oregon v. Riverfront Protective Association, 672 F.2d 792, 795 (9th Cir. 1982). Actual use for boating, whether commercial or sporting, can demonstrate susceptibility as a highway for public passage. Utah v. United States, 403 U.S. at 11. Although state ownership turns on navigability at the time of statehood, evidence of current recreational use by small craft such as canoes is probative of navigability at statehood. North Dakota v. Andrus, 671 F.2d 271, 277-78 (8th Cir. 1982).

The remoteness of a river and lack of actual use at statehood does not defeat a finding of navigability: The question is whether the river was susceptible of transporting people or goods. United States v. Utah, 283 U.S. 64, 83 (1931). A river is deemed navigable if it could transport people or goods by any conveyance - not merely those in use at the time of statehood. State of Alaska v. Ahtna, Inc. 891 F.2d 1401, 1405 (9th Cir. 1989). In fact, present-day use of a river for guided recreational trips can provide conclusive evidence of navigability at statehood. Id. at 1405. Conversely, the fact that dams or diversions render a waterway non-navigable today does not matter, as long as it was passable in its original condition. See Frank, Forever Free, 16 U.C. Davis L. Rev. 579, 586 (1983).

Under the standards set forth above, the Arizona Court of Appeals concluded in 1991 that there was substantial evidence from which a factfinder might conclude that portions of rivers and streams other than the Colorado met the applicable standard of navigability at the time Arizona became a state. Hassell, 837 P.2d at 165. In reaching that conclusion, the Court had before it much of the same evidence that is now before this Commission. If anything, the Commission has before it even more substantial evidence of navigability than was before the Court, due to extensive studies conducted by the State Land Department since the Court's decision, and other evidence offered by various parties.

Unfortunately, the Legislature has tried to restrict this Commission's ability to find watercourses navigable by imposing a number of tests and presumptions that are flatly contrary to the federal test of navigability. These include the following:

1. A presumption that the entire watercourse was nonnavigable if any determination of nonnavigability in a public proceeding exists for the watercourse or a portion thereof. ARS §37-1128.B. The presumption can be overcome only by "clear and convincing evidence." There is absolutely no such presumption under the Federal test, and the presumption is absurd on its face. The mere fact that a "public proceeding" took place does not mean that the state's title claims were properly adjudicated (or even represented). Moreover, the state does not have the authority to relinquish its public trust ownership where the watercourse was in fact navigable at statehood. Illinois Central RR v. Illinois, 146 U.S. 387 (1892). Further, the mere fact that a small reach of a river was found nonnavigable hardly means that another reach (which could be hundreds of miles away) is presumptively non-navigable. It is also violative of the public trust doctrine for the state to place a higher burden of proof on itself to show navigability than applies in an order civil case.

2. A requirement that the Commission must find and recommend a watercourse was nonnavigable, if as of statehood it either was not used or susceptible of being used for both commercial trade and travel; or flowed only in direct response to precipitation and was dry at all other times. ARS 37-1128.C. There are absolutely no such restrictions on finding navigability under the federal test. As noted above, the federal test merely requires susceptibility for use as a highway for the transportation of people or goods. There is no requirement that such transportation be "commercial." Nor does the federal test in any way prohibit a finding of navigability where a watercourse flows "only in direct response to precipitation." The issue under the federal test is susceptibility for use for transportation -- if that susceptibility is due to rain events, then the test is met.

3. A presumption of non-navigability, defeatable only by clear and convincing evidence, if any of the following applied: i)

no sustained trade and travel occurred both upstream and downstream in the watercourse; ii) no profitable commercial enterprise was conducted; iii) vessels customarily used for commerce in 1912, such as keelboats, steamboats or powered barges, were not used on the watercourse; iv) diversions were made from the watercourse for various purposes that would have been inconsistent with or impediments to navigation; v) any boating or fishing was for recreational and not commercial purposes; vi) any flotation of logs or other material that occurred or was possible on the watercourse was not for commercial purposes; vii) there were structures constructed in or across the watercourse that would have inconsistent with or impediments to navigation; viii) transportation in proximity to the watercourse was customarily accomplished by methods other than by boat; ix) the United States did not regulate the watercourse under the rivers and harbors act of 1899. ARS §37-1128.D.

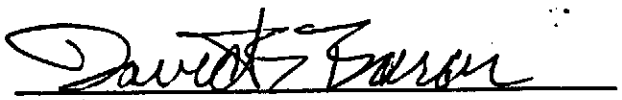
None of the above create any sort of presumption of non-navigability under the federal test, let alone the kind of presumption against navigability imposed by ARS 37-1128.D. As the above discussion of the federal test shows, the federal test does not require evidence of actual use for travel **at all**, let alone commercial use by large vessels of the period. Moreover, the federal test looks to the watercourse's **ordinary and natural** condition - not its condition when altered by human activity. The fact that floating of logs, boating, and fishing occurred is probative of **navigability** under the federal test: it does not become evidence of **non**-navigability merely because it was not commercial. Nor does the federal test create any presumption of non-navigability merely because a rivers was not regulated under the rivers and harbors act, or because travel near the watercourse was customarily done other than by boat. The test is susceptibility for use in travel, not whether the watercourse was regulated under other laws or whether boats were the preferred mode of travel.

4. A bar on consideration of: a) previously appropriated water as being within the ordinary and natural condition; b) use of ferries; c) fishing from the banks; d) use under flood conditions. ARS §37-1128.E. There is absolutely nothing in the federal test that allows these types of exclusions. Federal law looks to whether the watercourse was navigable in fact - it does not impose artificial restrictions on what can be considered in making that determination. For example, federal courts have explicitly relied on ferry travel as evidence of navigability. City of Centralia v. FERC, 851 F.2d 278 (9th Cir. 1988). They also routinely consider evidence of actual boating and fishing use, and do not bar such evidence based on the conditions or location of use.

5. A requirement to considers dams and diversions and other human uses as part of the ordinary and natural condition of the watercourse. Such a requirements is not a part of the federal test, and conflicts with the plain meaning of the word "natural."

For all the foregoing reasons, any determination of non-navigability by this Commission under the tests set out in ARS §37-1128 will have no legal validity or persuasive value in establishing ownership of streambeds. Accordingly, we urge the Commission to: a) suspend further proceedings to determine navigability or non-navigability of watercourse; b) refrain from making any findings or recommendations on navigability or non-navigability; and c) advise the legislature that there is no point in conducting further proceedings or making findings and recommendations unless and until the standards for determining navigability in ARS 37-1128 are changed to accurately reflect federal law.

DATED this 18th day of February, 1997.



David S. Baron
Assistant Director
Arizona Center for Law
in the Public Interest
1840 E. River, Suite 207
Tucson, AZ 85718
(520) 529-1798

TAB 2

ORIGINAL

Central Arizona Paddlers Club
Boating Survey of Arizona Rivers
1992

RECEIVED 6-10-96

(Approximately 20% of our membership responded to the survey.)

River	Segments our members have boated
Salt	K&M Mine to Hwy. 60
	→ Alma School Rd. to Mill Ave. (Mesa/Tempe)
	Hwy. 60 to Roosevelt Lake
	→ Granite Reef to McKellips Rd. (Past Tri-City Landfill)
	Saguaro Lake to Granite Reef (Tuber's Run)
	Hwy. 60 Bridge to Hwy. 288 Bridge (Bridge to Bridge)
	Upper Salt
	Lower Salt
	Horseshoe Bend
	→ 100% of Salt River including normally dry & lakes
	→ All Sections
	→ Country Club Rd. to 35th Ave.
	→ Source to Phoenix
	→ Granite Reef to Gilbert Road
	→ Lower Salt through town
	→ Upper, Middle, Lower, and In Town
Verde	Perkinsville to Clarkdale
	Camp Verde to Childs
	Beasley Flats to Childs
	Childs to Horseshoe Lake
	Rio Verde to Salt River
	Camp Verde to Sheep Bridge
	Needle Rock to Beeline Hwy.
	Lower Verde
	Upper Verde
	Camp Verde to Beasley
	Needle Rock to Salt River
	Horseshoe Lake to Salt
	All of Verde from Camp Verde down
	All Sections
	Camp Verde to Horseshoe Lake
	Clarkdale to Horseshoe Lake
	Between Horseshoe and Bartlett and below Bartlett
East Verde	Doll Baby to Verde to Horseshoe Lake
San Pedro	Palominas to Hereford Rd.

Agua Fria	Black Canyon/New River Area
	Black Canyon City to above Lake Pleasant
Gila	Gila Box
	115 Ave. in Phoenix to Estrella Parkway
	91st Ave. in Phoenix (Salt River) to Estrella
	Mineral Springs to Ashurst Hayden Dam
	Old Bridge (near Clifton) to Safford (Gila Box)
	Confluence of San Francisco to Safford
	San Carlos Dam to Ashurst Hayden Dam
	10 miles above Winkelman to Winkelman
	Most of the Gila (dry parts too) through Arizona
	Winkelman to Ashurst Hayden Dam
	Winkelman to Kearny
	Gillespie Dam to Painted Rock Dam
	Below San Carlos Dam
	Clifton to Solomon, Arizona (Gila Box)
	Clifton to Safford
	Christmas to Winkelman
San Francisco	New Mexico to Clifton
	Clifton to Confluence of Gila
Colorado	Lee's Ferry to Phantom Ranch
	Diamond Creek to Pierce's Ferry
	Lee's Ferry to Pierce's Ferry
	Grand Canyon
	Below Hoover Dam
	Through Topock Canyon
	Hoover Dam to Yuma
	Parker to Lake Havasu
	Topock to Lake Havasu
	Below Hoover Dam (Black Canyon)
	Parker Dam to Martinez Lake
	Glen Canyon to Lee's Ferry
	All Sections
Little Colorado	
Blue	
Black	Bonita Creek to Black River Crossing
	Point of Pines to Salt River
	Source to Salt

White	Indian Reservation to K&M Mine Road White River Crossing to Salt River
Sycamore Creek	Hwy. 87 Bridge to Sugarloaf Mountain
Tonto Creek	Gisela to south of Jake's Corner Rye Creek to Roosevelt Lake Gisela to SRP Gauge Gisela to Roosevelt Tonto Box Rye Creek to Jake's Corner
Bonita Creek	Tonto Creek to Black River
Cherry Creek	
Fish Creek	
Burro Creek	
Indian Bend Wash	

TAB 3

ORIGINAL

RECEIVED 9-19-97

RICHARD A. FRIEDLANDER
WILLIAM NOVOTNY
GARY L. BIRNBAUM
PETER A. WINKLER
MICHAEL R. SCHEURICH
LES RAATZ
BRIAN M. MUELLER
P. BRUCE CONVERSE
JAMES T. BRASELTON
LEONCE A. RICHARD
DAVID J. OUIMETTE
MARK J. ROBENS
MICHAEL D. HOOL
FRANKLIN D. DODGE
SCOT L. CLAUS
DANA M. LEVY
DAVID I. THOMPSON

GERALD GAFFANEY
MICHAEL S. RUBIN
ROBERT A. SHULL
ROBERT V. KERRICK
FRED C. FATHE
ANDREW L. PRINGLE
ANNE L. TIFFEN
TERRY L. TEDESCO
LESLIE A. KRESIN
SCOTT A. HOLCOMB
D. SAMUEL COFFMAN
KENNETH A. HODSON
ROBERT L. SCHWARTZ
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WRITER'S DIRECT LINE

285-5024
OUR CLIENT NUMBER
3864-2

September 19, 1997

VIA HAND-DELIVERY

Christina Waddell, Executive Director
State of Arizona Navigable Stream
Adjudication Commission
1700 W. Washington, Room 404
Phoenix, AZ 85007

Re: **Historic Evidence Regarding Statewide Water Course Non-Navigability**

Dear Christina:

On behalf of our clients, various insureds of Chicago Title Insurance Company, we are submitting the following evidence for use and consideration by the Arizona Navigable Stream Adjudication Commission ("ANSAC") in connection with its determinations/recommendations with respect to navigability on the various watercourses which the Commission is addressing pursuant to its authority under A.R.S. § 38-431.01, et. seq.:

1. Seven (7) copies of the relevant portions of a document entitled "Map of the Navigable Waterways of the United States." This map, dated December 14, 1914, was prepared by the Chief of Engineers, USA. We have enclosed copies of both the legend to the map and that portion relating to the State of Arizona. As is readily apparent from examination of the legend and the portion with regard to the State of Arizona, by failing to identify any watercourse in the Arizona with any of the colors indicated in the legend, the Chief of Engineers has indicated his determination that none of Arizona's

waterways were deemed to be "navigable" in accordance with the definition utilized by the Chief of Engineers for purposes of preparing the map.

2. Seven (7) copies of a map entitled "Official Map of the Territory of Arizona" compiled by Richard Gird, C.E. Commissioner, dated October 23, 1864. This map is of significance in that it depicts the alignment of various watercourses at or about the date on which the Territory of Arizona was created. In addition, the members of ANSAC should note that the map contains a specific reference to the "present head of navigation" and "supposed head of navigation" at two locations on the Colorado River in the northwest corner of the then-Territory. Those two notations with regard to navigability are in stark contrast to the absence of any other indications of navigability with respect to the balance of the waterways in the Territory.[1]

We appreciate your assistance in making copies of both of these maps available to the members of ANSAC.

Very truly yours,

MARISCAL, WEEKS, McINTYRE
& FRIEDLANDER, P.A.

By _____
James T. Braselton

JTB/tg
Enclosures
cc: Richard Marsh (w/out enc.)
Burt Levinson (w/out enc.)
F:\USERS\JTB\-L3864.WAD

[1] For ease of reference, we have highlighted the two notations with regard to navigation in yellow.

ORIGINAL

MAP
OF THE
NAVIGABLE WATERWAYS
OF THE
UNITED STATES
SHOWING IN COLORS THE DEPTHS OF PROJECTS ADOPTED BY CONGRESS

Prepared under the direction
of the
CHIEF OF ENGINEERS, U.S.A.
December 1914

Scale 50 Miles to 1 Inch

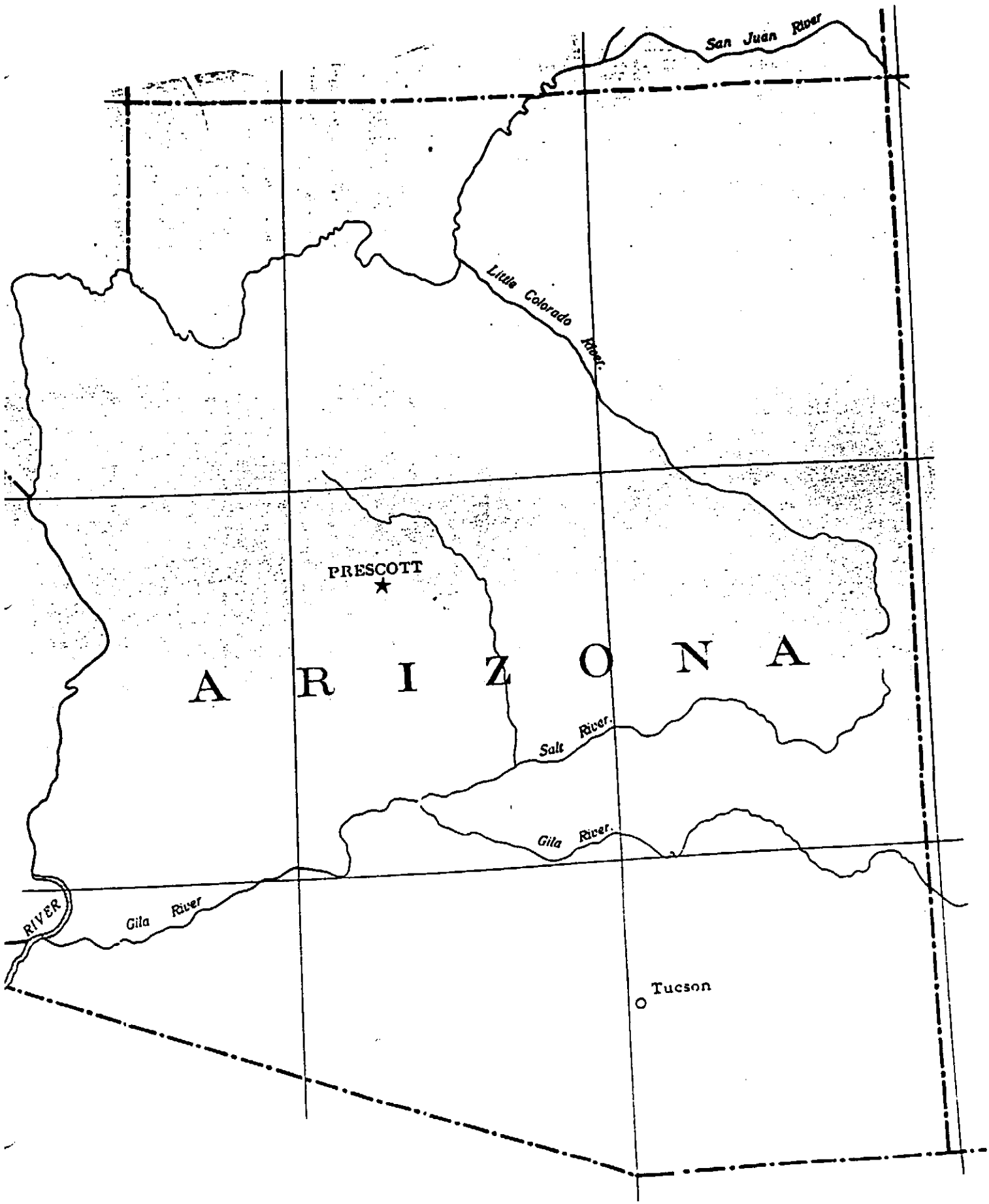
50 0 50 100

LEGEND

- Less than 6 feet deep
- 6 feet to 12 " "
- 12 " " 18 " "
- 18 " " 30 " "
- 30 " deep and over
- Dams completed
- " under construction
- " projected

29°
27°
25°
23°

ORIGINAL


San Juan River
Little Colorado River
PRESCOTT
A R I Z O N A
Salt River
Gila River
RIVER
Gila River
Tucson

TAB 4

ORIGINAL - RECEIVED 7-22-96

Winkelman Natural Resource Conservation District

96 - 004 - 001
SAN PEDRO
RIVER

July 17, 1996

Navigable Stream Adjudication Commission
1700 West Washington
Room 404
Phoenix, AZ 85007

Re: Statement Re: San Pedro River

To The Commission:

This statement is made on behalf of the Winkelman Natural Resource Conservation District, an agency of the Arizona State Land Department.

Our membership is composed of ranchers, farmers and other agricultural related persons. Many of our members have lands along the San Pedro River. It is the overwhelming consensus that the San Pedro River has never been a "navigable" waterway. Personally, my own family settled outside of Mammoth, Arizona in the 1880's, and a portion of our ranch is on the San Pedro. In all my family history there has never been a report of the San Pedro being used as a navigable waterway.

This issue was discussed this date at the quarterly meeting of the WNRCD, with approximately 30 people in attendance. The membership agreed to submit this letter as part of the evidence you will review concerning the San Pedro River. If you have any questions, please contact me.

Sincerely,

Virgil E. Mercer

Virgil E. Mercer
Chairman

Virgil E. Mercer, Chairman, P.O. Box 158, Mammoth, AZ 85618
Voice (520) 487-2431, Fax (520) 487-2270

TAB 5

33d Congress, 2d Session. | SENATE. | Ex. Doc. No. 78.

96 - 004 - 002
SAN PEDRO RIVER
001

ORIGINAL

RECEIVED 10-10-90

REPORT:

OF

EXPLORATIONS AND SURVEYS,

TO

ASCERTAIN THE MOST PRACTICABLE AND ECONOMICAL ROUTE FOR A RAILROAD

FROM THE

MISSISSIPPI RIVER TO THE PACIFIC OCEAN.

MADE UNDER THE DIRECTION OF THE SECRETARY OF WAR, IN

1853-4,

ACCORDING TO ACTS OF CONGRESS OF MARCH 3, 1853, MAY 31, 1854, AND AUGUST 5, 1854.

VOLUME I.

WASHINGTON:
BEVERLEY TUCKER, PRINTER.
1855.

Exhibit 1

The region between the Rio Grande and the Pimas villages on the Gila, just above which point the latter leaves the mountain region, may be described as a great plain, interrupted irregularly and confusedly by bare, rugged, abrupt, isolated mountains or short ranges, around or through the passes in which a railroad may be constructed with quite practicable grades. The mean elevation of this plain, or series of basins into which the ridges divide it, is about 4,100 feet; the mean elevation of the summits of the passes through the ridges is 4,700 feet, the highest, through the Chiricahui range, being 5,180 feet. Except through the passes, the surface is so smooth as to require but little preparation to receive the superstructure of a railroad; and even in the two most difficult of the passes, the natural slope of the ground may be used for a railroad until the construction of the road reduces the cost of materials and supplies to the lowest rates. In one of these two passes (the Chiricahui) the steepest natural slope is 194 feet per mile for 2¼ miles. In the second pass the steepest natural slope is 240 feet per mile for three-fourths of a mile. Both these grades are within the power of a thirty-ton engine, carrying 200 passengers and baggage.

In one case deep cutting in rock, or a tunnel near the surface, at the summit, with heavy side cutting and high embankments for short distances; and, in the other, a short cut of 60 feet, probably through rock, are proposed by Lieut. Parke, to attain grades of 45 feet and 90 feet per mile, or less by increasing distance.

The great difficulty experienced in crossing this district is in the long distances over which no water is found at certain seasons. The survey by Lieut. Parke was made during the dryest season of the year, and, irrespective of the springs found at intermediate points, the whole distance between the two rivers, Rio Grande and Gila, may be divided into five spaces, varying from 80 to 53 miles in length, at the termination of which large permanent supplies of water are found at the most unfavorable season of the year.

These spaces and points are—

From the Rio Grande to the Rio Mimbres	71 miles.
From the Rio Mimbres to the stream of the Valle de Sauz	72 "
From the Valle de Sauz to the San Pedro	80 "
From the San Pedro to Tucson	53 "
From Tucson to the Gila	79 "

Not counting the stream of the Valle de Sauz, the distance from the Rio Mimbres to the San Pedro is 152 miles; which distance is not so great that railroad trains could not cross it without water, special arrangements having been made for the purpose. But this is the worst aspect of the case. At other seasons the supply of water is more abundant, and lakes and ponds are formed upon the plains, which may be drained into tanks; and the geological formation is such as to indicate the existence of sufficient supplies of water beneath the surface, which may be brought to it by artesian wells.

The line proposed by Lieut. Parke leaves the Rio Grande near Fort Fillmore, 35 miles from Molino, between which points the river, where confined to one channel, is about 300 yards wide, crosses the district just described, and enters the valley of the Gila near the Pimas villages, the elevation above the sea being 1,365 feet. The route then follows this river to its junction with the Colorado, a distance of 223 miles, with a general slope of 5.6 feet per mile. The Gila, in this distance, flows through a plain with occasional mountains, ridges, and peaks; its valley is highly favorable to cheap construction from its generally smooth surface, and from not being liable to freshets.

From the point now attained, the nearest port in our territory is San Diego, but the passes of the intervening Coast range are very difficult, if not impracticable, and the route is forced northward to the San Gorgonio Pass, which is much the most favorable of the passes in the Coast range explored by Lieut. Williamson for this route. It is an open valley, from two to five miles wide, the surface smooth and unbroken, affording, in its form and inclination, every facility to the building of a railroad. The entrance of this pass is 133 miles from the mouth

33d Congress, 3d Session. } HOUSE OF REPRESENTATIVES. { Ex. Doc. No. 91.

96 - 004 - 002
SAN PEDRO RIVER
002

ORIGINAL

RECEIVED 10-10-96

REPORTS

OF

EXPLORATIONS AND SURVEYS,

TO

ASCERTAIN THE MOST PRACTICABLE AND ECONOMICAL ROUTE FOR A RAILROAD

FROM THE

MISSISSIPPI RIVER TO THE PACIFIC OCEAN.

MADE UNDER THE DIRECTION OF THE SECRETARY OF WAR, IN

1853-4,

ACCORDING TO ACTS OF CONGRESS OF MARCH 3, 1853, MAY 31, 1854, AND AUGUST 5, 1854.

VOLUME II.

WASHINGTON:
A. O. P. NICHOLSON, PRINTER.
1855.

Exhibit

analogous to a meteoric mineral that I described as forming the chief part of the Bishopsville (S. C.) meteoric stone. It is this feature that makes your iron entirely peculiar. To see this trait, you have only to polish a little surface, and etch with hydrochloric acid, when the surface becomes speckled over with the white earthy mineral, imparting to it a porphyritic character; but to see this *well*, will require the aid of a microscope.

"Large quantities of the white mineral remain undissolved after the solution of the main mass in the acid; and floating among the residuum may be seen also a dark gray flocculent matter, which I took to be the meteoric mineral I have named Dyslytite. Much of the white earthy mineral is thus seen to be in grains, perfectly rounded; some of which are transparent and resemble hyalite; other portions of them are milk-white and nearly opaque. These last are soft, and precisely resemble chladnite."

February 22.—Again got under way, starting about noon; but, instead of taking the emigrant route via the mission of San Javier del Bac to the Cienega de los Pimas, thereby making a great détour, travelling first south, and then due east, we took a course direct for the gap, there intervening apparently a smooth and uniformly ascending plain; camped without water, but an abundance of grass. The officers of the garrison, and Inspector General Gomez, accompanied us to the camp; thus adding another to the list of polite attentions and serviceable offices rendered us by these gentlemen, for which we are under many obligations.

February 23.—Soon after leaving camp this morning, we were compelled to diverge from our course, owing to the thick growth of cactus, and were finally compelled to cut a road through it. Reaching the emigrant road, we turned almost due east, and travelled over an undulating country, the swells increasing as we neared the entrance of the gap, where we encountered a cañon debouching from this pass and opening out into a broad drain or valley to the northwest. Entering this cañon we commenced its ascent, travelling through deep and heavy sand, alternating with contracted meadow patches, hemmed in by walls, approaching verticality, of irregular, shapeless masses of rock, generally of a metamorphic character; limestone, granite, copper-green, and a pudding-stone, all being found without any marked characteristics or apparent order of superposition. Camped at the first water, with grass and wood, having made 18.4 miles.

February 24.—Made an examination of the country adjacent to the camp, and found that this cañon is the main drain of the gap or depression, and that the slopes on either side are rough and broken up by deep ravines and washes. Our teams started at nine and a half, and were soon forced to the hills by the narrowing of the cañon, rendering it impassable for wagons without much labor bestowed on removing the obstacles. Avoiding this cañon by a rough and rugged road, we again entered the valley, and thus continued through long, smooth meadows, and over rough and steep pitches (fortunately not high) for nine miles, when we ascended the table-land on our left and commenced the approach to the divide, following a set of wagon-trails. On the table-land had a good road over a red gravelly soil of decomposed igneous rock, yielding a rich growth of grama grass, which, although not in season, is nevertheless very nutritious, being perfectly cured hay, standing as it grew. Camped near the divide between the waters of the Tuczon and those of the San Pedro, without water and but little wood, having made 13.5 miles.

February 25.—Last night was cold and squally, a rain setting in immediately after dark. Started early and soon made the summit of the divide, whence we had a view of the San Pedro valley—a dry, parched-looking plain, bounded on the east by a low, bare ridge, beyond which loomed up in the blue distance the Dos Cabezas, the most striking and prominent landmark in this region. The trail bearing too much to the south, we left it, and turning eastward descended to the San Pedro, where we camped. From the summit there is a gradual slope to the valley proper, or bottom, which we entered by an abrupt descent of about sixty feet. This bottom is bounded on both sides by an irregular zigzag step, much indented by deep washes, and is at this point about three miles wide. It is covered with a growth of grass, now dry and

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

February 26.—Started down the stream about two miles to the ford, Lieutenant Stoneman having despatched a fatigue party to improve it; but in spite of this and the great exertion of Lieutenant S., we had no little trouble in effecting a crossing. There being no trail leading eastward from the river, the party again encamped, while I started to examine the several gaps in the ridge on our front. Leaving the river-bottom, we followed up a lateral valley; but finding it narrowing as we advanced, becoming a tortuous dry sand-bed or arroyo, bounded by steep slopes, we took to the table-land; and after a few miles of rough riding reached the gap immediately to the east of our camp, and found it not only impracticable for our wagons, but presenting no advantages for our profile beyond the mere direction. We then skirted the western base of this ridge southerly, and found a cañon leading directly through it, with walls of rounded masses of granite, which formed in many places, also, quite a step-like bottom. Passing through this cañon, we continued on the east slope, southward, and found that the ridge terminated, leaving a very inviting and apparently feasible pass between it and the terminus of an overlapping ridge from the south. In this pass we found comparatively fresh wagon-trails. Returned by following these trails to the river, and thence down to camp, arriving at midnight with our mules broken down.

February 27.—Lieutenant Stoneman and myself examined the fourth gap on the north of those examined yesterday, through which I am now satisfied that Mr. Nugent must have passed. We found the approaches difficult and hazardous to attempt with loaded wagons, according well with Mr. Nugent's notes: "a succession of steep hills and rocky ravines."

From the river bottom to the base of this ridge extends a foot-slope, appearing as if once smooth and of uniform ascent, but now cut up into a perfect labyrinth of washes and gullies, ramifying and branching into a multitude of arms as we ascend. Returning to camp, I determined to take the gap through which we passed last night. Packing up, we followed the river until striking the wagon trails, then turned eastward up a large sandy ravine, and camped at sundown without water, but a sufficiency of grass. Made fourteen miles.

February 28.—Left the ravine near the mountains, the road leading over a smooth, rolling, prairie-like surface through the pass, the summit of which we reached at 11 o'clock. Before us lay an extended plain, in the middle of which is the Salt lake, Playa de los Pimas, and beyond this the Chiricahui ridge, with its lofty Dos Cabezas; to the north the massive Mount Graham, with an apparently continuous ridge extending northwestward till lost below the horizon. Between this ridge and that over which we have just passed there is a wide opening towards the mouth of the San Pedro, apparently a continuation of the plain Playa de los Pimas. To the north of the Chiricahui ridge is a wide gap between it and Mount Graham; and immediately to the south of the Dos Cabezas is a third gap, Puerto del Dado, which is very inviting, and, lying directly on our course, I determined to travel through it.

From the summit we had a perfectly smooth road over a reddish soil, covered with grass, and devoid of trees with the exception of a few scattering palmettos down to the Playa, which, at present, is a hard, smooth, and apparently level area of about fifteen miles in length by nearly ten in width, without a particle of vegetation, it being the perfection of sterility. These playas, in my opinion, have no outlet, and are so nearly level that the rain and drain waters are spread over a large surface; and there being but little absorption and very rapid evaporization, it is left smooth and baked. In some places it is much cracked, and covered by a nitrous efflorescence, which gives rise to the ordinary name for all like places—"Salt lake." On the Playa we crossed two very large trails leading from south to north, doubtless those of

face, or mesa, has an average altitude above the river-bottom of three to six hundred feet, and is connected with it by an irregular slop of a loose, light soil, extending to a point opposite, and a short distance below Fort Fillmore, where, in place of the deep-washed, loamy slope, is found an outcrop of a black, igneous rock, with a foot-slope of its angular debris. To descend to the river-bottom will require a diagonal trace, hugging the mesa slope, until a distance is made sufficient to overcome the difference in altitude; the direction of this depending upon location of route to the eastward, whether leaving the valley at the pass near Doña Ana, or on the south at El Paso.

The supply of timber along the route is very limited. Cotton-wood, the only growth of size sufficient to answer the purposes of sills, is found in but four localities; on the Gila, at Tucson, on the Mimbres, and Rio Bravo. Water being so essential to the very existence of this tree, it only grows on the banks of streams, and disappears with the sinking of the waters, as is the case at Tucson and Rio Mimbres. At Tucson I was informed that a variety of the pine is found in the cañadas of Sierra de Santa Catarina to the east and northeast of the town. In the mountains, about fifteen or twenty miles north of the crossing of the Mimbres, the pine also exists. But the plains are entirely destitute of trees of any description, and the mountains have a general appearance of sterility and ruggedness, yielding in the concealed nooks and valleys a meagre growth of cedar and dwarfish evergreen oak.

The rocks are generally of a metamorphic character, but there is found at many points along the line stone answering well the purposes of construction. Granite appears in the Cienega de los Pimas, in the ridge to the east of the San Pedro, outcropping in the Puerto del Dado, and overlying masses of secondary limestone in the ridge east of the Valle de Saux. Sandstone and limestone are both found in the Puerto del Dado. Near the Rio Bravo both limestone and gypsum are found, the veins or seams of the anhydrous variety of the latter being exposed in the clayey walls of the ravine leading down to the river.

There is a great scarcity of water along the line, there being but nine localities where the supply could be said to be permanent. These are: 1st, at Tucson—a clear running stream, but disappearing a few hundred yards below the town; 2d, in the Cienega de los Pimas—fine springs, but the water soon sinks into the sand, as is the case at camp No. 16; 3d, the Rio San Pedro, a turbid stream, winding its way to the Gila; 4th, a spring near camp No. 22, in the Puerto del Dado—the water cold and very palatable, but the supply very limited, our animals having entirely exhausted the basin before they had a sufficiency; 5th, in the bottom of the Valle de Saux—a stream of clear but slightly brackish water, spreading out into a marsh and extending towards the Gila in a succession of pools; 6th, a hole near camp No. 25, where, although the water rose in the bottom, still every other feature would indicate that a blind drain of mere surface-water had been tapped; 7th, the Ojo de Vaca—a spring of slightly sulphureous water, rising in the open plain and forming a marsh, beyond the limits of which there is no appearance or indication of the existence of water; 8th, Rio Mimbres—a rippling mountain stream of clear cold water at the crossing, being the more beautiful from the contrast with the state of things a few miles below, where the water is absorbed by the parched plain, the trees disappear, and there is nothing left but the dry, gaping bed; 9th, Cook's spring—is of similar character to the Ojo de Vaca, and bears more of a resemblance to a pond-hole than to a spring.

In addition to the above constant waters, there are holes or depressions on the plains intervening, which are filled by the rains of the wet season, and thus often afford relief to the anxious and solicitous traveller. These holes are lined with a clay allowing but little absorption; but, being generally shallow and broad-surfaced, evaporization soon empties them of that necessary which one requires, but has to be deprived of in order fully to appreciate it.

At Tucson the rainy season commences in April, and continues for three or four months; so that the emigrant who passes this point during the summer months finds himself in this country in the most favorable season with water abundant and grass green and nourishing, whereas we were there, and *en route*, about the end of the dry season, as our experience proved, meeting

IN THE SUPERIOR COURT OF THE STATE OF ARIZONA

IN AND FOR THE COUNTY OF MARICOPA

96 - 004 - 002
SAN PEDRO
RIVER
003

ORIGINAL RECEIVED 10-12-96

MARICOPA COUNTY, et al. and ARIZONA CENTER FOR LAW IN THE PUBLIC INTEREST, et al., and CALMAT CO. OF ARIZONA, et al.,

Plaintiffs-Intervenors,

vs.

STATE OF ARIZONA, ARIZONA STATE LAND DEPARTMENT, M. JEAN HASSEL, and MILO J. HASSELL, et al.,

Defendants.

NO. C 569870

DEPOSITION OF JIM SLINGLUFF

NOVEMBER 23, 1987

TUCSON, ARIZONA

BOULEY, SCHLESINGER, DI CURTI & SCHIPPERS
Registered Professional Reporters
601 Pioneer Plaza
100 North Stone Avenue
Tucson, Arizona 85701
(602) 623-7573

Exhi

A This are my mine, but I focused in on the, I would use that as my base mark, the six class thing.

Q The International Rating Scale?

A Correct.

Q I wonder if you can tell me -- most of these streams if not all of the streams that you've included in your affidavit and that we have talked about here today are in at least north-central Arizona. Are there any streams in southern Arizona that you canoe at all?

A I have had, now I have had my eye on the San Pedro, the section that the feds just took control of for their project down there between -- what is it -- it is from Sierra Vista to Bisbee. I have scouted that at a couple points, and I believe it's boatable by my level of boating. But I have not in fact boated it.

Q Can I stop you and ask you to either use this map or some other map --

A Use this map.

Q -- and just try to describe generally for the record -- since this isn't an exhibit, maybe you can show me where that is.

MR. KOLSRUD: For the record, you are referring to the Arizona Highway Map?

THE WITNESS: Yes.

AFFIDAVIT

ORIGINAL

RECEIVED 10-10-96

96 - 004 - 002
SAN PEDRO
RIVER
004

STATE OF ARIZONA)
) ss
County of Pima)

My name is James Anthony Slingluff. I have twenty-two years of canoeing experience. I have canoed extensively in Arizona since 1984.

I have canoed each of the following sections of Arizona rivers on multiple occasions (exceptions noted) and believe each to be very suitable for river travel in the seasons indicated at the boating skill level noted.

1. Salt River:

A. Highway 60 bridge to Horseshoe Bend; all seasons; intermediate boating skills.

B. Horseshoe Bend to Highway 288 bridge; all seasons; beginning boating skills.

C. Stewart Mountain Dam to Granite Reef Dam; subject to dam releases (ordinarily in summer); beginning boating skills.

2. Verde River:

A. Perkinsville to TAPCO power plant (Clarkdale); all seasons; beginning boating skills (except for two particular rapids).

B. Dead Horse Park to Thousand Trails Campground; Fall/Winter/Spring; beginning boating skills.

C. Beasely Flat to Childs; Fall/Winter/Spring; intermediate boating skills.

Exhibit 4

D. Childs to Horseshoe Lake; Fall/Winter/Spring; beginning boating skills.

3. Little Colorado River, Grand Falls to Black Falls; snowmelt, monsoons; beginning boating skills.

4. Wet Beaver Creek:

A. Ranger Station to Montezuma Castle, one trip; snowmelt, monsoons; advanced boating skills.

B. Montezuma Castle to confluence with Verde; snowmelt, monsoons; beginning boating skills.

5. Dry Beaver Creek, Highway 179 to Interstate 17, one trip; snowmelt, monsoons; intermediate boating skills.

6. Oak Creek:

A. YMCA Camp to Page Spring, one trip; snowmelt, monsoons; intermediate boating skills.

B. Page Spring to Cornville; Fall/Winter/Spring; beginning boating skills.

C. Cornville to confluence with Verde; all seasons; beginning boating skills.

I have encountered other recreationists (boaters, hikers, and/or fishermen) on all the aforementioned sections of the Salt, Verde, Little Colorado, Wet Beaver, Dry Beaver and Oak Creek.

Further affiant saith not.

Dated this 15 day of July, 1987.

James Anthony Slingluff

Subscribed and sworn to before me this 15th day of July, 1987.

Leta R. Chapman

Notary Public

My commission expires: My Commission Expires February 5, 1989

96 - 004 - 002
SAN PEDRO
RIVER
005

ORIGINAL

ARIZONA CENTER FOR LAW IN THE PUBLIC INTEREST

1840 East River Road
Suite 207
Tucson, Arizona 85718-5892
(520) 529-1798
FAX (520) 529-2927

RECEIVED
10-10-96

October 10, 1996

BY FAX (602) 542-9220

Chistina Waddell
Stream Adjudication Commission
1700 West Washington, Room 404
Phoenix, AZ 85007

RE: San Pedro River evidence

Dear Ms. Waddell:

We offer the following evidence regarding navigability of the San Pedro River:

1. Government surveys from the 1850's describe the San Pedro as a "permanent" river with a flow about 18 inches deep and 12 feet wide. Exhibit 1 (attached hereto); Exhibit 2.

2. An experienced Arizona river runner believes the San Pedro is currently boatable at times on the stretch from Sierra Vista to Benson. Exhs. 3 & 4.

3. Please incorporate by reference Exhibit 2 from our January 13, 1994 Exhibits Submitted in Admin. Docket No. 94-1 on the Salt River. That Exhibit is a 1978 U.S. Fish and Wildlife Service paper entitled: "Methods of Assessing Instream Flows for Recreation."

Sincerely,

David S. Baron
Assistant Director

Printed on recycled paper.

ARIZONA CENTER FOR LAW IN THE PUBLIC INTEREST

1840 E. River Road
Suite #207
Tucson, Arizona 85718-5892
(520) 529-1798
FAX (520) 529-2927

THE PAGES THAT FOLLOW MAY CONTAIN SENSITIVE, PRIVILEGED OR CONFIDENTIAL INFORMATION INTENDED SOLELY FOR THE ADDRESSEE NAMED BELOW. IF YOU RECEIVE THIS MESSAGE AND ARE NOT THE AGENT OR EMPLOYEE OF THE ADDRESSEE, AND HAVE THEREFORE BEEN SENT OR RECEIVED THIS FACSIMILE COMMUNICATION IN ERROR, YOU ARE ASKED NOT TO DISSEMINATE OR COPY ANY OF THE ATTACHED AND TO NOTIFY THE SENDER IMMEDIATELY BY TELEPHONE. PLEASE ALSO RETURN THE ORIGINAL MESSAGE TO THE SENDER BY MAIL.

DATE: 10/10/96 APPROXIMATE TIME SENT: 1 pm

FROM: David Baron

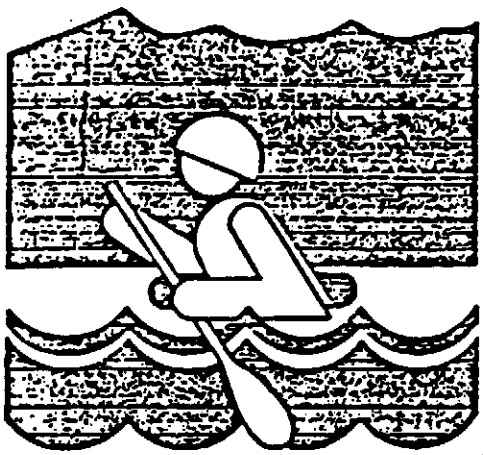
TO:
Christina Waddell 602-542-9220

We are sending you 13 pages including this cover letter. If you do not receive all pages, or if you encounter any other difficulty, please telephone (520) 529-1798 at your earliest convenience.

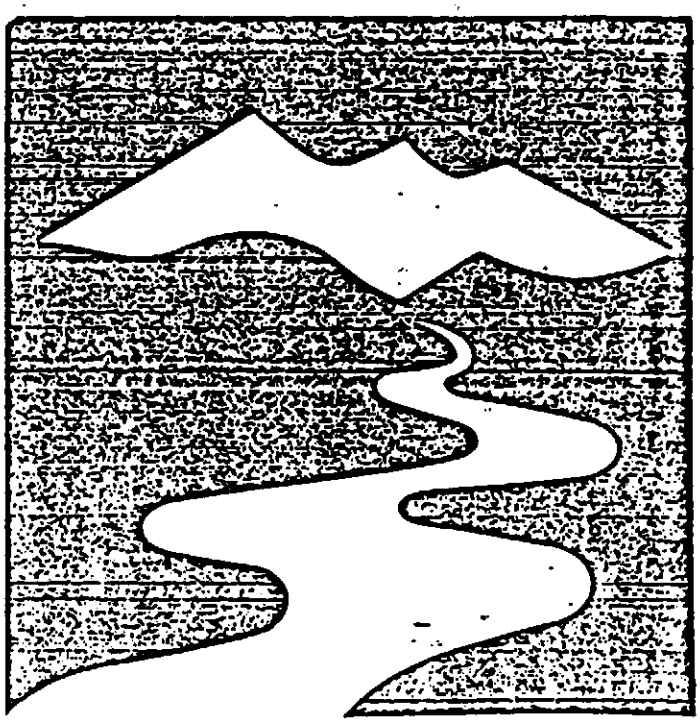
REMARKS:

96-004-002
San Pedro
River
006

ORIGINAL



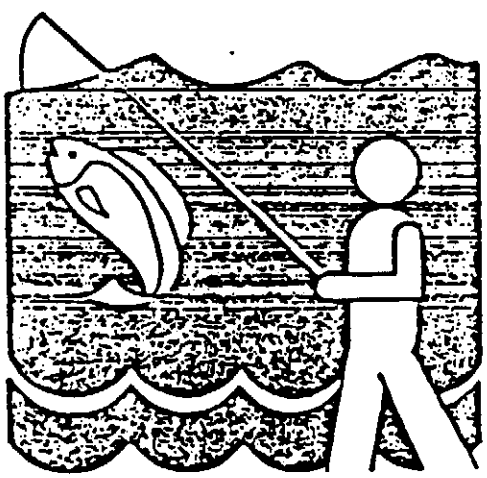
Methods of Assessing Instream Flows for Recreation



COOPERATIVE
INSTREAM FLOW
SERVICE GROUP

INSTREAM
FLOW
INFORMATION
PAPER: NO. 6

FWS/OBS-78/34
JUNE 1978



Cooperating Agencies:

Fish and Wildlife Service
Environmental Protection Agency
Heritage Conservation and Recreation Service
Bureau of Reclamation

FWS/OBS-78/34
June 1978

METHODS OF ASSESSING INSTREAM FLOWS FOR RECREATION

Instream Flow Information Paper No. 6

by

Ronald Hyra[1]
Cooperative Instream Flow Service Group
Creekside Building
2625 Redwing Road
Fort Collins, Colorado 80526

This study was financed in part through the Water Resources Council under provisions of the Federal Non-Nuclear Energy Research and Development Act of 1974

Cooperative Instream Flow Service Group
Western Energy and Land Use Team
Office of Biological Services
Fish and Wildlife Service
U.S. Department of the Interior

[1]Detailed to the Cooperative Instream Flow Service Group from the Heritage Conservation and Recreation Service.

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ABSTRACT

The Instream Flow Group (IFG) has conducted research into methods of quantifying instream flow needs for fish, wildlife, and recreation. This paper describes two techniques developed by IFG for performing recreational instream flow studies. The single cross section method is relatively simple and provides a base flow figure which will provide for the boating activities which make use of the of river. The incremental method is more sophisticated and may be used to develop recommendations regarding streamflows required for various types of recreation, or to provide a recreation analysis of any streamflow. Streamflow suitability criteria for recreation are presented for both methods.

INTRODUCTION

It has been long recognized that there are many competing demands for the use of stream water. Diverting stream water for irrigation, water supply, and energy developments can deplete streamflows to the point where opportunities for recreation and the associated environmental values of the stream are seriously impaired. Numerous water planning studies, both basin-wide and project oriented, have emphasized the need to quantify the amount of water required to support recreation, fish and wildlife resources, and to maintain aesthetic conditions.

The tools and techniques for estimating streamflows required for recreation and aesthetics, and for insuring reasonable consideration of recreation and aesthetics in the allocation of stream water, are currently undergoing study. Instream flow requirements and values for recreation, in the past, have often been based only upon the amount required to maintain a fishery. However, several studies have indicated that recreation and aesthetic requirements, at times, may not be the same as for a fishery.

This paper presents the techniques of assessing instream flows for recreation. These techniques were developed by the Cooperative Instream Flow Service Group and closely parallel techniques used to assess instream flows for fisheries. The data collection procedures, the physical and hydraulic simulation of the stream, and the computer models which analyze the data are the same for both fisheries and recreation. The major difference between the two techniques is the response of the individual fish or recreationist to various physical parameters of

stream flow. These responses to stream flow by different user groups are the criteria which are basic to the methods introduced here.

The first method is called the single cross section approach. This method is useful primarily for identifying flows below which a recreation activity is not feasible and results in a so called "minimum" flow recommendation.

The second method is called the incremental method. With this method the recreation planner is able to analyze various flows and determine the recreation potential of a stream at different flows.

This paper is being distributed with four objectives in mind. These are:

1. To bring the problem of preserving instream flows to the attention of recreation agencies and the research community in order to encourage more research in this vital and neglected area.

2. To discuss the development of the recreation probability-of-use curves and of recreation criteria in general, which are necessary for quantifying instream water requirements for recreation.

3. To obtain review and comment on the recreation criteria and probability-of-use curves, and to request data which may be used to test or improve the criteria or curves.

4. To describe the two approaches for assessing stream flows and discuss how various recreation planning processes can be served by their application.

Both methods of instream flow analysis discussed in this paper utilize computer modeling techniques. Both approaches also require that streamflow data be collected. The single cross section approach, as its name implies, requires that information be collected at only one location on the stream. The incremental method requires that data be collected at multiple locations on the stream. In addition to cross sectional data, data relating the streamflow parameters to recreation potential are necessary. These data are termed recreation criteria.

Recreation criteria for instream flow methodologies are the recreation activity information bases necessary to describe a relationship between the quantity of water flowing in a stream, and the quantity and

quality of a particular recreation activity which takes place in the stream.

SINGLE CROSS SECTION METHOD

This method requires that only a single cross sectional measurement be taken across a stream. The product of such an approach is a determination of the lowest flow acceptable for recreation. The approach is based on the assumption that a single cross section, properly located, can define a minimum flow requirement. Such a cross section is located at an area displaying the least depth across the entire stream. When this area provides minimum depths for boat passage, the flow at this level may be defined as a minimum acceptable flow. It is assumed that when sufficient water to support boating is available in these critical areas, other areas will have sufficient water to support most of the other instream recreation activities. This approach is best applied to those streams in which flows are expected to be higher than the minimum most of the time.

Criteria for this approach are set forth in Table 1. Criteria have been developed for boating activities only, but for various types of boating craft. Only minimum criteria are presented because this approach provides information on "minimum flows." Criteria are measured in terms of stream depth and width. Velocity is not considered because a minimum velocity is not considered necessary for this approach.

Table 1. Required stream width and depth for various recreation craft as determined by single cross section method.

Recreation Craft	Required depth (ft)	Required width (ft)
Canoe-kayak	0.5	4
Drift boat, row boat-raft	1.0	6
Tube	1.0	4
Power boat	3.0	6
Sail boat	3.0	25

The criteria of Table 1 are minimal and would not provide a satisfactory experience if the entire river was at this level. However, the cross section measured for this method is the shallowest in the stream reach. Therefore, these minimum conditions will only be encountered for

a short time during a boating trip, and the remainder of the trip will be over water of greater depths and widths. An important assumption is that all water greater than the minimum is equally useful for the activity (i.e., more is better until bank-full stage).

A computer program (IFG-1) has been developed which predicts width and depth across the transect of any stage (water surface elevation). The output shows discharge and the width with depth equal to or greater than a specific depth. Different water surface elevations may be put into the computer model which are translated into flow in cubic feet per second. When a flow provides the minimum width and depth necessary for an activity, discharge may be considered minimum. Such a minimum indicates that significant losses, if not elimination of this activity, will occur if minimum flow is not equaled or exceeded.

THE INCREMENTAL METHOD

This method, more sophisticated than the single cross section method, describes a relationship between the amount of water in a reach of stream and the associated recreation potential. The incremental method can describe the potential for any recreation activity at any streamflow. A major difference between the methods is that the single cross section method can only be used to identify low flow and cannot be used to assess the recreation potential at any other flow; the incremental method can be used to assess the potential at other flows or to calculate the change in receation potential caused by a change in stream flow..

The incremental method involves a modeling procedure whereby the surface area of a stretch of stream is calculated. In addition to the total surface area of the reach of stream, the area which has certain depths and velocities is calculated. The usable surface area for each activity is then calculated by use of depth and velocity requirements.

It is necessary to make three assumptions regarding the relationship between the quantity of water and the recreation uses of the water: (1) water depth and water velocity are the two streamflow components which are most important in determining whether or not a certain recreation activity may be safely and pleasurably engaged in[1]; (2) there are

[1]Other parameters such as water quality and temperature are also very important in determining the amount of instream recreation use but in many cases are not significantly influenced by flow. Width is also important but is considered outside of the computer model (i.e., width is not a part of the calculation of usable surface area).

TAB 6

ORIGINAL

received
10/11/96

96 - 004 - 003
SAN PEDRO
RIVER

503 E Medlock Dr
Phoenix, AZ 85012
542-7331 W

October 6, 1996

Arizona Navigable Stream Adjudication Commission
1700 W Washington; Room 404
Phoenix, Arizona 85007

Re: San Pedro River, navigability

Dear Commissioners:

In response to your request for evidence regarding characteristics of navigability of the San Pedro River, I submit the following information.

I have boated the San Pedro River on one occasion. Accompanying me on this kayak float trip was Dick Juetten. We launched at the Highway 92 bridge crossing at Palominas, takeout point was at the bridge crossing at Hereford Road. (Trip date: August 9th and 10th, 1992). According to personnel we spoke with at the BLM office in Fairbank, the flow of the river on those two days was 12 cfs, a figure that we can confirm. On this trip we dragged our boats about as often as we paddled them. If we had had more time or higher flows that week, we would have boated further north on the river.

From Az Highway 77 I have often observed navigable flows lasting for one or two weeks at a time in the reach from San Manuel to Winkelman during the winter and springtime rainy period. I am certain that these flows also would allow for navigation in the southernmost reaches of the San Pedro River.

The low and unpredictable flows make the San Pedro River difficult, but not impossible, to navigate. However, the San Pedro River is more than "navigable"; it is actually "navigated," albeit infrequently. Boating was an excellent way to monitor water quality and the household trash along the river (especially at the lower end of this reach), and to observe the diverse birdlife in the jungle-like riparian area. I consider the entire length of the San Pedro River as navigable.

Sincerely,

Timothy J Flood

Timothy J Flood

TAB 7

Arizona
State Land Department
1616 WEST ADAMS
PHOENIX, ARIZONA 85007

FIFE SYMINGTON
GOVERNOR

M.J. HASSELL
STATE LAND COMMISSIONER

96-004-005
San Pedro
River
001

December 16, 1996

Christina Waddell
Arizona Navigable Streambeds Adjudication Commission
1700 West Washington, Room 404
Phoenix, Arizona 85007

ORIGINAL

RECEIVED 12-19-96

RE: Streambed Studies Submitted as Evidence

Dear Ms. Waddell:

The Drainage & Engineering Section of the Arizona State Land Department would like to verify that you still have the following documents that were submitted to the previous Commission:

HASSAYAMPA RIVER: Gila River Confluence to Headwaters

SAN PEDRO RIVER: Gila River Confluence to the Mexican Border

VERDE RIVER: Salt River Confluence to Sullivan Lake

All three documents were prepared by CH^{2}MHILL in November, 1993.

If you are unable to locate your copies of these river studies, please contact us immediately so that we may submit additional copies of each document as soon as possible.

Thank you.

V. Ottozawa-Chatupron by SH

V. Ottozawa-Chatupron, P.E., Ph.D
Section Manager
Drainage and Engineering Section

VOC:sh

c:\wp51\strmbeds\lttr1216.sh

STATE OF ARIZONA
NAVIGABLE STREAM ADJUDICATION COMMISSION
1700 WEST WASHINGTON, PHOENIX, ARIZONA 85007
PHONE (602) 542-9214 FAX (602) 542-9220
CHRISTINA WADDELL
Executive Director

96-004-005
San Pedro
River
002

December 19, 1996

ORIGINAL

RECEIVED 12-19-96

V. Ottozawa-Chatupron, P.E., Ph.D.
Section Manager
Drainage and Engineering Section
Arizona State Land Department
1616 West Adams
Phoenix, Arizona 85007

Dear Mr. Ottozawa-Chatupron:

This is written in response to your letter dated December 16, 1996.

The evidence received from the "previous" commission does not contain the following CH_2MHILL reports:

Hassayampa River: Gila River Confluence to Headwaters

San Pedro River: Gila River Confluence to the Mexican Border

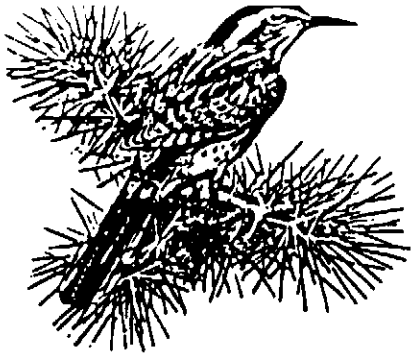
Verde River: Salt River Confluence to Sullivan Lake

The only CH_2MHILL report we received from the "previous" commission is the 1993 Salt River: Granite Reef Dam to the Gila River Confluence. As per your letter, we are requesting that the reports on the Hassayampa River, the San Pedro River and the Verde River be resubmitted to the Arizona Navigable Stream Adjudication Commission office for their inclusion as evidence in the proceedings. If you have any questions, please feel free to call.

Thank you.

Thomas J. Vogt
Research and Statistical Analyst

TAB 8



ARIZONA AUDUBON COUNCIL

Huachuca Audubon Society, Maricopa Audubon Society
Northern Arizona Audubon Society, Prescott Audubon Society
Tucson Audubon Society, Yuma Audubon Society
White Mountain Audubon Society

RECEIVED 1-27-98

ORIGINAL

96 - 004 - 009
San Pedro River

97 - 004 - 004
Santa Cruz River

December 26, 1997

Navigable Stream Adjudication Commission
1700 West Washington Street, Rm. 404
Phoenix, Arizona 85007

Dear Sirs,

The Arizona Audubon Council has researched the navigability conditions of the Santa Cruz and San Pedro Rivers. We have determined that both of these rivers were navigable during the period when Arizona joined the United States of America.

The Arizona Audubon Council requests to be on the mailing list to receive information and updates pertaining to this adjudication process.

Sincerely,

Al Anderson
Secretary, AAC

3305 Eagle Ridge Drive, Sierra Vista, Arizona, 85635 (520) 378-2460 fax (520) 378-2107

TAB 9

RECEIVED 2-9-98

ORIGINAL

96-004-3
San Pedro River

Dear Navigable Stream Comm.

My father came to San Pedro Valley in 1872 they settled on land that was given to the Boquillion Land Co by the King of Spain sometime before 1872. They didnt know the land belonged to Spain when they settled there. So in about 1905 all the Mormons moved to the Gila Valley. "Nearly all" In 1935 I worked for the Forest Service and was in the Cochise Stronghelts and met an old man named Rockefeller who said he was the chief of the Survey Crew who laid out the land Grant He said they surveyed and were weary trying to find the north Boundary of the land Grant. One Morning a man named Curtis rode out to their camp on a mule with a Shotgun. He had built a fence E + W across part of the Valley when he claimed property. He pointed to the fence with the shot gun and Mr Rockefeller heard him say "that is the boundary of the north part of the land Grant." Curtis saved this land and the home of many pioneers in San Pedro Valley. The river in 1872 was about 8 feet wide. after a few years the river is 50 feet wide due to over grazing. I do not think anyone in his right mind would try to make a Navigable Stream anywhere on the Old San Pedro River. Oh! Rockefeller said They were happy to know where the north boundary was and that is where they put the boundary" I am 95 and dont write too good Joseph Nahum Curtis was the man on the mule, my Grandfather brother

Respectfully yr A Ruth Curtis

TAB 10

ORIGINAL

96 - 004 - 011
San Pedro
River

97 - 004 - 007
Santa Cruz
River

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RECEIVED 2-23-96

BEFORE THE
ARIZONA NAVIGABLE STREAMBED ADJUDICATION COMMISSION

IN THE MANNER OF THE NAVIGABILITY OF THE SAN PEDRO, AND SANTA CRUZ RIVERS ETAL.

Admin. Docket No. _____

COMMENTS AND EXHIBITS

The National Encyclopedia, Collier & Son, 1950, Page 370, Vol. 1.

Arizona. The lower reaches of the Colorado River, the western boundary of the state, are its only navigable waters.

Howell v. Johnson et al. 89 Fed. Rep. 556, (1898) Knowles, District Judge:

In the case of Basey v. Gallagher, 20 Wall. 670, The supreme court said in regard to this act: "The act of congress of 1866 recognized the right to water by prior appropriation for agricultural and manufacturing purposes as well as mining;" and also decided that if the right to appropriate water for any of the purposes named was recognized by either local customs, or by the legislation of any state or territory, or by the decisions of the court, it would be sufficient.

...A state, upon its admission into the Union, acquires, by virtue of its sovereign powers, the title to the beds of all navigable rivers, lakes, and tide waters within its boundaries,...This title gives it, to some extent, a control over the waters of such rivers and lakes, and the power to establish and determine what shall be riparian rights...

The idea that there can arise any international water right question in the case of the appropriation of the waters...cannot be maintained. The right to such waters...must always be a question pertaining to private persons.

Arizona Territorial Statutes 1863, Bill of Rights Art. 22; All streams, lakes, and ponds of water capable of being used for the purpose of navigation OR irrigation, ar hereby declared to be public property;...

Revised Statutes 1901 Sect.4174(civil Code): " All rivers, creeks, and streams of running water in the Territory of Arizona are hereby declared to be public, and applicable to the purposes of irrigation and mining as hereafter provided."

TITLE XXI Eminent Domain Sect. 2445 (2);...The right of eminent domain may be exercised in behalf of the following uses: 4. Wharves, docks, ferries,

for public transportation, and for floating logs and lumber on streams not navigable.

Hill v. Lenormand 2 Ariz 354 (1888) Wright, C.J.-...The...plaintiffs... appropriated the waters of the San Pedro river,...As is very generally the case in the Pacific states and territories, the conditions are so changed that riparian rights do not attach. In the case at bar, riparian rights do not apply.

Boquillas v. Curtis 213 U.S. 339 (1908) Mr. Justice Holmes; This is a bill in equity brought by the appellant to prevent the defendants from withdrawing water from the San Pedro River...

It is not denied that what is called the common law doctrine of riparian water rights does not obtain in Arizona...

...In this Territory irrigation was practiced in the Santa Cruz Valley prior to the cession and it is well known the right of appropriation without regard to the riparian character of the lands was there in force probably from the time when the Spaniards first settled in the valley. Our statutes, as well as those of New Mexico, seem to have had their origin in the Mexican law as modified by custom.

I will present something at this time that may not seem relevent, except for GAT, and NAFTA, in which the Federal Government gave away water rights to Mexico it may not have held title to. Water Rights of the Western States, Bancroft-Whitney Company (1911) Vol.I, Page 221: The case (Boquillas V. Curtis) is an unequivocal decision in support of the Colorado doctrine so far as it affects the rights of riparian proprietors:...if riparian rights do not exist, the United States has no more right to waters on its lands than other land owners.

Blackstone, Modern american Law, Vol.VI, (1917) Page 47,49: Property is the right of a person to a thing and consists in the right of use or enjoyment of the thing and the disposal and transfer of the same right to others. Rights to the use of water acquired by appropriation come within this definition. Indeed, the term "right" itself, when used in this connection,imports a property right, and carries with it all the elements of property. 16 Colo. 61

The property right acquired by the appropriation is not in the corpus of the water, but in the incorporeal right of diversion and use, and the right itself is an incorporeal hereditament. 18 Colo. 298

The right is usufructuary: it is a right to divert and use water belonging to the stream and does not attach primarily to the body of the water in the stream. 3 Cal. 249

In December,1846, at the Gila, Lt. George Stoneman decided to perform a naval experiment on that shallow stream. Lashing together some cottonwood logs, he set sail with about twenty-five hundred pounds of food and supplies. He hadn't traveled far when the craft sank. Stoneman went down with his ship, then walked ashore declaring the river unsuitable for navigation. In 1862 Stoneman was made Major General, and was governor of California 1883-87. Diamond in the Rough, Marshall Trimble,1988.

Collier's Encyclopedia, Vol. 11, 1986, Page 99: In the San Carlos Reservation the Gila was dammed (Coolidge Dam) to provide water for irrigation, and there are several other irrigation projects along its lower course. The dam was complete in 1928.

The rest of the streams, washes, lakes, rivers, etc., of this State, are to numerous for me to cite individual case law, at this time. I shall include all of them, and the before mentioned, now.

U.S. v. Rio Grande Irrigation Co. 174 U.S. 690,705,706, (1989): March 3, 1877, an Act, c. 107, was passed for the sale of desert lands, which contained in its first section this proviso, 19 Stat. 377:

...water of all lakes, rivers, and other sources of water supply upon the public lands and not navigable, shall remain and be held free for the appropriation and use of the public for irrigation, mining, and manufacturing purposes subject to existing rights.

...To infer therfrom that Congress intended to release its control over the navigable streams of this country and to grant in aid of mining industries and the reclamation of arid lands the right to appropriate the waters on the sources of navigable streams..., is to carry those statutes beyond what is their fair import permits.

Fletcher v. Peck, 10 U.S. (6 Cranch.)87, (1810)...If an act be done under a law, a succeeding legislature cannot undo it. The past cannot be recalled by the most absolute power.

Supra. 4174; All rivers, etc, in the Territory of Arizona are...applicable to the purpose of irrigation and mining...

ARIZ. CONST. ART.XXII Sect. §1. No rights,...claims,... existing at the time of the admission of this state into the union, shall be affected by a change in the form of government, from territory to state, but all shall continue as if no change had taken place;...

ART. XVII §1. The common law doctrine of riparian water rights shall not obtain or be of any effect in the state.

THE RECORDS OF THE ARIZONA CONSTITUTIONAL CONVENTION OF 1910, November 29, afternoon; Mr Kingan: I would like to ask the gentleman from Maricopa a question. What is the reason for inserting that (ART XVII, §1) in the constitution? It is the law of this territory and has been for forty or fifty years, and it seems to me it is a matter purely segislative.

Mr. Baker: The answer is that it is purely fundamental. If a future legislature should undertake to establish a common law doctrine of water rights in this territory, they could do so. I want it fixed so that no legislature can ever do that thing.

There may be riparian rights,even if there are no navigable streams in a state, in order to claim a stream bed; but, there can be no claim to navigabilty if riparian rights do not exist. The state may only derive its rights and powers from those that exist in the people.

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Last paragraph my thoughts. RLD

TAB 11

ORIGINAL

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San Pedro
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Arizona Stream Navigability Study for the San Pedro River:

Gila River Confluence to the Mexican Border

DRAFT

Prepared by

CH2MHILL

SWCA Environmental Consultants
Arizona Geological Survey

November 1993

Draft Final Report

Arizona State Land Department
&
Arizona Navigable Stream Adjudication Commission

Preface

This report is the third in a series of four reports prepared for the Arizona State Land Department, which summarize information relating to the navigability of Arizona streams as of the time of statehood. This report documents information relating to the San Pedro River, from its confluence with the Gila River to the Mexico border. Other rivers currently under study include the Salt, Verde, and Hassayampa Rivers. Information presented in this report is intended to provide data to the Arizona Navigable Stream Adjudication Commission from which they will render a decision regarding the navigability of the San Pedro River. This report does not make a recommendation or conclusion regarding title navigability of the San Pedro River.

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

The San Pedro River Stream Navigability Study was performed by CH2M HILL, Inc. and SWCA, Environmental Consultants, Inc. in cooperation with the Arizona Geological Survey (AZGS). The study was completed under contracts #A3-0061 and #A3-0061-001 for the Arizona State Land Department on behalf of the Arizona Navigable Stream Adjudication Commission. Project staff included V. Ottosawa-Chatupron, Arizona State Land Department, Project Manager; J. Fuller, CH2M HILL team leader, hydrologist, and geomorphologist; R. Borkan, SWCA team leader; D. Gilpin, SWCA, historian; M. Cederholm, SWCA, GIS specialist; P. Pearthree, AZGS team leader; G. Huckleberry, geomorphologist. Data summarized in this study were obtained from numerous agencies, libraries, and collections named in the appendixes of this report. Use of this document is governed by the Arizona State Land Department and the Arizona Navigable Stream Adjudication Commission. This document was prepared by CH2M HILL; use or reproduction in whole or in part without the consent of CH2M HILL, or without citation is prohibited.

Executive Summary

CH2M HILL, in cooperation with SWCA Environmental Consultants and the Arizona Geological Survey (AZGS), was retained by the Arizona State Land Department (ASLD) to provide information to the Arizona Stream Navigability Adjudication Commission (ANSAC). ANSAC will use information provided by the CH2M HILL team to make determinations of navigability or non-navigability for four Arizona streams: the Salt, Verde, San Pedro, and Hassayampa Rivers. This report provides information on a portion of the San Pedro River between the Gila River confluence and the Mexico border.

The basic approach to this study was to develop a database of information to be used by ANSAC in making determinations of 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 San Pedro River. For the latter task, public officials from every community, town, city, and county located along the San Pedro River were contacted. The objective of the literature search was to obtain published and unpublished documentation of historical river uses and river conditions. Information collected from agency contacts was supplemented by published information from public and private collections.

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

conditions as of statehood, as well as for existing stream conditions. Geomorphic data provide information on river stability, river conditions as of statehood, and the nature of river changes since statehood.

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

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

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

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

the stream to be boatable. An undocumented account of a ferry operated near Pomerene, is the only evidence for boating on the San Pedro River found during this study.

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

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

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

Currently, private land owners hold title to most of the land along the San Pedro River. The Bureau of Land Management and the State of Arizona are the second largest land owners. Other important title holders include the San Carlos Indian Community and the Nature Conservancy. Land uses along the San Pedro River include grazing, agriculture (orchards and miscellaneous crops), residential, and mining. Most of the river is

undeveloped.

ANSAC's decision whether the San Pedro River was a navigable stream as of statehood hinges on how several questions are addressed. These questions include what duration of flow must be susceptible to boating for the river to be navigable, what types of boating are considered navigation, and how the ordinary highwater mark is defined.

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Chapter 1
Introduction

CH2M HILL, in cooperation with SWCA Environmental Consultants and the Arizona Geological Survey (AZGS), was retained by the Arizona State Land Department (ASLD) to provide information to the Arizona Stream Navigability Adjudication Commission (ANSAC). ANSAC will use information provided by the CH2M HILL team to make determinations of navigability or non-navigability for four Arizona streams: the Salt, Verde, San Pedro, and Hassayampa Rivers. This report summarizes information on the San Pedro River.

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

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

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

Project Background

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

On July 7, 1992, the Governor signed House Bill 2594 (H.B. 2594; A.R.S. 37-1101 to -1156) which established a systematic administrative procedure for gathering information and determining the extent of the State's ownership of streambeds. The main purpose of the Bill is to settle land titles by confirming State or private ownership, and to confirm State ownership in lands located in the beds of streams. This Bill also created the Arizona Navigable Stream Adjudication Commission (ANSAC), a five-member board appointed by the Governor. ANSAC was directed to establish administrative procedures, prioritize

[1] Arizona became a state on February 14, 1912.

Arizona streams to be analyzed, hold public hearings, and adjudicate navigability. The Bill also directs the ASLD to assist determinations of navigability by ANSAC in its investigatory and adjudicatory role, and act as technical support staff for the ANSAC.

For the stream navigability studies, ASLD: a) establishes the procurement process and scope of services for consultant participation; b) appraises land values in navigable streams; c) develops information recording systems; d) develops rules, implementation, and coordination plans; e) surveys navigable stream boundaries; f) establishes processes for the public trust fund, and acquisition and management of riparian lands; g) coordinates the disposition and judicial review processes with the public, the Department, and ANSAC; and h) plans for future expenditures for projects and ANSAC. This study provides supporting data for the San Pedro River.

Definition of Navigability

H.B. 2594 established a definition of navigability for use in the streambed program. The data collection effort for this study attempts to provide information that would enable ANSAC to determine if a given river meets the criteria of the State's definition. The State's definition is:

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

Limit of Study

Stream navigability studies were completed for four Arizona rivers (see Figure 1) including:

- Salt River, from the Gila River confluence to Granite Reef Dam
- Verde River, from the Salt River confluence to its headwaters[2]
- San Pedro River, from the Gila River confluence to the Mexico border
- Hassayampa River, from the Gila River confluence to the headwaters[3]

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

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[2] The headwaters of the Verde River are located at Sullivan Lake, near Paulden, Arizona, at the confluence of Big Chino Wash and Williamson Wash.

[3] The headwaters of the Hassayampa River are located on the slopes Mount Union in the Bradshaw Mountains, south of Prescott, Arizona.

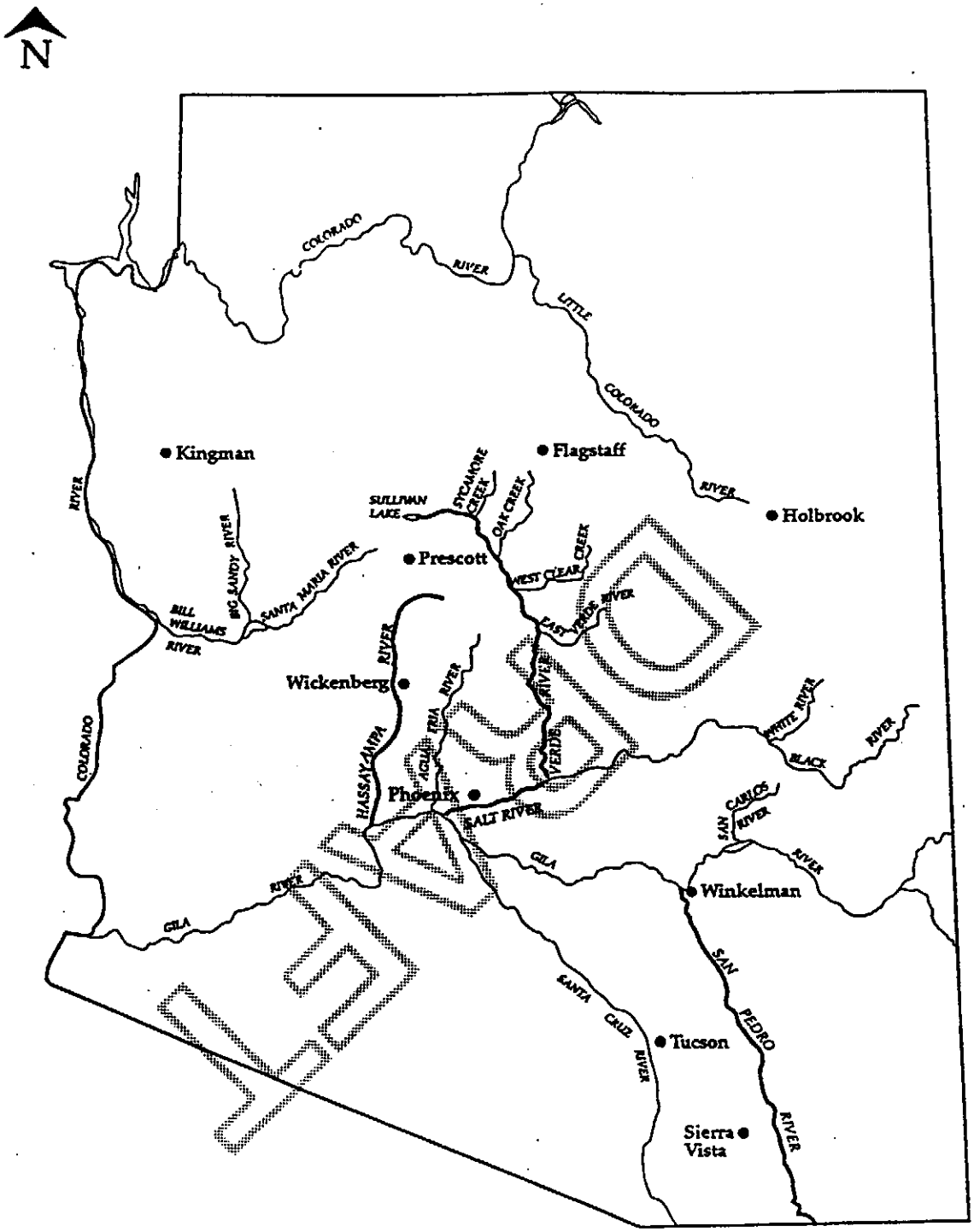

FIGURE 1
General Location Map for Arizona Stream Navigability Studies

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

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

Methodology

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

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

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

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

Agency Contact

The objectives of the agency contact task were to inform community officials of the studies, to obtain information on historical and potential river uses, and to obtain access to data collected by agency personnel on the four rivers. For this task, public officials from every community, town, city, and county located along the San Pedro River were contacted. Contact consisted of an initial letter describing the stream navigability study, its potential impacts on the community, and requesting information to be used in the study. Each community official was then contacted by telephone to answer questions about the study

and to provide a second opportunity to provide information for the study. In addition, officials from most local, state, and federal agencies with jurisdiction or interest in the river study areas were contacted by letter and telephone. Finally, a public meeting was held in Sierra Vista to describe the purpose of the State's streambed program and to provide a forum for collection of data from the general public.

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

Literature Search

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

- Archaeology
- History
- Hydrology
- Hydraulics
- Geomorphology

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

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Data Summaries

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

Archaeology

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

History

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

Oral History

Oral history, or ethnographic data, are the recollections of individuals with personal knowledge of historical conditions. Oral history supplements formal historical and archaeological records. SWCA ethnographers conducted interviews with long-time residents, professional historians, avocational historians, and professional land managers who were knowledgeable about the San Pedro River. Names of potential interviewees were obtained from historical societies, public agencies, and private organizations contacted during the agency contact task. A total of 25 interviews were conducted for the San Pedro River. Chapter 4 and Appendix D summarize oral history information collected for the San Pedro River.

Hydrology/Hydraulics

Hydrologic/hydraulic information is the primary source of information regarding susceptibility to navigation. These data include estimates of flow depths, width, velocity, and average flow conditions as of statehood, based on the available records. CH2M HILL evaluated information collected during agency contact and literature search tasks. Literature, stream gage records, topographic maps, aerial photographs, and other data were

used to develop an estimate of natural stream conditions as of statehood, as well as for existing stream conditions. Depth, velocity, and topwidth rating curves for existing and (near) statehood channel conditions were developed from historical gaging records. Estimates of 2-, 5-, 10-, 50-, 100-year, and average annual flow rates were obtained from stream gage data. Flow duration curves, and average monthly flow rates were also summarized. Finally, reports were prepared which discuss the role of climate change, irrigation, modern boating activities, and recreational navigation criteria on stream navigability. The data from these reports are presented in Chapters 7 and 8, and Appendixes E, F, and G.

Geomorphology

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

Land Use

Land use data were compiled for the San Pedro River and were entered in a GIS database. Land use data included existing title owner records from county assessors' offices, state and federal land leasing records, ASLD, the Bureau of Land Management, and the US Forest Service. Existing improvements, commercial activities, and present use of lands were identified from land use mapping and reports, aerial photographs, and in some cases, by field visits.

Conclusion

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

before and as of statehood (Chapter 7). Seventh, information on federal boating criteria and boating records for the San Pedro River will be summarized (Chapter 8). Finally, appendixes which provide additional data on topics related to the San Pedro River study are attached.

DRAFT

Chapter 2
Archaeology of the San Pedro Valley

Introduction

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

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

Archaeological Projects

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

The earliest site descriptions were provided in the 1930s by Trischka (1933) and Fulton (1934) on Texas Canyon. The Amerind Foundation sponsored excavations at major sites such as Tres Alamos (Tuthill 1947), Babocomari Village (DiPeso 1951), and Reeve Ruin (DiPeso 1958) in efforts to learn more about the Dragoon (Tuthill 1950) and Babocomari cultures, and to establish spatial and temporal boundaries for San Pedro Valley prehistory and history (Bronitsky and Merritt 1986:48).

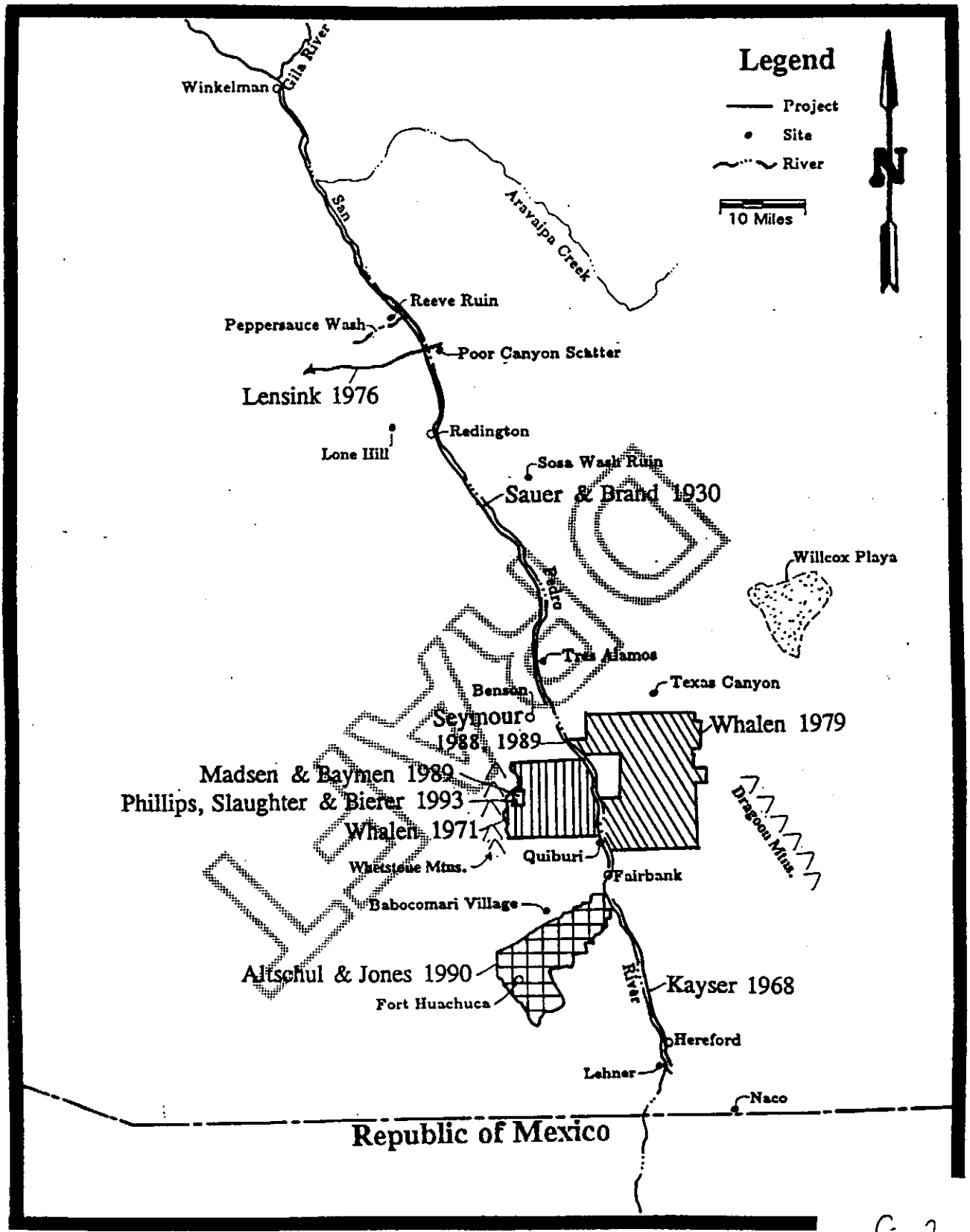


Figure . Archaeological sites and project areas along the San Pedro River.

Fig 2

Table 1
Archaeological Projects Along the San Pedro River.

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

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

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

Investigations into Archaic period sites began relatively late along the San Pedro River (Agenbroad 1966, 1970, 1978). The temporal sequence and characterization of each stage was fostered by work initiated by Gila Pueblo (Sayles 1983:1). Archaic period settlement patterns along the upper San Pedro River took great strides when Whalen (1971, 1979) conducted surveys of large areas on either side of the river. Between 1966 and 1969 he surveyed a 100 square mile area on the west side of the valley between the Whetstone Mountains and the river. Ninety sites were located, only four of which postdated the Archaic period. Later, a systematic sample survey was conducted on the east side of the valley between the river and the Dragoon Mountains (Whalen 1979) that covered 16 1/2 square mile, or 9% of a 180-square-mile area. The survey documented 293 prehistoric sites dating from 3000 B.C. to A.D. 1450.

Overviews of San Pedro River culture history and discussions regarding prehistoric site distributions derived from these earlier studies. The characterization of Salado manifestations in the lower San Pedro River Valley was presented by Franklin and Masse (1976), with strong arguments for the migration of Salado populations from the north, rather than indigenous development from earlier Hohokam occupants. Masse (1980) presented an overview of the lower San Pedro River and compared cultural developments in that area to developments in the northern Papagueria to the west of the river. Masse also used the opportunity to present new data from field school investigations of the Big Ditch Site, near the confluence of the Aravaipa Creek and the San Pedro River. A more in-depth overview was produced by Bronitsky and Merritt (1986) for the Bureau of Land

Management (also see Teague 1974). It was in the form of a Class I type cultural resource inventory that included a literature and records search to compile information of known cultural resources of southeast Arizona, including both government and private lands. The study unit embraced a much larger area than the San Pedro Valley and was conducted to assist in the management of cultural resources in that area.

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

Culture History

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

Archaic period populations practiced seasonal exploitation of a wide range of wild resources and were adapted to an increasingly arid environment, generally similar to the present climate of the San Pedro Valley. The earliest evidence for Archaic period occupation, represented by the Cochise Culture of southeastern Arizona, along the San Pedro River is the Chiricahua stage (9,000-1,500 B.C.), which had more of an emphasis on hunting than the San Pedro phase (1,500-200 B.C.), which had a plant gathering emphasis. Whalen (1979) describes Cochise sites as either base camps or work camps. Base camps were loci for daily household tasks and the centers for band activities. Work camps were transient stations for activities such as plant gathering, hunting, and the procurement of resources (Whalen 1979:8). Most Archaic sites are scatters of lithic materials, both flaked and ground stone, sometimes with associated hearths. During the late San Pedro phase, shallow house features, as well as large storage pits, appear, indicating a shift to sedentism. Archaic sites are found

most often on the river terraces (Whalen 1971, 1979). Few sites have been found on the floodplain due to alluviation and erosion. Sites typical of this time period are the Lone Hill site (Agenbroad 1966, 1970, 1978), Benson:8:3(GP) (Sayles 1945:1), and Benson:5:10(GP), the San Pedro stage type site.

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

Lower San Pedro River

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

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

By A.D. 1200, there was a marked population decline along the lower San Pedro River and many sites were abandoned. By A.D. 1250, a new influence, the Salado Culture, was felt in this area and was accompanied by an increase in occupation and a change in architectural style, pottery, and other cultural traits. Hohokam traits that were retained originated from the Tucson Basin rather than from

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

Upper San Pedro River

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

Between A.D. 1225 and 1300, there was a decrease in population, suggested by a paucity of sites in the area, and a cessation of indigenous ceramic styles, such as the Dragoon and San Simon series (Bronitsky and Merritt 1986:192-193). Sites that date after A.D. 1200 are located mostly on arable land between the mountains and the river (Altschul 1992:7) and are represented by Tres Alamos, Babocomari (DiPeso 1951), and Boquillas Ruin (DiPeso 1953), near Fairbank. Settlement occurs

in adobe-walled compounds with houses clustering around a central plaza. At Tres Alamos two compounds were composed of 12 rooms each. The average room size was 195 or 209 ft^2, with a wide range (5-340 ft^2) of room sizes (Tuthill 1947:20), due to differences in room function. Unique structural features found at this and the Texas Canyon sites have been interpreted as granaries. They were circular structures that ranged between approximately 5 and 8 feet in diameter. The walls were adobe, and the platforms were adobe-cemented rocks.

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

Prehistoric Use of the San Pedro River

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

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

Environmental Reconstruction

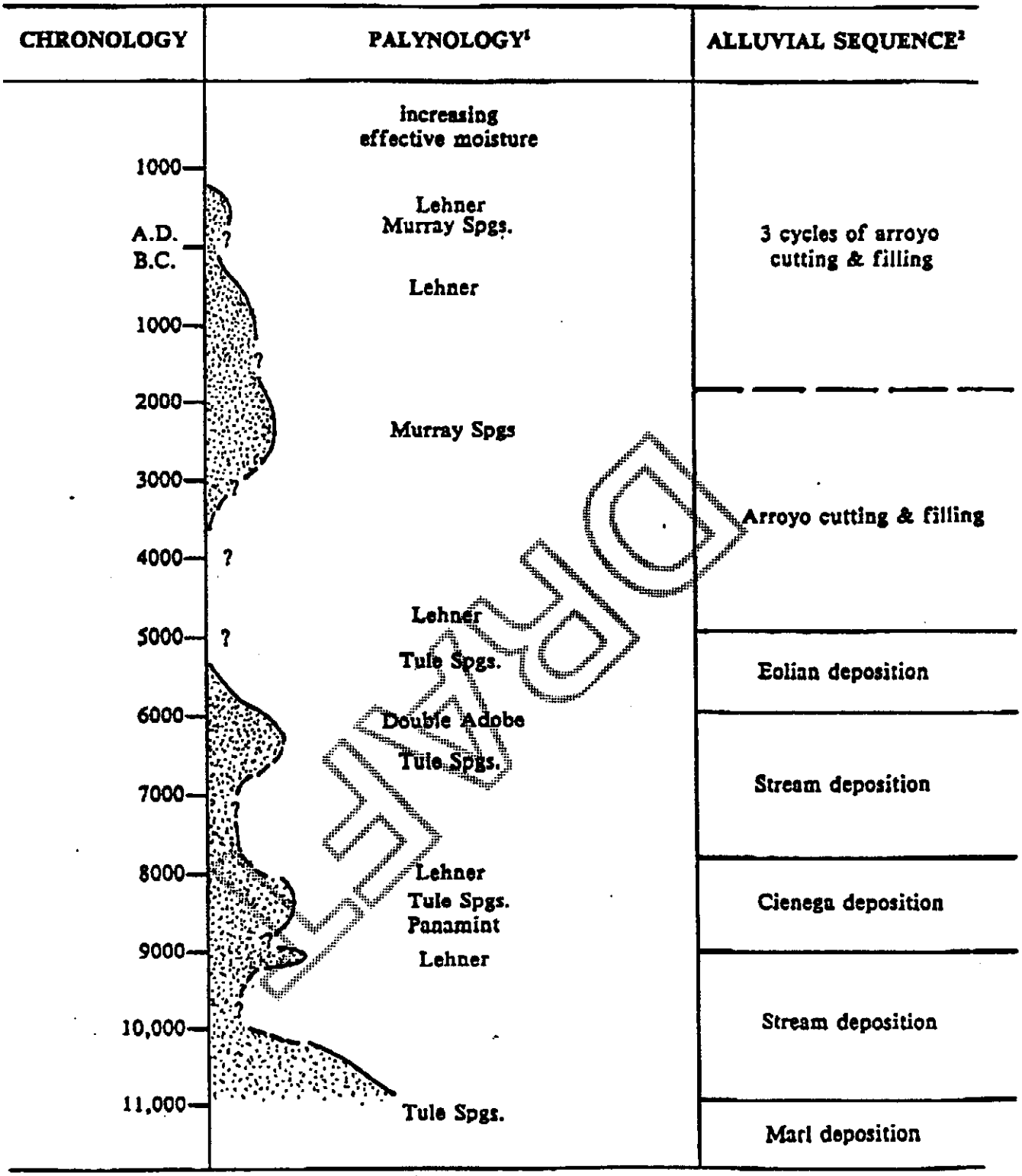
Environmental information for the San Pedro Valley is more prevalent for the pre-ceramic period of prehistory than for the later ceramic period occupation. Geoarchaeological investigations have been carried out at Paleo-Indian sites along the river (Haynes 1981, 1982) and at Archaic period sites east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

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

Conclusion

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

Table 2. Correlation Between Pollen Evidence and the Alluvial Sequence in Southeastern Arizona.



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

Chapter 3
History of the San Pedro River

Introduction

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

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

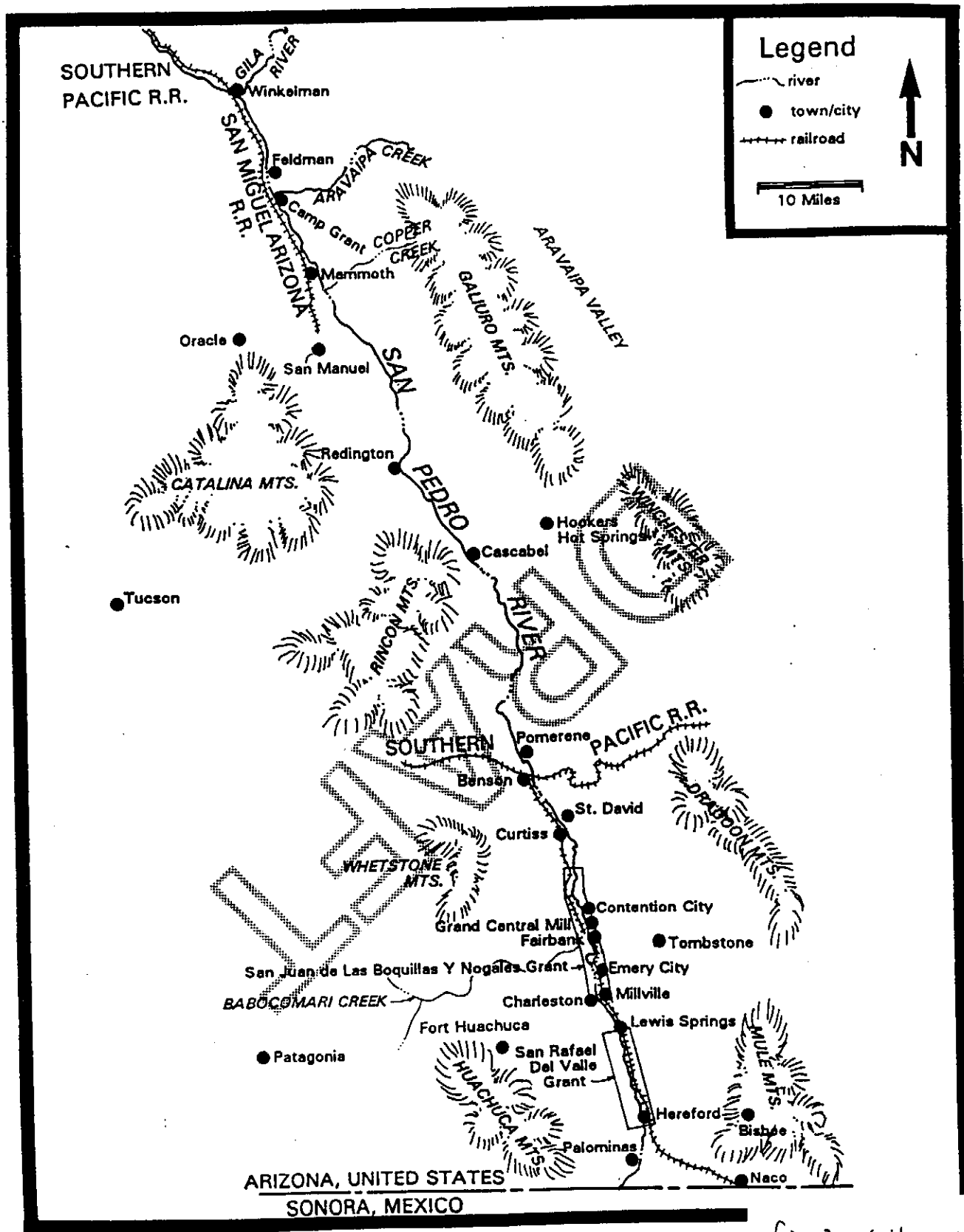


fig 3. Sites of Historical Signif along SP line

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

Table 3. San Pedro River Chronology	
1827-8	James Ohio Pattie and company trap beaver on the river (Davis 1982; Wagoner 1975:99).
1828	San Rafael de Valles grant paid for (Officer 1987:109).
1830	Lieutenant Antonio Comaduran left Tucson presidio, traveled to Tres Alamos (north of present-day Benson) on the San Pedro, then proceeded toward the Sierra de Santa Teresa to Cajon de Agua Caliente (Hooker Hot Springs) and then to the Aravaipa Valley (Hadley et al. 1991:41, citing Dobyns 1981:16-26).
1830s	People from Tucson farming Tres Alamos, guarded by troops from Tucson presidio (Officer 1987:148).
1831	Tres Alamos land grant (Officer 1987:109-110).
1832	San Rafael del Valle--sold to Rafael Elías Gonzales for $240 as a stock farm (McClintock 1916:531).
1833	San Juan de la Boquillas y Nogales land grant awarded to Elías González family (Officer 1987:108-110).
1836	Pinaleno and Aravaipa bands of the Western Apache agree to settle at the junction of the Aravaipa and the San Pedro (Hadley et al. 1991:41).
1846	Mormon Battalion described their camp in the San Pedro River Valley "in a marshy bottom with plenty of grass and water" and the stream as a "beautiful little river." (Tyler 1881, cited in Jackson 1987:21). Lt. Col. Philip St. George Cooke called the river by the name Jose Pedro River (Granger 1984:471). "The San Pedro River...was described in 1846 as a river 'an active man could jump across.'" (Mann 1963:4).
1846?	Captain Philip St. George Cooke marched his battalion up the river to the present site of Benson (Walker and Bufkin 1986:18).
1846-48	San Pedro Valley traversed by the Army of the West under General Kearny, and the Mormon Battalion traverses it on its way from Santa Fe, New Mexico to San Diego, California (Clarke 1961 and Golder 1928 cited in Hoffman 1982:40).
1848	Treaty of Guadelupe Hidalgo.
1849	Cooke's Road went along the river (Walker and Bufkin 1986:40).
1853	Boquillas grant (17,355 acres)--title given to Ignácio Elías Gonzales and Nepomuceno Felix for sale price of $240. Was confirmed to the possession of George Hearst and Janet G. Howard (McClintock 1916:531).
1854	Gadsden Purchase (from the Gila River to the present international border).
1854-55	San Pedro Valley traversed by Major William Emory during his survey of the international U.S.-Mexico border established by the Gadsden Purchase of 1853 (Emory 1848 cited in Hoffman 1982:40).
1855-1865	Farms along the river were targets for the Apaches (McClintock 1916:182).
1857	Major W.H. Emory describes the San Pedro River not having a great amount of water, and backed by a series of large pools by beaver dams and full of fishes (Emory 1857 cited in Jackson 1987:22).
1857	James B. Leach and N.H. Hutton surveyed wagon road from El Paso to Fort Yuma. (Hutton 1859:88, as cited by Hadley et al. 1991:57).
1857	"Captain" James H. Tevis and Mose Carson hunting and trapping on Aravaipa, Gila, and San Pedro. Trapped beaver on the San Pedro near the junction of the Aravaipa (Hadley et al. 1991:57).
1857-9	Leach's Wagon Road--Followed the river north almost to the Gila River junction (Walker and Bufkin 1986:40).

Table 3. San Pedro River Chronology	
1857	Benson established as a stage stop at the San Pedro River crossing of the Overland and Butterfield Trail. Later the town became a railroad center to serve the mining areas that developed in the San Pedro River Valley (Arizona Office of Economic Planning and Development [AOEPD] 1977:3). [The date is incorrect; the Butterfield Trail dates from 1858 to 1861.
1858-1861	Butterfield Stage Route in operation.
1859	Fort Arivaypa [sic] established at the junction of the Aravaipa and San Pedro (Hadley et al. 1991:45).
1860	Fort Arivaypa renamed Fort Breckenridge and then abandoned (Hadley et al. 1991:45).
pre-1861	San Pedro Mine discovered and located about 1/2 mile from east side of river (Adams 1930:140).
1862	Military post re-established at junction of Arivaipa and San Pedro and named Fort Stanford (Hadley et al. 1991:45).
1863	Silver-lead ore discovered in Copper Creek in Galiuro Mountains above the San Pedro River (Hadley et al. 1991:114).
1865	Fort Stanford renamed Camp Grant (Hadley et al. 1991:45, citing Granger 1985:295).
1867	William A. Bell surveyed route for Kansas Pacific Railroad (Bell 1869, as cited by Hadley et al. 1991:58).
1868	Irrigation in use on the river (Farish 1915:207).
1870	"the valley of the San Pedro 'had a shallow grassy bed and banks covered with luxuriant vegetation.'" (Mann 1963:4).
1871	Camp Grant named reservation for Aravaipa and Pinaleno bands of the Western Apache (Hadley et al. 1991:47).
1872	Reservation status for Camp Grant ended (Hadley et al. 1991:47).
1873	Location of Camp Grant moved from junction of Aravaipa and San Pedro to west side of Pinaleno Mountains near present-day Bonita, Arizona (Hadley et al. 1991:43). Indians removed to San Carlos Reservation (Hadley et al. 1991:47).
1873-4	Wet years (Hadley et al. 1991:144-145).
1874	San Rafael del Valle--claimed under mortgage by Camou Brothers of Sonora who eventually gained title (McClintock 1916:531).
1875	Reddington settled by brothers Henry and Lem Redfield (Barnes 1988:358).
1877	copper mine established at Bisbee (Barnes 1988:48).
1878	mine established at Tombstone (Barnes 1988:446).
1879	Charleston Post Office established (Barnes 1988:88).
1880	Charleston established--mill town for reduction for Tombstone Milling & Mining Company--"wild river camp" (Granger 1985:33).
1881	Mammoth Mine established (Barnes 1988:262).
1881	San Manuel Mine began production. Prior to this the Mammoth and Mohawk mines were chief producers in the area (San Manuel Copper Corporation [SMCC] 1955:1). Neptune Mining Co. of Bisbee built a smelter at Hereford (Myrick 1975:179).
1881	St. David Post Office established at Mormon settlement on spur line of EP&SW Railroad (Barnes 1988:374).

Table 3. San Pedro River Chronology	
1881-2	New Mexico & Arizona Railroad built between Benson and Fairbank. The haul from Bisbee to Fairbank was accomplished by teams of 18 and 20 horses and mules (Myrick 1975:179). Atchinson, Topeka & Santa Fe Railroad built the New Mexico & Arizona Railroad from Benson to Nogales (Walker and Bufkin 1986:47).
1882	Fairbank established on EP&SW Railroad (Barnes 1988:150).
ca. 1884	River description: The San Pedro rises near the lone between Arizona and Sonora, and runs in a general northerly course a distance of over one hundred miles, and enters the Gila River at the foot of Gila Cañon, in Pinal County. It has a number of small tributaries, among them Arivaypai, which enters near its mouth, after passing through Grass Valley for five miles. On the western side is a tributary called Babacomari, rising in the Huachuca Mountains (Wallace W. Elliot & Co. 1884:90).
1884	"It is a sluggish, narrow stream, but carrying sufficient water to irrigate the rich bottom-lands through which it flows." (Hamilton 1884:48). Cited river as being "capable of irrigating vast stretches of land" (Hamilton 1884:361).
1885-1903	Drought years (Hadley et al. 1991:144-145).
1886	Flooding (Hastings & Turner 1965:42).
1887	More flooding (Hastings & Turner 1965:42).
1888	More flooding (Hastings & Turner 1965:42).
1889	More flooding (Hastings & Turner 1965:42).
1889	Lewis Springs established on EP&SW Railroad (Barnes 1988:246).
1890	More flooding (Hastings & Turner 1965:42).
1890	"Where the San Pedro River of southeastern Arizona formerly wound its sluggish course northward through a marshy, largely unchanneled valley, in August, 1890, it began carving a steep-walled trench through which it thereafter emptied rapidly and torrentially into the Gila. Where it formerly ran more or less consistently throughout the year, after 1890 its flow became intermittent, leaving the new channel dry over much of its length for most of the time." (Hastings & Turner 1965:3)
1891	Stamp mill for Mammoth Mine built at Mammoth (Granger 1985:298).
1894	Arizona Southeastern Railroad Company--"Near Fairbank the track was washed for 100 feet, and 11 miles down the line a 45-foot bridge and 1-1/2 miles of track were knocked out. Mail from Bisbee was carried on horseback during the week the railroad was being repaired." (Myrick 1975:191)
9/26/1894	Arizona Southeastern Railroad track between Benson and Fairbank completed (Myrick 1975:192).
1899	Naco Post Office established on railroad to mines at Nacozori, Mexico (Barnes 1988:294).
1900	Three railroads serve the San Pedro River Valley area, and Benson is known as The Hub City (AOEPD 1977:3).
1904-5	Wet years (Hadley et al. 1991:144-145).
1905	Arizona Eastern Railroad line completed from Phoenix to junction of Gila and San Pedro at Winkelman (Hadley et al. 1991:112).
1915	Pomerene Post Office established (Barnes 1988:342).
1916	Cascabel Post Office established (Barnes 1988:80).
1917-21	Drought (Hadley et al. 1991:144-145).

Table 3. San Pedro River Chronology	
1920s	The Arizona Southeastern Railroad along the river was in use at least through the 1920s (Myrick 1975).
1933-4	Drought (Hadley et al. 1991:144-145).
1945	San Manuel Copper Corporation incorporated (SMCC 1955:1).

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Historical Overview/Chronology

Historic Indian Use of the San Pedro Valley

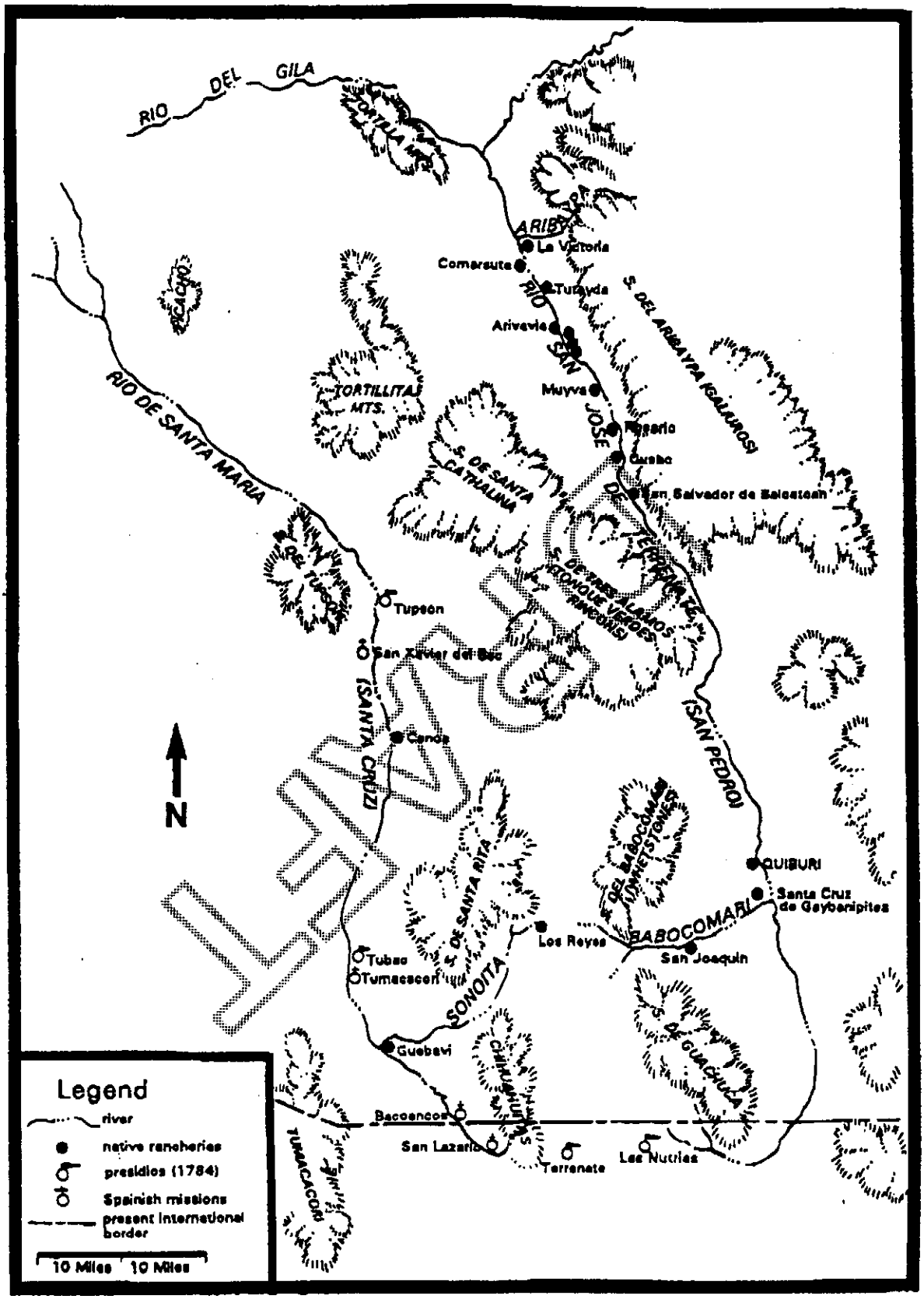
When the Spanish first explored and colonized the San Pedro Valley, it was occupied by the Sobaipuris, a band of upland Pimas. The Sobaipuris of the San Pedro Valley, whose population was estimated at between 1,800 (Keller's estimate [Hammond 1929:227, as cited by Hadley et al. 1991:39]) and 2,000 (Kino's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

Spanish Exploration

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

Spanish Colonization

Father Eusebio Kino arrived in Pimería Alta in 1687, and in 1691 was invited by the Pimas to establish missions in what is now southern Arizona. By the time of his death in 1711, Kino had founded a chain of missions throughout Pimería Alta. In conjunction with these missions, military presidios were established. Spanish missionaries introduced herds of cattle to the Pimas and by 1694, "100,000 cattle ranged the grasslands around the headwaters of the San Pedro River and Bavispe Rivers" (Bolton 1948: map, as cited by Hastings and Turner 1965:31). The missionary activities of Father Eusebio Kino are discussed in many books and articles (Bolton 1936, 1960;


RIO DEL GILA
TORTILLA MTS.
ARIBAYPA
La Victoria
Comarsuta
Tutayda
Arivavia
RIO SAN JOSE DE TERRENATE
S. DEL ARIBAYPA (GALAUROS)
Muyva
Rosario
Cuebo
San Salvador de Balcatoan
PICACHO
TORTILLITA MTS.
RIO DE SANTA MARIA
S. DE SANTA CATHALINA
S. DE TRES ALAMOS (TONQUE VERDES RINCONS)
S. DEL TUPSON
Tupson
San Xavier del Bac
(SANTA CRUZ)
Canoa
(SAN PEDRO)
N
S. DEL BABOCOMARI (INHETSTONES)
QUIBURI
Santa Cruz de Gaybanipitas
S. DE SANTA RITA
Los Reyes
BABOCOMARI
San Joaquin
Tubac
Tumacacori
SONOITA
S. DE GUACHUCA
Guebavi
CHIHUAHUITAS
Bacoancos
San Lazario
Terrenate
Las Nutrias
TUMACACORI
Legend
river
native rancherias
presidios (1784)
Spainish missions
present international border
10 Miles 10 Miles

Burrus 1965, 1971; Kessell 1966a; Smith, Kessell, and Fox 1966) that contain information on the San Pedro Valley in the Spanish Period. Figure 4 shows the locations of Spanish-Period sites mentioned in the text.

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

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

His party found about 2000 Indians living in twelve villages scattered along the valley between Babocomari and Aravaipa Creeks. The approximate site of the fields of the southernmost of the rancherías, Santa Cruz de Gaybanipitea, appears in Plate 57. In 1697 the village contained about one hundred people, who practiced irrigation and tended a herd of cattle that Kino had given them earlier (Bolton 1948: I, 165). Below Santa Cruz about three miles lay Quiburi, the largest of the rancherías, populated by about five hundred Indians.

For some fifty miles thereafter the valley contained villages recently abandoned because of an internal war among the Sopaípuris. Below these, within a stretch of thirty-five miles, Kino found ten occupied rancherías. All of them practiced irrigation and raised corn, beans, cotton, and squash (Hastings and Turner 1965:26).

In 1698, both Santa Cruz de Gaybanipitea and San Pablo de Quiburi were attacked by the Apaches and abandoned (Di Peso 1953:30-32). The Sobaipuris rebuilt Quiburi in 1704 or 1705, renaming it Santa Ana del Quiburi (Di Peso 1953). In 1732, Captain Juan Bautista de Anza and a German Jesuit missionary, Father Ignacio Xavier Keller, followed the San Pedro River to the Gila River, inspecting the six mission visitas (including Quiburi) that served an estimated 1800 Sobaipuris in the valley (Di Peso 1953:38; Hammond 1929:227, as cited by Hadley et al. 1991:39). When Keller visited the area five years later, though, the Sobaipuris had largely abandoned it because of Apache attacks. When Keller tried to inspect the region again in 1743, the Apachean threat forced him to turn back (Officer 1987:35). By 1763, the Sobaipuris had completely abandoned the San Pedro River Valley, moving to Santa Maria de Suamca and San Xavier del Bac (Di Peso 1953).

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In 1772, the Spanish attempted to move the Presidio of Santa Cruz de Terrenate to the old site of San Pablo and Santa Ana del Quiburi (Di Peso 1953:42, 276). This event was significant because it represented an attempt by the Spanish to colonize the San Pedro Valley rather than merely to missionize the Indians living there. The attempt was unsuccessful, and the presidio was never completed.

From the winter of 1775-6 to 1780, the Spanish maintained a presidio at Santa Cruz de Terrenate on the west side of the San Pedro River north of what is now the town of Fairbank. In 1789, Santa Cruz de Terranate was moved to its present location in Sonora, Mexico (Di Peso 1953:276).

Mexican Colonization

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

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

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

Exploration by United States Citizens

The first reports on the San Pedro Valley by citizens of the United States were made by trapper James Ohio Pattie, who made three expeditions along the Gila River from 1824 to 1828. The first of Pattie's expeditions into what is now Arizona occurred between December of 1824 and April of 1825 and followed the Gila River down to the San Pedro River, which Pattie called the Beaver

River, then a short ways up the Beaver River, trapping all the way. Between January and April of 1826, Pattie traveled down the Gila River and up the Salt River (which he called the Black River). Between October of 1827 and February of 1828, Pattie again traveled down the Gila River to the Beaver (San Pedro) River (Davis 1982).

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

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

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

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

United States Colonization

During the Civil War, military posts in Arizona were abandoned until the arrival of the California Column. The San Pedro River was largely left to the Apaches. In 1867, homesteaders began to

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

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

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

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

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

The transcontinental railroad arrived in Tucson in 1880, and over the next 25 years, the San Pedro River Valley became laced with a network of railroads. In 1881, a railroad route linking Benson, Arizona, with Guaymas, Sonora, was completed (Greever 1957, as cited by Hastings and Turner 1965:40). According to Walker and Bufkin (1986: map 28), St. David (a Mormon settlement) was established in 1877. The St. David Post Office was established in 1881 when a spur line of the EP&SW Railroad reached the town (Barnes 1988:374). Fairbank was established in 1882 on the EP&SW Railroad (Barnes 1988:150). Lewis Springs was established in 1889 on the EP&SW Railroad (Barnes 1988:246). The Naco Post Office was established in 1899 on the railroad to the

mines at Nacozori, Mexico (Barnes 1988:294). The Arizona Eastern Railroad was completed from Globe to Winkelman in 1905 (Myrick 1984, as cited by Hadley et al. 1991:118).

Historical Descriptions of the River[1]

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

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

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

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

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

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

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

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

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

One of the principal routes for the forty-niners on their way to the gold fields of California ran along the present border between Arizona and Mexico, although at the time, the route lay in Mexican territory (Aldrich 1950; Chamberlain 1945; Cox 1925; Durivage 1937; Eccleston 1950; Evans 1945; Harris 1960; Hunter n.d.; Pancoast 1930; Powell 1931). The Evans (1945) and Harris (1960) accounts do not mention the San Pedro River, although they were favorably impressed by the Santa Cruz River. Cox (1925:141) stated only that on August 22 "arrived at our present camp ground which we suppose to be on the River San Pedro." From September 26 through 28, H.M.T. Powell

[2] In fact, they were probably squawfish.

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

On September 12, 1858, Leach stated:

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

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

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

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

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

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

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

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

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

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

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

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

> Where the San Pedro River of southeastern Arizona formerly wound its sluggish course northward through a marshy, largely unchanneled valley, in August, 1890, it began carving a steep-walled trench through which it thereafter emptied rapidly and torrentially into the Gila River. Where it formerly ran more or less consistently throughout the year, after 1890 its flow became intermittent, leaving the new channel dry over much of its length for most of the time (Hastings 1959).

Even after arroyo cutting entrenched the San Pedro River, cienegas remained in the uplands. "From the court records of an early suit over water rights there can be established the existence of a large cienega extending along the San Pedro River from about modern Benson to old Tres Alamos

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(Cochise County District Court 1889). The boggy, but treeless and trenched location already discussed lay at the foot of it" (Hastings and Turner 1965:37).

Historical Uses of the River

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

Farming

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

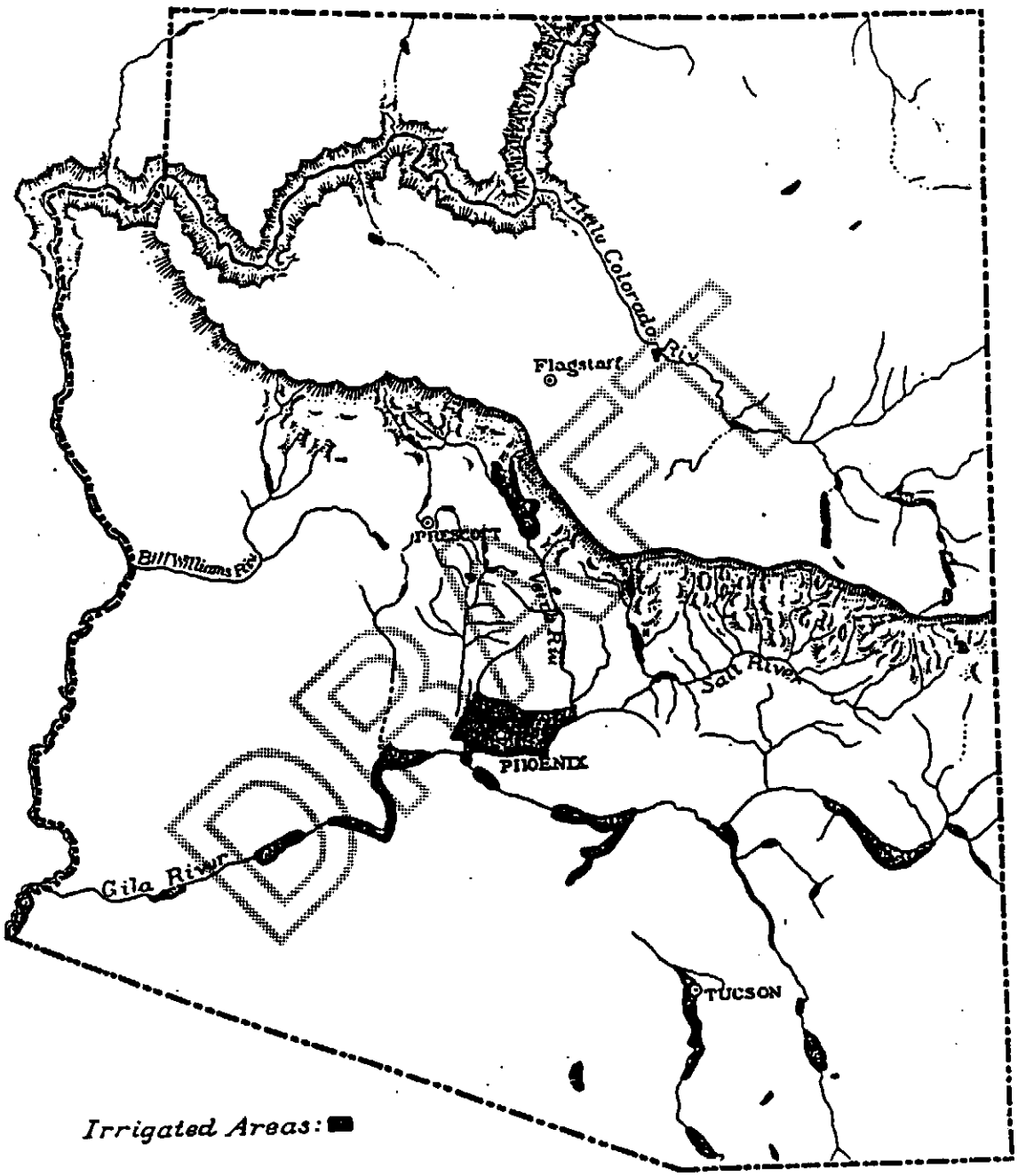
During the Civil War, the United States Army established a number of military posts in southern Arizona, which made the area safer for homesteaders. Some of the farms were in the San Pedro River Valley were established near Camp Grant. Joe Felmer's, Israel's, and Kennedy's farms on the San Pedro River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

Hodge (1877:47) wrote that the San Pedro Valley contained 50,000 acres "of good farming land, most of which can be successfully cultivated. At Tres Alimos, in this valley, are some well cultivated farms and one choice dairy farm, that of H.C. Hooker, Esq."

GLO maps dated to 1873, 1878, 1880, 1882, 1901, 1902, and 1903 show acequias and fields along the river in virtually every township. A map from the 1900 census shows irrigation farming all along the San Pedro River (Figure 5).

Fishing

Fish species found in the San Pedro River historically included some very large fish such as squawfish (aka Salt River Salmon, Colorado River Salmon) some of which grow to over three feet long, razorback sucker, and flannelmouth sucker. Historical accounts of fishing are centered on early explorer routes and settlements, as cited earlier in this chapter. There are numerous accounts of "salmon" runs (actually squawfish) on the San Pedro River, fish fish clogging canals on the San Pedro River, and catching fish with pitchforks for use as fertilizer on irrigated fields. A commercial operation reportedly harvested razorback suckers from the San Pedro River between 1870 and 1910 near Tombstone.



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1 From Census Bulletin No. 68, July 29 1902

Figure 5.
Irrigation along
SP River, 1900

Mining

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

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

Regional Transportation

The primary means of transportation along the San Pedro River has always been overland. Spanish missionaries and military expeditions, as well as the trappers of the 1820s, traveled on horseback. Kearny traveled by horseback in 1846, not even attempting to haul wagons. Later U.S. military expeditions did use wagons, as did the forty-niners. All of these groups followed expedient trails (Figure 6).

The Butterfield Stage Route, which crossed the San Pedro River at the present location of Benson, was in operation from 1858 to 1861, and in 1859, a bridge was constructed across the San Pedro River (Conkling and Conkling 1947:149; Eaton 1933:176). The military was responsible for surveying and constructing a number of formal roads in the region. In 1858, the Leach Wagon Road, which ran down the San Pedro River, was surveyed but never became popular because it bypassed Tucson. By 1870, a road ran up the Gila River to Camp Grant.

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

Transportation companies operating in Charleston in 1880 suggest the extent of stage transportation along the San Pedro River. According to Fulton (1966:17), four stage coaches arrived and departed daily from Charleston in 1880, "two from Tombstone, one from the Huachucas, and one from the

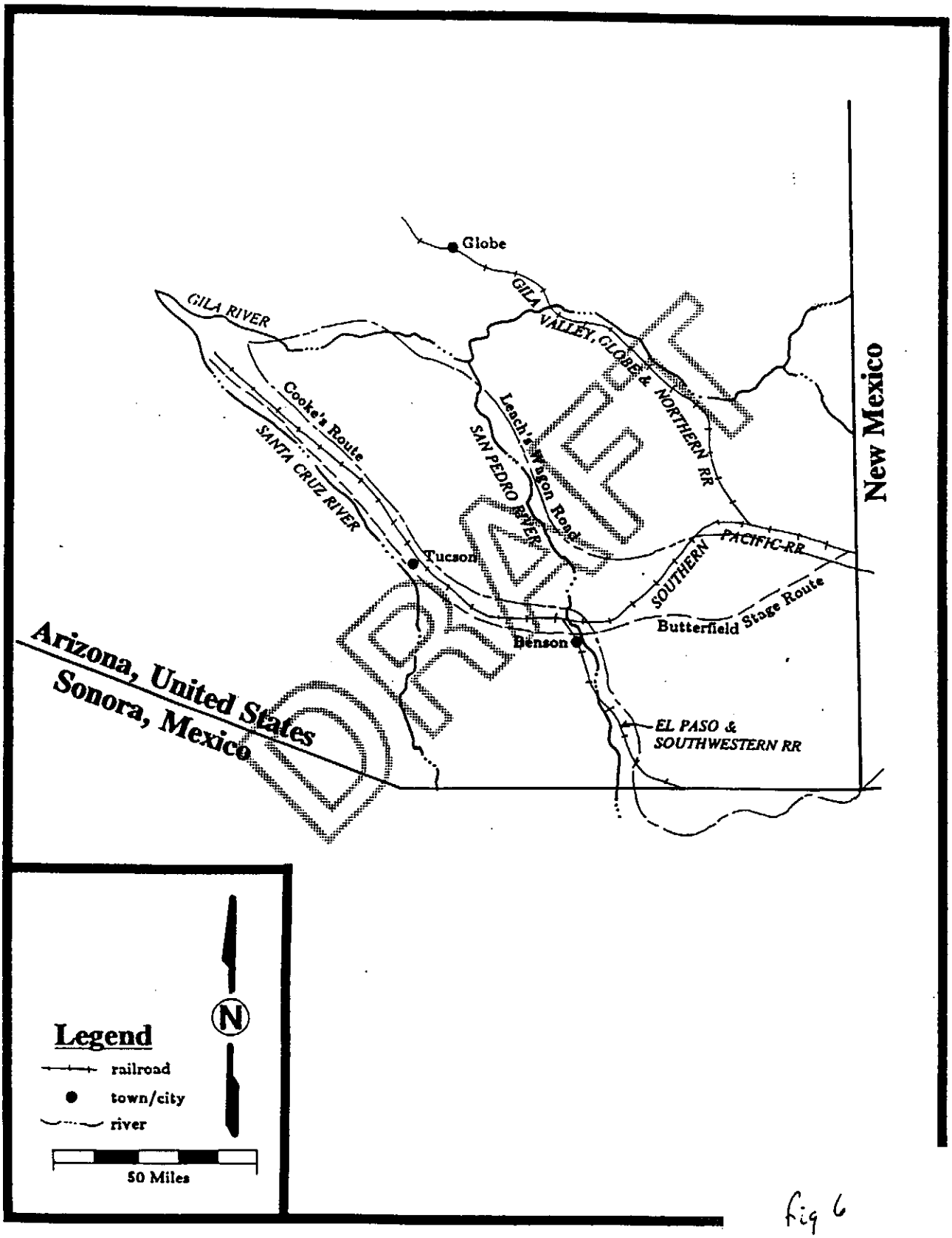
DRAFT
Globe
GILA RIVER
GILA VALLEY, GLOBE & NORTHERN RR
Cooke's Route
SANTA CRUZ RIVER
SAN PEDRO RIVER
Leach's Wagon Road
New Mexico
Tucson
SOUTHERN PACIFIC RR
Butterfield Stage Route
Benson
Arizona, United States
Sonora, Mexico
EL PASO & SOUTHWESTERN RR
Legend
railroad
town/city
river
N
50 Miles

fig 6

Mule Mountains." The Ohnesorgen and Walker stage line, established in 1880, extended from Tombstone to Charleston. The same year, the Stillwell and Dremen Company began stage service between Charleston and Patagonia. The Ingram and Company stage line ran from McGreary's Ranch on Babocomari Creek to Charleston and Tombstone. The Arizona Transportation Company, run by C. "Ham" Light, hauled ore from the mines to the mills in 16-mule teams. In 1881, a 160-foot bridge was built over the San Pedro River between Charleston and Millville.

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

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

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

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

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

Discussion

The history of the San Pedro River exemplifies the types of changes that occurred on some in southern Arizona during the historic period. Prior to the 1880s, more of the San Pedro River flowed year round, in some areas a few feet wide and perhaps a foot deep, in other areas meandering through marshes such that it could "hardly be said to have [had] a course" (Hastings and Turner 1965:36), and several feet deep in other reaches. During this period, the stream supported fish and

beaver. In protohistoric and early historic times, the Sobaipuris (upland Pimas) farmed along the river and lived in villages of perhaps as many as 500 people. During the Spanish and Mexican periods, Hispanics and peaceful Indians from the presidio of Tucson farmed along the river, supplying food to the presidio (Officer 1987). Descriptions of the river during the Mexican War, the 1849 gold rush, and the 1850s survey of the international boundary indicate that the river maintained this pattern.

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

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

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

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

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Chapter 4
Oral History

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

In general, individuals who were questioned during the initial and subsequent contacts might be characterized as falling into one of four groups: (1) professional land managers; (2) professional historians, archaeologists, and museum curators; (3) avocational historians; and (4) longtime residents along the rivers. For the San Pedro River, three professional land managers, nine professional historians, eight avocational historians, and five local residents provided information or were interviewed.

Professional land managers interviewed included Geoff Parker (Soil Conservation Service) and Terry O'Sullivan (Bureau of Land Management), who were interviewed, and Hollis N. Cook (Tombstone Courthouse State Historic Park), who sent a letter. Professional historians, archaeologists, and museum curators who were interviewed included Julio Betancourt (United States Geological Survey), Dan Brown (McFarland State Historic Park), Don Bufkin (Arizona Historical Society), Suzanne Dewberry (National Archives, Federal Records Center, Laguna Niguel, California), Mary Lou Heuett (Cultural and Environmental Systems, Inc.), Ken Kimsey (Prescott National Forest), Mary Lu Moore (Arizona State Attorney General's Office), Bob Trennert (Arizona State University), and Angie Vandereedt (National Archives of the Old Coast Guard). Avocational historians who were interviewed included Brother Tom of the Holy Trinity Monastery at St. David, Cindy Hayostek (Cochise County Historical and Archaeological Society), Helen Hume (San Pedro Valley Arts and Historical Society Museum), Rose Land (San Pedro Valley Arts and Historical Society Museum), Della Meadows (Pinal County Historical Society), Bob Rosen (Gila County Historical Museum), Nedra Sunderland (San Pedro Valley Arts and Historical Society Museum), and the secretary of the Bisbee Mining and Historical Museum. Local residents who were interviewed included Jay Bateman (Florence), Carl Black (St. David), Louise Larson (Benson), Dora Ohnesorgen (Benson), and Jerry Pratt (Sierra Vista). Earl Zarbin, a retired Phoenix newspaperman, has written extensively on water issues in Arizona and has compiled an index of articles on water in Arizona from Arizona newspapers published between 1859 and 1918 (Zarbin n.d.).

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

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

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

A number of people mentioned the changes that had occurred along the San Pedro River in historic times. Hollis Cook (Tombstone Courthouse State Historic Park) and Dora Ohnesorgen cited the presence of beavers in the San Pedro River. Louise Larson recalled that even when she was a child (in the 1920s), there was only a small amount of water in the river; now it rarely flows. Jerry Pratt, a retired wildlife biologist in Sierra Vista, thought that early fur trappers might have used boats on

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

the San Pedro River and that the river might have been navigable before the 1887 earthquake. The secretary of the Bisbee Mining and Historical Museum also suggested that the earthquake, grazing, and drought might have affected the stream.[2] Dora Ohnesorgen and Nedra Sunderland both recalled that Dora Ohnesorgen's grandfather had operated a ferry across the San Pedro River near Pomerene. This ferry represented the only historical account of boating on the San Pedro River found during this study.

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

Chapter 5
San Pedro River Geology

Introduction

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

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

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

Stream Reaches

Environmental and geomorphic contrasts between the upper and lower reaches of the San Pedro River (Tuan, 1962) allow the River to be divided into two reaches. The reaches may be separated at a bedrock constriction called "The Narrows" (Figures 7 and 8) following the format of Heindl (1952a,b). Geologically, this division is arbitrary since environmental and geomorphic variables are transitional between the two reaches.

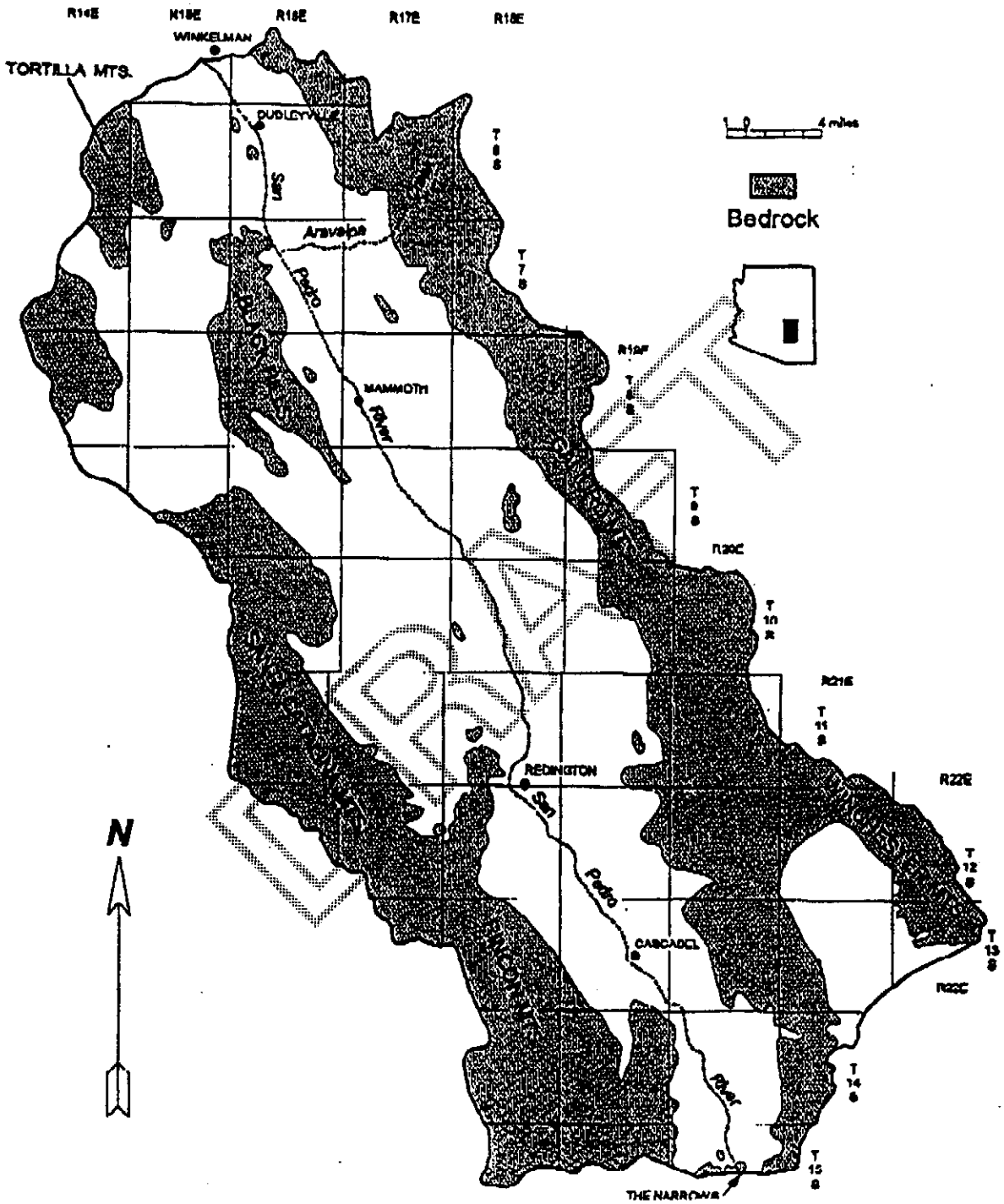

Figure . Lower San Pedro River (adapted from Heindl 1952b: Plate 10).

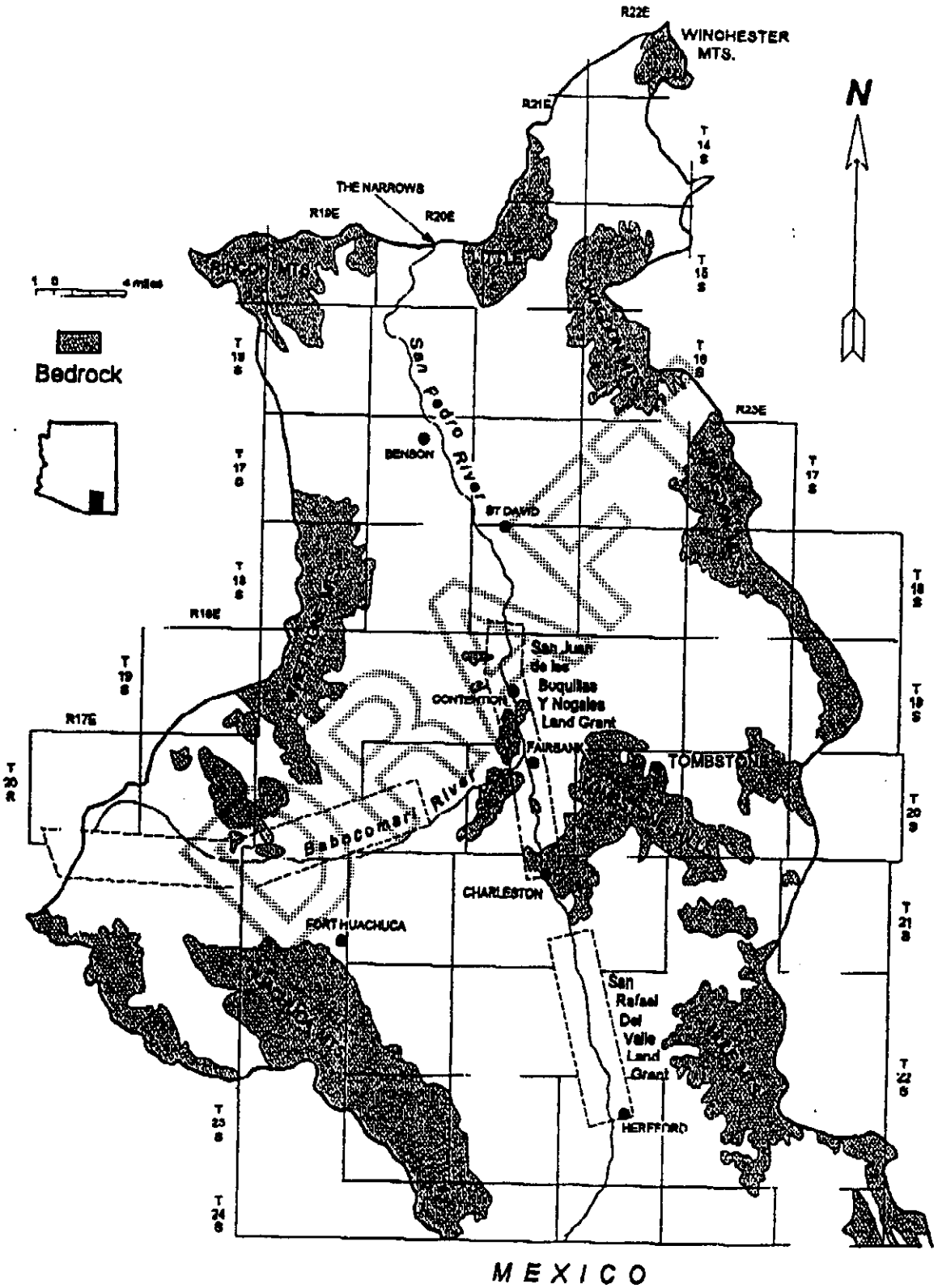

Figure . Upper San Pedro River (adapted from Heindl 1952a: Plate 9).

Physical Setting

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

Table 4
Major Mountain Ranges Bordering the San Pedro Valley, Arizona

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

* Reynolds (1988)

Climate in the San Pedro River valley varies with elevation. Overall, the valley is semi-arid. The lower San Pedro River valley receives less than 15 inches annually (Bahr, 1991). Some of the higher mountains bounding the valley average greater than 25 inches annually. Mean July maximum temperatures range from 103 °F at Winkelman (2,075 feet above sea level) to 89 °F at Fort Huachuca (4,664 feet above sea level; Sellers and Hill, 1974). Despite its lower

elevation, Winkelman has an average January minimum temperature of 29 °F compared to 34 °F for Fort Huachuca. The lower winter minimum temperatures at Winkelman probably reflect microenvironmental effects such as cold-air drainage within the middle Gila River Canyon. Throughout the entire San Pedro Valley, the bulk of precipitation comes primarily during the summer when moisture entering Arizona from the south triggers convective thunderstorms. There is also a lesser rainy season in the winter characterized by regionally extensive, frontal storm systems from the north Pacific. Occasionally during September and October, the San Pedro Valley experiences heavy rains associated with dissipating eastern Pacific tropical storms that commonly result in heavy rain and flooding (Hirschboek, 1985; Webb and Betancourt, 1992; Chapter 7).

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

Late Cenozoic Geologic History

Most elements of the modern topography in the San Pedro Valley can be traced back to the Basin and Range Disturbance (8-15 Ma[1]) (Damon and others, 1984; Menges and Pearthree, 1989; Shafiqullah and others, 1980). Tensional stresses associated with the change from convergent to transform motion on the west coast tectonic plate boundary resulted in a largely north-northwest trending series of alternating basins and mountain blocks separated by steeply dipping normal faults . As the basins dropped, they simultaneously began filling with debris shed from adjacent mountain blocks. Many of the mountain fronts, especially those composed of granite, retreated from the axis of the valley forming broad pediments (Melton, 1965; Morrison, 1985; Tuan, 1962). The upper San Pedro Valley is broader and less dissected with a more gently sloping piedmont than the lower San Pedro Valley (Tuan, 1962). The basin sediments grade from coarse clastics (e.g., boulders, cobbles, and gravels) near the valley margins to finer sediment (sand, silt, and clay) and evaporites in the center (Agenbroad, 1967; Heindl, 1957a,b; Smith, 1963). The upper basin fill stratigraphy is characterized by relatively fine-textured alluvial and lacustrine sediments overlain by coarse-textured fan deposits (Johnson and others, 1975; Melton, 1965; Smith, 1964). The thickness of the basin deposits vary. Geophysical data indicate maximum depths of 4,800 to 6,400 feet in the upper San Pedro River Valley between the Huachuca and Mule mountains and 3,200 to

[1] 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).

4,800 feet in the lower San Pedro River Valley between the Santa Catalina and Galiuro mountains (Oppenheimer and Sumner, 1980).

Initially, drainage in the San Pedro Valley was internal within a series of separate topographic and structural basins, but eventually the basins filled and streams became integrated sometime during the middle Pleistocene (Johnson and others, 1975). Since then, the San Pedro River and its tributaries have episodically downcut into the basin fill forming at least three major erosional surfaces, or strath terraces (Bryan, 1926; Bryan and others, 1934; Chronic, 1983; Haynes, 1987; Smith, 1963). Valley degradation within the last 1 My has been due to a combination of slow, regional uplift of the Central Highland Physiographic Province (Figure 9) in Arizona (Shafiqullah and others, 1980; Menges and Pearthree, 1989) and the San Pedro River's attempt to maintain a graded level or longitudinal profile of equilibrium (Mackin, 1948) as it became connected to the Gila River. During periods of temporary equilibrium the San Pedro River and its tributaries formed erosional strath terraces (Bull, 1991). Since latest Pleistocene and Holocene time, the river has deposited sediments within the axial trench of the basin. (Haynes, 1987; Hereford, 1993; Morrison, 1985). Stratigraphic investigations in the upper San Pedro River Valley by Haynes (1987) indicate that the San Pedro River has repeatedly incised and backfilled its flood plain during the Holocene (approximately 10 ka to present).

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Modern Channel Characteristics

Upper San Pedro River

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

Streamflow on the upper San Pedro River is variable spatially and temporally (Brown and others, 1981; Hirschboek, 1985; Chapter 7: This Report). Like many arid and semiarid

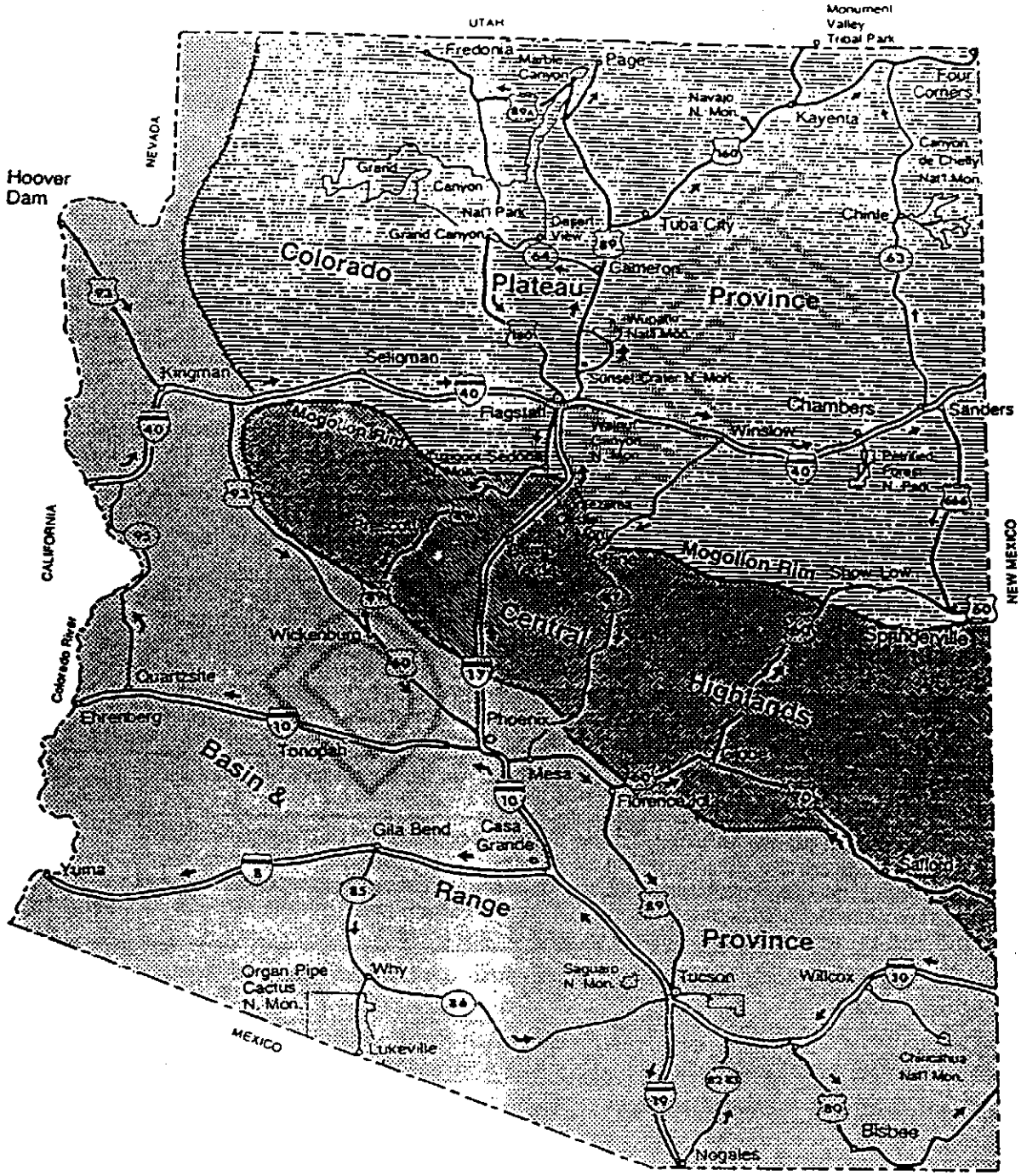

Fig 9

Figure . Physiographic Provinces of Arizona

streams, the ratio of peak annual flood to mean annual discharge is high. Based on the state surface flow map by Brown and others (1981), the reach between Hereford and 3 miles above Fairbank contains a perennial baseflow less than 10 cfs. From Fairbank to The Narrows, streamflow is intermittent.

Lower San Pedro River

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

Historical Channel Changes

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

The channel adjustment that has received the most attention in the Southwest is entrenchment or arroyo-cutting (Betancourt, 1990; Cooke and Reeves, 1976; Webb, 1985). Many alluvial streams in the region including the San Pedro River experienced extensive entrenchment in the late 19th and early 20th centuries (Bahr, 1991; Bryan, 1926; Cooke and Reeves, 1976; Hastings, 1959; Hendrickson and Minckley, 1985; Hereford and Betancourt, 1993).

Stratigraphic exposures of buried arroyos (Haynes, 1987; Waters, 1988) indicate that these rivers incised prehistorically as well.

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

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

Upper San Pedro River

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

More direct descriptions of upper San Pedro River begin with the Mexican-American War in 1846. Major Cooke (1938) and his Mormon Battalion marched along the upper San Pedro River from approximately Hereford to Benson and described it as "a fine, bold, stream" where he and his men caught "fine trout" up to 16 inches long (also in Hastings, 1959:62; Rodgers, 1965:16). During the U.S.-Mexico boundary survey if 1851, J.R. Bartlett (1854) also noted continuous streamflow in the upper San Pedro River, but he also noted that the river below St. David contained steep banks approximately 9 feet high (Bartlett, 1854; also in Hastings,

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1951, and Hereford and Betancourt, 1993). Bartlett further noted that incision limited the ability to irrigate adjacent terraces. A few years later, Parke (1857:24) noted that the upper San Pedro River was variably incised from a few cm to as much as 15 feet. Immediately upstream from The Narrows, Hutton (1859) described the upper San Pedro River as having a width of approximately 12 feet and a depth of 12 inches. Although Hereford (1993) cautions that some of these historical descriptions may be of steep banks on older terraces above the active channel, the cumulative archival evidence suggests that the upper San Pedro River was indeed discontinuously entrenched as early as 1850 (Henderson and Minckley, 1984:147), at least thirty years before the estimate of arroyo initiation made by Kirk Bryan (1926).

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

The first townships in the upper San Pedro River Valley to be surveyed were Townships T. 15, 16, and 17 S., R. 20 E., by Theodore White in 1873. He later surveyed Township T. 18 S., R. 21 E. in 1881. Very few channel measurements are provided for Townships T. 19, 20, and 21 S., R. 21 E. and Townships T. 21 and 22 S., R. 22 E. due to the private land grants, and Townships T. 23 and 24 S., R. 22 E. were not surveyed until 1901 by Phillip Contzen. Following the procedure of Burkham (1972), measurements of channel width (normal to cadastral lines) were compiled (Appendix E) and averaged for each Township (Table 5). Between St. David and The Narrows, the channel width in 1873 averaged less than 36 feet. Between the San Juan de las Boquillas y Nogales land grant and St. David, the channel width in 1881 averaged approximately 60 feet. This agrees with historical descriptions of a relatively narrow channel (Hastings, 1959; Hereford and Betancourt, 1993).

Table 5
Mean Channel Widths for the Upper San Pedro River (ft)

Township	Year	Mean
T15S R20E	1873[1] 1935[9]	35 266
T16S R20E	1873[2] 1935[9]	27 238
T17S R20E	1873[3] 1935[9]	28 285
T18S R21E	1881[4] 1935[9]	58 367
T19S R21E	-	-
T20S R21E	-	-
T21S R21E	1901[5] 1935[9]	73 492
T21S R22E	1909[6] 1935[9]	261 246
T22S R22E	-	-
T23S R22E	1901[7] 1935[9]	85 303
T24S R22E	1901[8] 1935[9]	137 321

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

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

Beginning in the 1880's and continuing into the 1890's were a series of large floods that impacted the geometry of the upper San Pedro River (Hereford and Betancourt, 1993). Large

floods occurred in 1886, 1887, 1890, and 1896. The impacts of these floods were variable, but overall they resulted in expanding the entrenched reaches upstream via knick-point retreat (Hastings, 1959; Hereford and Betancourt, 1993) and expanding channel width via bank cutting and collapse (Meyer, 1989). Cadastral survey notes confirm channel widening after 1890 (Cooke and Reeves, 1976; Appendix E). Average channel widths in Township T. 23 S., R. 22 E. and Township T. 24 S., R. 22 E. were 85 and 138 feet, respectively (Table 5). The archival record also indicate that more segments of the upper San Pedro River were intermittent after 1890 (Hastings, 1959). This change in streamflow may be related to the large Pitaycachi earthquake that shook the region in 1887 and modified spring activity in the valley (DuBois and Smith, 1980). Drought may also have affected the baseflow. Bahr (1991) notes that one of the worst droughts on record occurred 1891-1893. This drought coincided with a record number of cattle in the San Pedro Valley, and overgrazing undoubtedly increased the severity of the floods by increasing runoff and gullying (Carpenter and Bransford, 1921; Cooke and Reeves, 1976; Dobyns, 1981).

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

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

Lower San Pedro River

1697-1870. Descriptions of the lower San Pedro River during the Spanish, Mexican, and early American periods are less abundant than those for the upper reach since most of the

ranching and agricultural activity took place upstream from The Narrows. In general, descriptions of the lower reach during this period are consistent: a small unentrenched stream with low but generally consistent streamflow. The numerous Sobaipuri irrigation ditches described by Kino and Manje (Burrus, 1971) imply that the river in 1697 was unentrenched, at least at the Sobaipuri villages. They also described marshy conditions indicating shallow water tables (Henderson and Minckley, 1985). The river also contained numerous beaver ponds and edible fish (Patty, 1833).

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

1870-1933. Channel conditions changed little between 1870 and 1890 (Hastings, 1959). The first cadastral surveys were performed in the lower San Pedro Valley in 1877 and 1879 by John L. Harris. His survey notes indicate that the channel was generally less than 40 feet wide (Table 6). Moreover, survey plat maps show several "acequias" or irrigation ditches implying nonentrenchment.

Beginning in 1890, the lower San Pedro River started to change. A series of large floods in 1890, 1893, 1894, and 1896 resulted in channel cutting and widening (Hereford and Betancourt, 1993). Newspaper accounts indicate considerable farm property was lost along the river during this decade, especially near Dudleyville. Channel changes during this period are perhaps best summarized by rancher C.H. Bayless (Bahr, 1991:111) who in 1900 noted:

> About 12 years ago the [lower] San Pedro Valley consisted of a narrow strip of subirrigated and very fertile lands. Beaver dams checked the flow of water and prevented the cutting of a channel. Trappers exterminated the beavers, and less grass on the hillsides permitted greater erosion, so that within four or five years a channel varying in depth from 3 to 20 feet was cut almost the whole length of the river. Every year freshets are carrying away new portions of the bottom lands.

Table 6
Mean Channel Widths for the Lower San Pedro River (ft)

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

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

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During the early part of the 20th century, most of the lower San Pedro River was incised and the dominant process was channel widening. The first cadastral survey of Township T. 14 S., R. 20 E. was in 1902 (Table 6) and records wider channel dimensions than those in adjacent townships that were surveyed 25 years earlier. Large floods continued during this period with the largest recorded flood occurring in September, 1924.

1934-1993. The first systematic aerial photography of the lower San Pedro Valley was performed by the Soil Conservation Service in 1934. The photography reveals a shallow, braided channel within an incised flood plain. The channel is dramatically wider than in the 19th century (Appendix E; Table 6), especially downstream from Redington. The magnitude of widening during this period is greater on the lower reach, perhaps because the bank materials are coarser and more susceptible to erosion (Knighton, 1984:63; Schumm, 1977). Because of the wider, entrenched reach below Redington, changes in channel position through time are greater along this segment than any other part of the river. Channel widening has probably slowed if not stopped, and reaches below Mammoth are presently aggrading (Hereford and Betancourt, 1993).

Channel Conditions in 1912

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

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

Because much of the river was already entrenched, flood flows during the wet period of the early part of this century were largely confined within the walls of the channel. This undoubtedly increased the velocity and magnitude of floods along the river since less water was retained as storage on the vegetated flood plain (Burkham, 1976). The incised channel

also effectively concentrated flow and accentuated the erosive capacity of the river. Gravel bars within the channel deflected flow into the arroyo walls resulting in bank collapse and channel widening (Meyer, 1989). Thus the dominant channel process in 1912 was channel widening.

Although not as wide as shown in 1934 and 1935 photography, the entrenched channel of the San Pedro River in 1912 was considerably wider than what was recorded in the original cadastral survey notes of the 1870's and 1880's (Tables 5 and 6). On the upper San Pedro River, the width of the entrenched channel probably averaged between 130 and 260 feet. On the lower San Pedro River channel widths were greater and more variable. Between The Narrows and Redington, the width of the entrenched channel probably averaged 130 to 260 feet; downstream from Redington, channel width probably averaged 330 to 650 feet. The depth of the modern entrenched channel varies 16 to 82 ft throughout the San Pedro River (Kottlowski and others, 1965: Figure 1) and probably does not differ substantially from channel depths in 1912.

Ordinary Highwater Mark

Where channel conditions have not significantly changed since statehood, the limits of the ordinary highwater mark can be mapped using the current USGS topographic maps for the river. Where changes have occurred, and are not due to avulsions or are not man-made, ordinary highwater limits follow the existing channel geometry. The ordinary highwater mark was identified by topographic characteristics, slope changes at the channel margin, and vegetation changes visible on aerial photographs. For the upper San Pedro River, the lateral extent of the ordinary highwater mark is very similar to the lateral extent of the floodplain due to historic entrenchment of the river. In the lower San Pedro River, ordinary highwater marks are not necessarily similar to floodplain limits. The USGS maps were used a base map to map the ordinary highwater limits entered into the San Pedro River GIS.

Summary

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

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

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Chapter 6

San Pedro River Land Use

Introduction

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

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

Data Sources

The primary data sources for San Pedro River land ownership, land use, and improvements was information obtained from county assessors' offices, and other public agencies as described below. Leasing data was collected from ASLD (mining and other uses), BLM (agriculture and mining), and the U.S. Forest Service (grazing). Wildlife, riparian, and recreational classifications were obtained from Arizona Game and Fish Department and the U.S. Fish and Wildlife Service.

Methodology

The primary work product for the land use assessment is a GIS for the San Pedro River study reach. Geographical Information Systems combine the spatial characteristics of digital mapping with the resource information library capabilities of a database. Through a GIS, information such as land ownership (title), biological and hydrologic characteristics, land use, or other descriptive information can be tied to specific parcels or river reaches. The San Pedro GIS was constructed from assessor records from Pima County, Pinal County, and Cochise County, and other information from a GIS being constructed by ALRIS, an inter-agency group funded by the State of Arizona, and information from the BLM. However, parcel datasets for portions of the San Pedro received from Pima FCD, Cochise FCD, and BLM, but were found to be incompatible with ALRIS coordinates, and the parcels were digitized from the assessor maps.

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

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river bed as delineated on the assessor maps, though USGS maps and ALRIS's HYDRO layer were consulted as well. Where "meander lines" were delineated on assessor maps, all parcels within that area were digitized.

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

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

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

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

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

- Land Ownership
- Ordinary Highwater Mark
- Land Use

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

Land Use and Ownership

Land ownership, or current title, and land use information obtained from assessors' records other sources are shown in Tables 7 and 8. The largest percentage of land in the reach privately held. The BLM and the State are the next largest land holders. Land uses in the river valley include grazing, agricultural (orchards/crops/miscellaneous), residential, and undeveloped. The San Pedro River reach includes three land grant parcels, the San Pedro Riparian Preserve, and several Nature Conservancy holdings. The San Carlos Indian Community also claims a portion of the reach.

Table 7
San Pedro River Land Ownership

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

Table 8
San Pedro River Land Use.

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

Riparian Information

BLM provided riparian data for a portion of the San Pedro. The BLM's MOSS data file was converted to an Arc/Info coverage and was slightly reformatted. Riparian vegetation data are summarized in Table 9.

Table 9
San Pedro River Riparian Data

Land Use	Acres
Int.SW riparian deciduous forest	2486
Semidesert grassland	642
Private agricultural	199
Chihuahuan desertscrub	144
Agricultural	39
Int.SW swamp and riparian scrub	28
Chihuahuan interior marshland	3
Californian maritime marshland	26

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Chapter 7
Hydrology of the San Pedro River

Introduction

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

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

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

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Stream Reaches

The San Pedro River can be broken into two reaches with somewhat distinct hydrologic conditions (Figure 10). The two reaches meet at "The Narrows" a bedrock constriction located between the foothills of the Rincon Mountains to the west and the Little Dragoon Mountains[1] to the east. The upper San Pedro River extends upstream from The Narrows through the City of Benson, and the communities of St. David, Fairbank, Charleston, Hereford, and Palominas. The upper San Pedro River is perennial from about Hereford to Fairbank, and intermittent downstream of Fairbank. The lower San Pedro River extends downstream from The Narrows to the confluence with the Gila River, passing through the communities of Cascabel, Redington, Mammoth, and Dudleyville. The lower San Pedro River is characterized by an entrenched, broad, braided channel with only isolated reaches of perennial flow near areas of shallow bedrock.

Data Sources

Hydrologic data were derived primarily from published stream gage records of the U.S. Geological Survey (cf. USGS, 1954; 1991), historical accounts of the San Pedro River (cf.

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

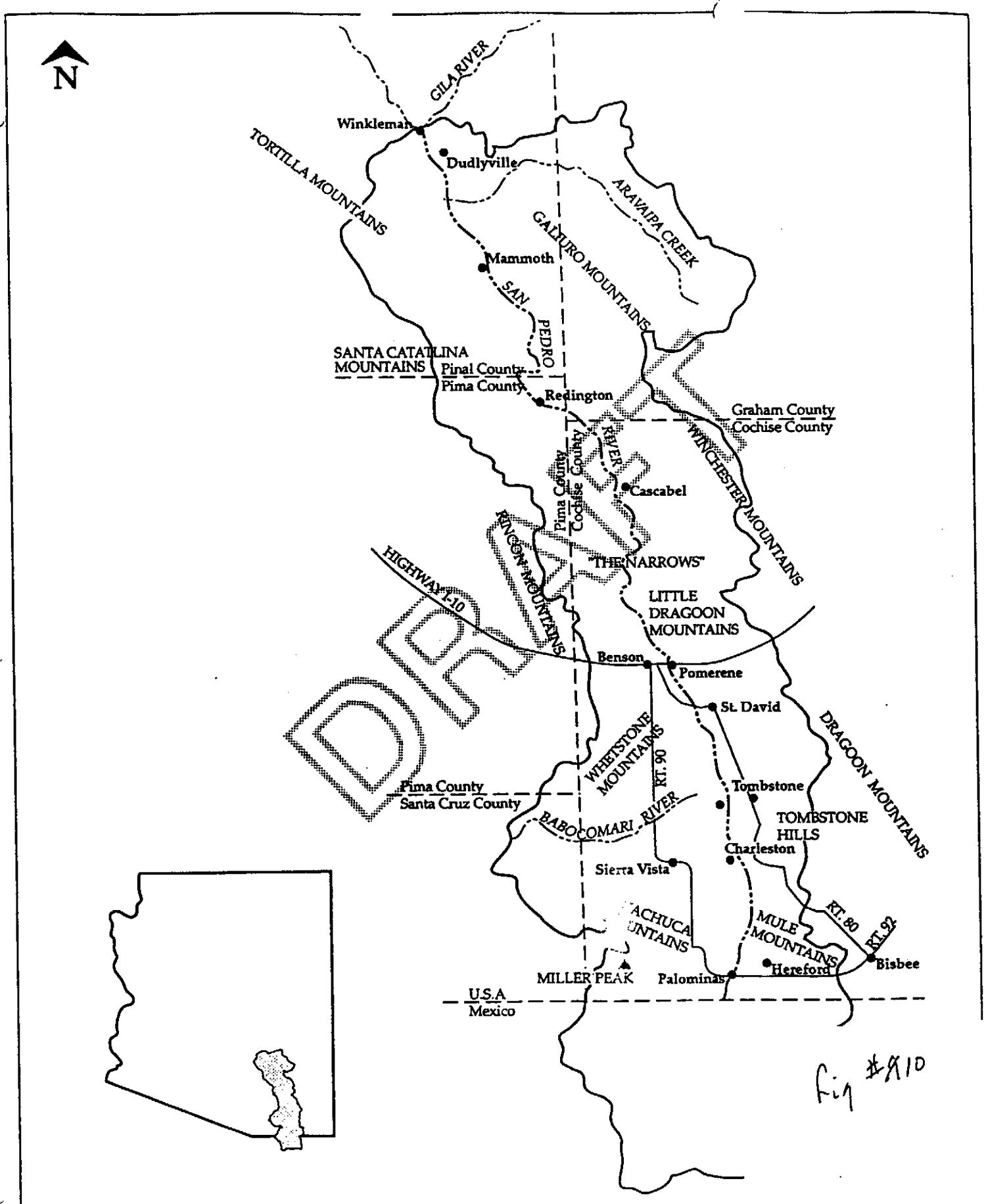

FIGURE
San Pedro Watershed Map

PHX35400.SR_30/SANPED

Dobyns, 1981; Davis, 1981), and other reports on the hydrology of the San Pedro River (cf. ADWR, 1991). More detailed descriptions of archeological and historical records, stream geology and geomorphology, boating, navigability criteria, and land use of the San Pedro River basin are summarized elsewhere for this study.

Hydrologic Setting

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

Climate conditions in the San Pedro River watershed vary with elevation, though the entire basin may be classified as semi-arid. Annual precipitation in bimodally distributed with about 55 percent occurring between July and August, and 20 percent occurring between December and February. Lower elevations receive about 15 inches of precipitation annually, but precipitation at higher elevations can reach 25 or more inches. Peak precipitation occurs from about July to September, during summer "monsoon" rainstorms caused by orographic release of tropical moisture entering the watershed from the Gulf of Mexico. A slight increase in average monthly rainfall occurs during winter months due to cyclonic storms originating over the Pacific Ocean. Tables 10 and 11 illustrate the temporal and areal variation of recorded precipitation and temperature within the watershed.

Table 10
Climatic Data for San Pedro River Watershed Stations

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

Table 11 Seasonal Climatic Variation in the Salt River Watershed. Precipitation (Inches) and Temperature (°F)			
Month	Winkelman 1942-1980 elev.=1,325 ft.	Benson 1900-1975 elev.=3,314 ft	Bisbee 1900-1982 elev.=5,410 ft.
January	1.3	0.7	1.1
February	1.1	0.8	1.3
March	1.1	0.5	1.0
April	0.4	0.2	0.5
May	0.3	0.1	0.2
June	0.3	0.3	0.7
July	2.0	2.7	4.0
August	2.6	2.8	4.7
September	1.5	1.3	1.8
October	1.3	0.6	0.9
November	0.9	0.6	0.8
December	1.4	0.7	1.4
Annual	14.1	11.4	18.4
SOURCE: Sellers et al, 1989			

Vegetation along the San Pedro River is predominantly Sonoran desert scrub in the lower reaches, with Chihuahuan desert scrub in the upper reaches. Historically, the upper San Pedro Valley was Chihuahuan desert grassland but has since been invaded by woody shrubs and other species (Huckleberry, 1993). Since the late 1800's riparian vegetation, such as cottonwood, willow, tamarisk, and mesquite have populated the river corridor (Hastings and Turner, 1965). At higher elevations oak woodland and mixed conifer species are found.

The hydrology of the San Pedro River is also impacted by irrigation diversions, ground water pumping, evapotranspiration (cf. ADWR, 1991), ground water-surface water interactions (cf Stetson, 1987), and watershed impacts including grazing, timber, and fire (Dobyns, 1978).

Statehood/Pre-Statehood Hydrology

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

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

However, for the purposes of analysis of the hydrology of the San Pedro River at statehood, it is important only to note that this transformation was substantially completed by 1912 (cf Cooke and Reeves, 1976; Hereford and Betancourt, 1993; Haury et al, 1959). By 1912, beaver were no longer found on the river, large fish were all but eliminated, and a deep arroyo had formed over most of the study area (Dobyns, 1978), leaving the San Pedro river channel as a braided stream winding back and forth on a sandy bed located within an entrenched floodplain (USGS, 1901). Furthermore, most investigators believe these channel changes to be, at least in part, caused by natural forces (cf. Cooke and Reeves, 1976; Hastings and Turner, 1965). Therefore, natural stream conditions as of statehood were probably not dissimilar to existing stream conditions.

Streamflow measurements. Four USGS gaging stations (Figure 11) were operated prior to or during 1912: (1) San Pedro at Charleston; (2) San Pedro near Fairbank; (3) San Pedro at Fairbank; and (4) San Pedro at Winkelman. Unfortunately, none of the stations were in operation during February 1912.

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

- The San Pedro near Fairbank station was operated downstream of a diversion dam for irrigation on the Boquillas Ranch. Stream flow

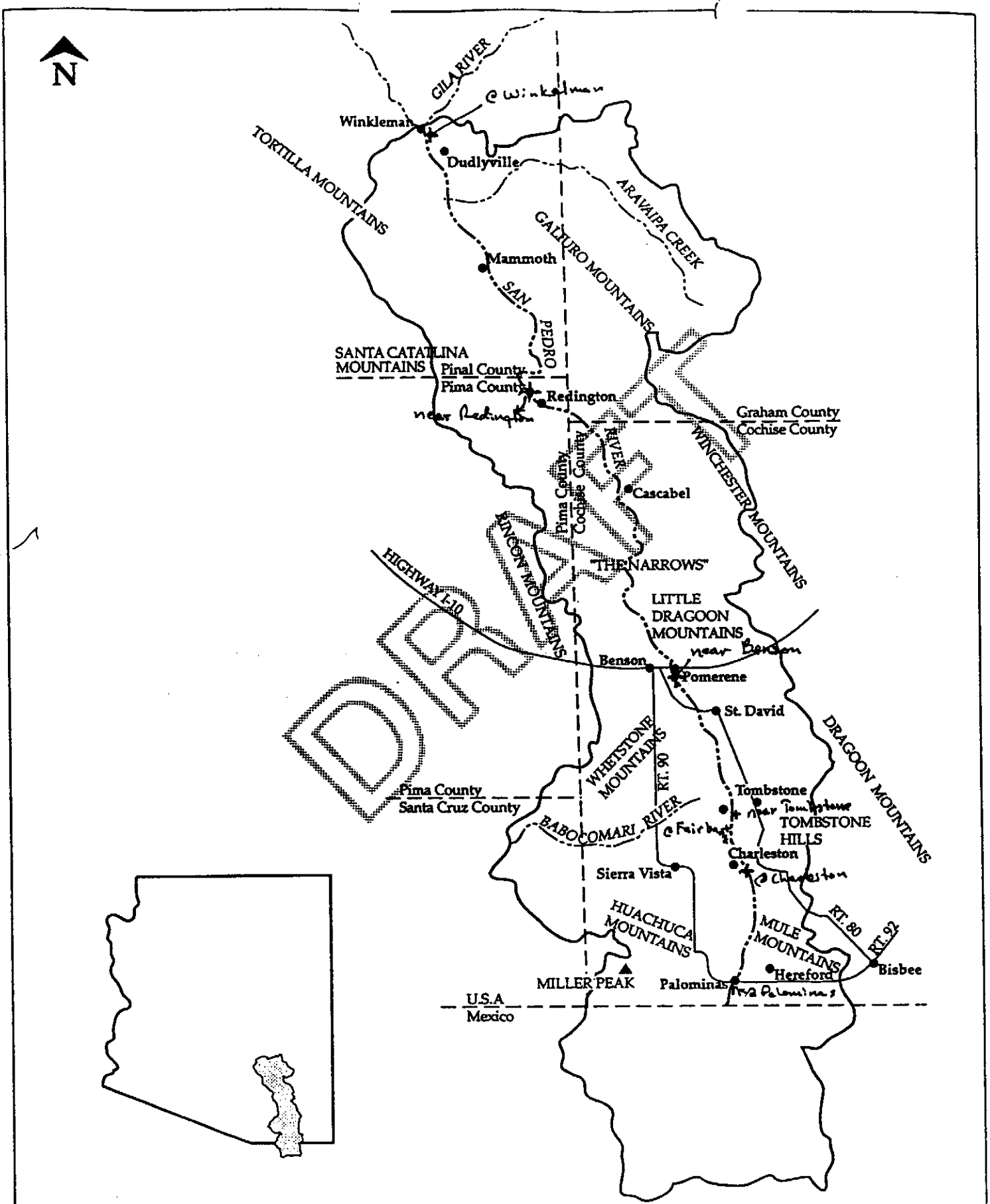

FIGURE 14

Location of San Pedro River Gages

PHX35403.SR.30/SANPED

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

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

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

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

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

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

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

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

Post-Statehood Hydrology

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

Gage Records. Streamflow records for nine gaging stations are available for the San Pedro River, not including tributaries (Table 12). Sufficient data to develop statistical streamflow summaries are available for six of these stations (Tables 13 and 14).

Table 12
San Pedro River USGS Streamflow Gaging Stations

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

Sources: USGS, 1914; 1954; 1991

Flow Duration Curves. A flow-duration curve shows the percentage of time (frequency) during some time period studied that a specified rate of flow was equaled or exceeded. The curve also provides a useful method for analyzing the availability and variability of streamflow. That is, the slope of a flow-duration curve is a good indication of the capacity of a basin to store water. Storage of water in alluvium or bedrock aquifers tends to lower the variability of the flow by reducing the peak flows and spreading the same volume of runoff over a longer time period. A steeply sloping flow duration curve indicates high variability in flow rates and small amounts of natural storage, and gently sloping curve indicates a low variability, which is characteristic of a consistent component of base flow per unit drainage area (Owen-Joyce and Bell, 1983). The station at Palominas and the stations from Benson downstream have steeply sloping flow duration

curves. These stations correspond to the intermittent reaches of the river. The Charleston and Tombstone station have less steeply sloped flow duration curves, though they are steep compared to Arizona rivers such as the Verde. All of the stations converge for low frequency events (less than 20%), indicating a similar flood hydrology for the entire river.

Table 13
San Pedro River Streamflow Statistics (cfs)

Gage	Average Annual[a]	90% Flow Rate	50% Flow Rate	10% Flow Rate
Palominas	32	35	27	0
Charleston	59	77	14	4
Tombstone	56	82	13	0
Benson	32	41	0	0
Redington	45	55	1	0
Winkelman	44	52	3	0

Average Flow Rates. Monthly and average annual flow rates at San Pedro River gage stations are shown in Table 14. Floods with high peaks tend to skew the average as indicated by median flow rates and flow duration statistics shown in Table 13. However, average flow rates are useful for showing spatial and temporal variation of streamflow during the year at various locations in the study area. The skew of average rates is best illustrated at the Benson, Redington, and Winkelman stations were the median flow rates (50% duration) in this intermittent reach are close to zero, but average flow rates are about 40 cfs.

Table 14
Average Flow Rates, San Pedro River (cfs).

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

Sources: USGS (1954; 1991)
NOTE: Compare average and median flow rates, as in Table 13.

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

- Most of the San Pedro River between Hereford and the St. David Irrigation ditch is perennial. Only about four miles of the river downstream of St. David is perennial.
- The few springs in the study area discharge at rates of only a few gallons per minute (0.002 cfs).
- Ground water in the San Pedro River basin flows toward or into the San Pedro River.
- Surface water flows are highly variable, with the major component of flow (including base flow) resulting from direct response to precipitation.

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

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

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

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

Hydraulic Rating Curves

Hydraulic rating curves relate stream discharge to flow depth, width, and velocity. Two sources of information were used to develop rating curves for the San Pedro River: (1) historical measurements of stream stage, velocity, and discharge taken around the time of statehood by the USGS; and (2) recent streamflow characteristics recorded by USGS field personnel working at stream gage stations still in operation. A typical rating curve for the San Pedro River is shown in Figure 12; locations of San Pedro stream gages are shown in Figure 11; documentation on rating curves is attached in Appendix F.

Historical streamflow data were available from the Charleston (1904-1906), and (near) Fairbank (1915-1924), stations. To reconstruct rating curves from stage, velocity, and discharge readings from the period of record closest to statehood was tabulated. Stream stage was then related to average stream depth. Finally, other streamflow parameters such as topwidth and velocity were estimated using Manning's equation[4], assuming a rectangular channel. Rating curves were then developed and compared to monthly and annual streamflow statistics, as illustrated below.

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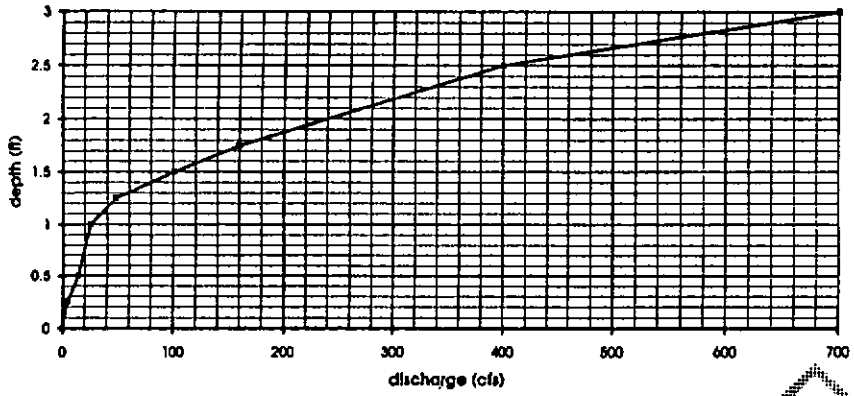
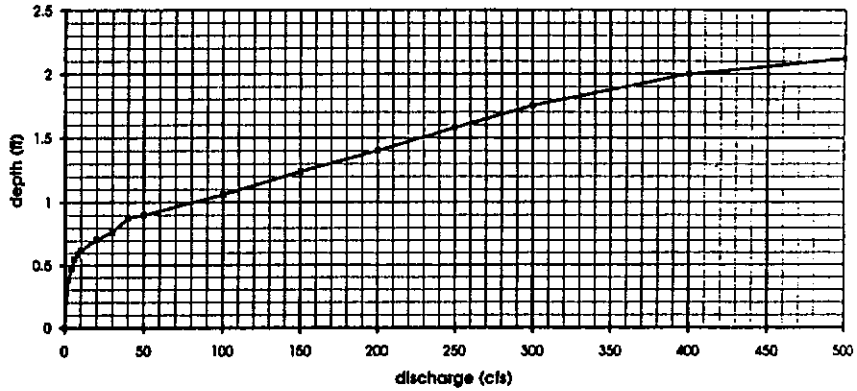
[4] Manning's equation: $Q = 1.49\ A/n\ R^{0.67}\ S^{0.5}$; where: Q = Discharge, cfs; A = Flow Area, ft^2; n = roughness coefficient; R = hydraulic radius, ft.; S = channel slope, ft/ft.

San Pedro River at Charleston (1904 to 1906)



San Pedro River near Fairbank (1915 to 1924)



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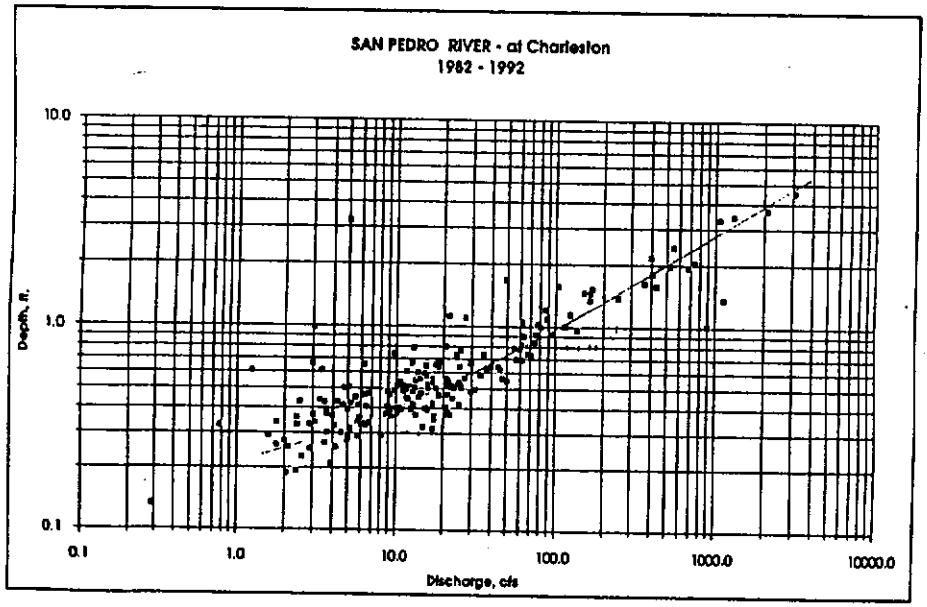

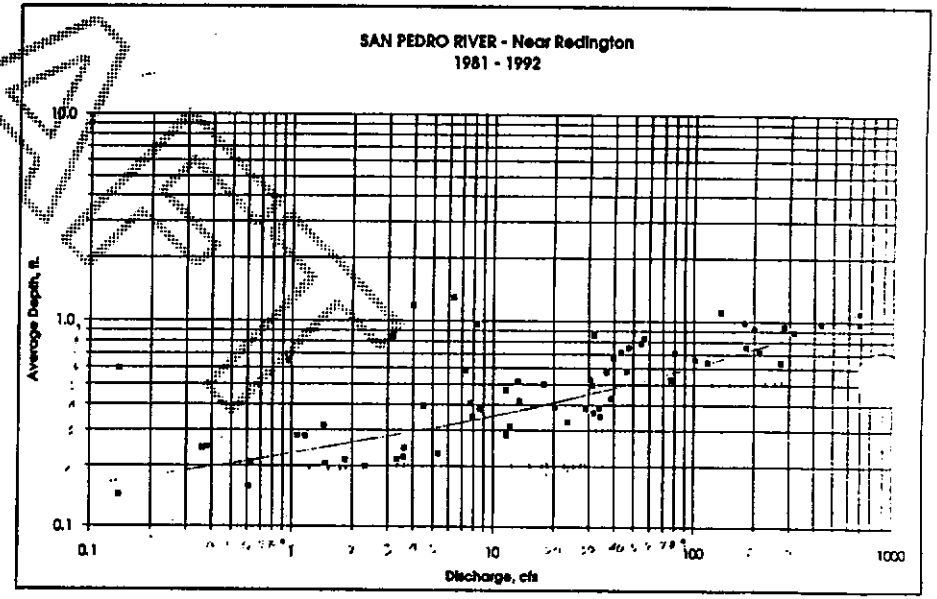

Recent streamgage measurements were available for the Redington (10/81 to 10/92) and Tombstone (9/81 to 10/86) gages. Field measurements of stream width, velocity, topwidth, and velocity were entered into a data base and a rating curve was fit to the data. Hydraulic characteristics for monthly and average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

Summaries of the data from the rating curves for each station are shown in Tables 15 to 19. These data are intended to be representative of the following reaches:

- Upper San Pedro River: Charleston (Table 15, Historical Data); Charleston (Table 16, Recent Data); Fairbank (Table 17, Historical Data); Tombstone (Table 18, Recent Data)

- Lower San Pedro River: Redington (Table 19, Recent Data)

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

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Table 15a
San Pedro River at Charleston, 1904 to 1906
Average Hydraulic Characteristics

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

NOTE: Discharges from entire gage record: 1904-1991

Table 15b
San Pedro River at Charleston, 1904 to 1906
Flow Duration Hydraulic Characteristics

Flow Period	Flow Rate (cfs)	Average Depth (ft)	Velocity (ft/sec)	Topwidth (ft)
Average Annual Flow	59	1.3	4.3	10
90% Flow	77	1.4	4.4	12
50% Flow	14	0.5	3.0	5
10% Flow	4	0.2	2.5	3

Table 16a
San Pedro River at Charleston Gage #09471000
Average Hydraulic Characteristics

Month	Flow Rate (cfs)	Average Depth (ft)	Velocity (ft/sec)	Topwidth (ft)
January	38	0.7	1.7	37
February	28	0.6	1.5	33
March	24	0.5	1.4	31
April	13	0.4	1.2	23
May	9	0.4	1.1	19
June	3	0.3	0.9	10
July	148	1.2	2.3	60
August	233	1.4	2.7	69
September	91	0.9	2.1	50
October	40	0.7	1.7	38
November	18	0.5	1.3	28
December	50	0.7	1.8	41
Annual	59	0.8	1.9	43

NOTE: Discharges from entire gage record: 1904-1991

Table 16b
San Pedro River at Charleston, Gage #09471000
Flow Duration Hydraulic Characteristics

Flow Period	Flow Rate (cfs)	Average Depth (ft)	Velocity (ft/sec)	Topwidth (ft)
Average Annual Flow	59	0.79	1.9	43
90% Flow	77	.88	2.0	48
50% Flow	14	.44	1.3	24
10% Flow	4	.30	0.95	12

Table 17a
San Pedro River at Fairbank, 1915 to 1924
Average Hydraulic Characteristics

Month	Flow Rate (cfs)	Average Depth (ft)	Velocity (ft/sec)	Topwidth (ft)
January	56	0.9	3.0	20
February	45	0.9	2.9	17
March	37	0.9	2.8	15
April	15	0.7	2.4	9
May	8	0.5	2.2	6
June	4	0.5	2.0	5
July	104	1.1	3.3	29
August	160	1.3	3.7	34
September	58	0.9	3.0	20
October	95	1.0	3.2	28
November	16	0.7	2.4	9
December	63	1.0	3.0	22
Annual	56	0.9	3.0	20

NOTE: Discharges derived from San Pedro near Tombstone gage.

Table 17b
San Pedro River near Fairbanks, 1915 to 1924
Flow Duration Hydraulic Characteristics

Flow Period	Flow Rate (cfs)	Average Depth (ft)	Velocity (ft/sec)	Topwidth (ft)
Average Annual Flow	56	0.9	3.0	20
90% Flow	82	1.0	3.2	25
50% Flow	13	0.7	2.4	9
10% Flow	0	0	0	0

Table 18a
San Pedro River: Near Tombstone, Gage 09471550
Average Hydraulic Characteristics

Month	Flow Rate (cfs)	Average Depth (ft)	Velocity (ft/sec)	Topwidth (ft)
January	56	0.5	1.9	58
February	45	0.5	1.8	53
March	37	0.5	1.7	48
April	15	0.4	1.4	28
May	8	0.3	1.3	16
June	4	0.3	1.2	9
July	104	0.6	2.1	72
August	160	0.8	2.4	84
September	58	0.5	1.9	59
October	95	0.6	2.1	70
November	16	0.4	1.5	29
December	63	0.5	1.9	61
Annual	56	0.5	1.9	58

Table 18b
San Pedro River: Near Tombstone, Gage 09471550
Flow Duration Hydraulic Characteristics

Flow Period	Flow Rate (cfs)	Average Depth (ft)	Velocity (ft/sec)	Topwidth (ft)
Average Annual Flow	56	0.5	1.9	58
90% Flow	82	0.6	2.0	66
50% Flow	13	0.4	1.4	24
10% Flow	0	0	0	0

Table 19a
San Pedro River: Near Redington, Gage 09472000
Average Hydraulic Characteristics

Month	Flow Rate (cfs)	Average Depth (ft)	Velocity (ft/sec)	Topwidth (ft)
January	33	0.5	2.2	27
February	22	0.4	1.9	21
March	16	0.4	1.7	18
April	4	0.3	1.1	8.5
May	1	0.3	0.8	5.7
June	2	0.3	0.9	6.0
July	103	0.6	3.1	50
August	215	0.8	3.6	74
September	50	0.5	2.6	33
October	51	0.5	2.6	33
November	4	0.3	1.1	8
December	36	0.5	2.3	28
Annual	45	0.5	2.5	31

Table 19b
San Pedro River: Near Redington, Gage 09472000
Flow Duration Hydraulic Characteristics

Flow Period	Flow Rate (cfs)	Average Depth (ft)	Velocity (ft/sec)	Topwidth (ft)
Average Annual Flow	45	0.50	2.5	31
90% Flow	55	0.5	2.6	35
50% Flow	0.6	0.2	0.6	4
10% Flow	0	0	0	0

Rating curves of depth vs. discharge for high flow conditions have been developed by the BLM (1987) for seven locations between Hereford and St. David. BLM rating curves are based application of Mannings' equation to surveyed cross section information. These rating curves probably have little applicability to navigability since flows in excess of 1,000 cfs occur less than one percent of the time, according to flow duration statistics, and

because no flow velocities are given. In general, the BLM curves agree with the low flow rating curve data summarized in Tables 15 to 19, in that low flows are about two feet deep or less. The BLM cross section data also predict flow depths of 5 to 10 feet for the 2-year flood. BLM cross section plots are attached in Appendix E.

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

Floods

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

Flood Recurrence Intervals. Flood discharge rates at various key concentration points are listed in Table 20. Flow rates obtained from Flood Insurance Studies (FIS, 1989; 1990) are based on rainfall runoff modeling and are significantly different from flow rates determined by the USGS (1991) using streamflow records.

Table 20
Summary of San Pedro River Flood Frequency Discharges (cfs)

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

Source: FEMA, 1989; 1990; USGS, 1991

Historic Floods. The largest floods recorded at USGS gaging stations are summarized in Table 21. USGS (1991) gage records site the 1926 flood as the largest since 1906. However, no estimates of the magnitude of the 1906 event. All of the largest floods on the San Pedro River have occurred during late summer. Dobyns (1978) also records that large floods on the San Pedro River occurred in 1833[5] 1868, 1874, 1880, 1887, 1890, 1891 prior to gaging by the USGS. Dobyns claims that the flood of 1890 caused the "death of the San Pedro River", which removed or drained numerous swamplands along its course. The 1891 flood may have actually been larger than the 1890 flood, but the newly entrenched channel of the San Pedro conveyed the flood more efficiently (Dobyns, 1978).

Table 21
Dates and Discharges of Large San Pedro River Floods (cfs)

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

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

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

data were available in this reach. These average velocities do not exceed federal maximum recommended velocities for floating-type boats such as canoes. However, other river conditions during floods, such as floating debris, could indeed making boating in flood waters hazardous.

Irrigation

The first irrigation diversions on the San Pedro River date back to 500 to 1500 A.D., and were operated by Hohokam Indians who lived near the Babocomari River confluence (Wilken and Galante, 1987). In the late 1600's, Father Kino noted the extensive irrigation systems of the lush agricultural area along the San Pedro Valley. Anglo irrigation of the valley dates to the 1880's, with the first diversions located on Aravaipa Creek and at St. David (ADWR, 1991). By 1900 there were about 2,500 acres of irrigated land between Palominas and Winkelman, although much of this land was irrigated from artesian wells (ADWR, 1991). In 1899, the USGS (1901) reported that 3,160 acres were irrigated[6] from ten canals 1.5 to 2 miles in length, and that the lower San Pedro River was dry due to the large number of small canals. Today, the majority of irrigation water is pumped from the subsurface to supply water to more than 20,000 acres of farmland, although some surface water diversions remain (Table 22).

Table 22
San Pedro River Surface Water Irrigation Diversions

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

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

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

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

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

Summary

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

Chapter 8

Boating on the San Pedro River

Introduction

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

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

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

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Federal Criteria for Navigability

The federal government has not yet published universally applicable criteria to explicitly define title navigability. Rather, specific agencies use criteria defining title navigability that have been developed at the state level based on case law. These criteria vary somewhat from state to state. However, some federal agencies have formally described stream conditions which favor various types of boating. One such description was developed by an intergovernmental task force, the Instream Flow Group, to quantify instream flow needs for certain recreational activities, including boating (US Fish and Wildlife, 1978). The US Department of the Interior independently developed its own boating standards (Cortell and Associates, 1977). These federal criteria, summarized in Tables 23 and 24, were developed primarily for recreational boating (transport of people), not necessarily for commercial boating. Minimum stream conditions required are summarized in Table 23. Minimum and maximum conditions are summarized in Table 24.

Table 23
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 24 Minimum and Maximum Conditions for Recreational Water Boating						
Type of Boat	Minimum Condition			Maximum Condition		
	Width	Depth	Velocity	Width	Depth	Velocity
Canoe, Kayak	25 ft.	3-6 in.	5 fps	-	-	15 fps
Raft, Drift Boat	50 ft.	1 ft.	5 fps	-	-	15 fps
Low Power Boating	25 ft.	1 ft.	-	-	-	10 fps
Tube	25 ft.	1 ft.	1 fps	-	-	10 fps
Source: Cortell and Associates, 1977						

Some Arizona boaters surveyed for this study did not agree with the minimum velocity criteria given in Table 24. They argue that since boats can be used on lakes and ponds which have no measurable (zero) velocity, no real minimum velocity exists, except perhaps for tubing. Minimum velocities in Table 24 are probably intended to indicate what stream conditions are most typically considered "fun."

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

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

No documentation of application of these guidelines by the BLM in Arizona was uncovered, although BLM apparently did not consider the Salt River navigable at statehood due to the closure of Roosevelt Dam (BLM, 1964). No evidence of any other federal agency's decision of navigability for the San Pedro River was found for this study.

Historical Accounts of Boating

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

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

Several accounts of floating logs down other Arizona rivers are also documented. Review of historical records of boating gives the general impression is that there was no shortage of boats in certain parts of Arizona as of the time of statehood. Whenever a boat was needed to cross a flooded river, even during the period of early exploration, boats were borrowed from local residents, used and returned.

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

Historical Accounts of Fish

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

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

Modern Accounts of Boating

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

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

indicates that canoes could have been used as of the time of statehood.

The Central Arizona Paddlers Club (CAPC), an organization of boaters, recently conducted a survey of their members to determine what rivers had been boated. With 20 percent of members responding, the survey indicated that the San Pedro from Palominas to Hereford Road has been boated in recent years (Central Arizona Paddlers Club, 1992). CH2M HILL informally polled CAPC members willing to be interviewed to determine flow conditions at the time the San Pedro River was boated. Data collected in this poll reveal that all of the San Pedro River except the reach from Mammoth to Aravaipa Creek, and from Curtis to I-10 have been boated at least once. A brief summary of the CAPC poll showing reaches and flow data is presented in Table 25 (See Appendix G).

Although the San Pedro River has been boated, Arizona State Parks Department classified the river as a hiking or general recreation reaches (1989). Some boaters who have travelled on the San Pedro River described driving to the reach and waiting for summer monsoons to occur before being able to float the stream. Others have attempted to float some reaches merely on base flow. All but one of the modern, documented boating excursions on the San Pedro River occurred in the month of August, during the monsoon season. A boating guide to the southwest does not list the San Pedro River (Anderson and Hopkinson, 1982).

Table 25
Central Arizona Boaters Club
Survey Results: Selected San Pedro Reaches Boated

River	Reach	Date mo-yr	Flow (cfs)	Depth (ft)	Width (ft)	Craft	Portage (%)
San Pedro	Mexican Border to Palominas	8-92	n.a.	< 1	< 15	Kayak	50
	Palominas to Hereford Rd.	8-92	12	< 1	< 10	Kayak	50
	Hereford to Highway 90	1-93	n.a.	< 5	< 40	Rubber Raft	0
	San Pedro Preserve	8?-92	n.a.	n.a.	n.a.	Canoe	n.a.
	I-10 to Mammoth	8-73	200	> 0.5	< 20	Small Raft	5
	Aravaipa Ck. to Hayden	3-79	1,000	1.5	< 120	Canoe	0

It is noted that for all of the instances of boat use on the San Pedro River, the boaters travelled downstream or across the river. No evidence of boating in the upstream direction was found. The type of boats typically used were low-draft boats, such as canoes, kayaks, or inflatable rafts. Information presented in Table 26 summarizes probable stream characteristic required to support use of the type of boats available at statehood. The criteria for canoes available as of the time of statehood are not substantially different from criteria for canoes available today.

Table 26 Flow Requirements for Pre-1940 Canoeing	
Boat Type	**Depth**
Flat Bottomed (Wood or Canvas)	4 in.
Round Bottomed (Wood or Canvas)	6 in.
Source: Slingluff, J., 1987	

Navigability Decisions

No evidence of any federal or other formal decisions of title navigability for the San Pedro River were discovered.

Summary

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

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

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Chapter 9
Conclusions

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

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

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

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

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

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

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

river. Flow rates which would result in greater flow depths generally occur during floods or brief periods of higher flow.

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

Whether the San Pedro River was susceptible to navigation as of the time of statehood is a function of how the State's definition of navigability is applied. Specific questions which must be addressed include:

- Duration of Ordinary and Natural Flow. Median flow rates generally would not meet federal criteria for recreational boating due to low flow depths in most reaches. However, months of higher flow that typically occur during summer monsoons could create periods of sufficient flow to meet federal criteria. The duration of boatable flow depths would vary unpredictably from year to year, in response to monsoonal weather patterns.

- Susceptible Streamflow Conditions. Whether a stream conditions would be susceptible to navigation depends on the type of boat that is considered as evidence of navigability. In 1912, as for today, canoes could operate in shallower, narrower streams than could steamboats and barges, although both types of boats were used for commercial purposes in various parts of the United States.

- Ordinary Highwater Mark. Specific criteria for identifying the ordinary highwater mark have not yet been described, nor has an existing agency definition of the ordinary highwater mark been identified.

No documented record of use of the San Pedro River for navigation on water was found. It is unlikely that the river would be, or was, susceptible to most types of boating, under median flow conditions during most months of the year, though hydraulic ratings of the channel indicate that some types of boating could occur in some reaches during portions of some years.

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Appendix A
Agency Contact List

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Appendix B
General Bibliography for San Pedro River

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Appendix C
Note on Historical Sources

A Note on Historical Sources for San Pedro River

The primary libraries for historical research in Arizona are (1) the Arizona State Library and Archives, (2) the Arizona Historical Society libraries in Tucson and Phoenix, (3) the University of Arizona Library, especially the special collections, (4) the Hayden Library at Arizona State University, especially the special collections and the Arizona Historical Foundation, which maintains an office in the Hayden Library. The Salt River Project maintains archives that are important in documenting the history of the San Pedro and other rivers. The Cline Library at Northern Arizona University and the library of the Museum of Northern Arizona have secondary sources, but with regard to the San Pedro River, duplicate the holdings of the libraries at the University of Arizona and Arizona State University. It should be noted that the computerized card catalog at the Cline Library at NAU can access the collections of the other university libraries in Arizona.

The San Pedro River and Valley are one of the key case studies in Hastings and Turner's (1965) *The Changing Mile*, a study of environmental changes in southern Arizona during historic times. Hastings and Turner reviewed virtually all of the historical descriptions of the San Pedro and rephotographed historic views of southern Arizona landscapes to document arroyo cutting and changes in vegetation. Dobyns (1981), Hastings (1959b), and Hereford and Betancourt (1993) also explore the theme of environmental changes along Sonoran Desert rivers. A similar study by Davis (1982) documents wildlife observed by American explorers in Arizona, and contains numerous and extensive accounts of the San Pedro. Hadley, Warshall, and Bufkin (1991) prepared a history of the ecology of Aravaipa Creek, a major tributary of the San Pedro. This volume deals tangentially with the San Pedro from prehistoric times to the present, and is especially useful in discussing the history of Camp Grant, which is located at the junction of the Aravaipa and the San Pedro.

Other secondary sources that provide general overviews on the history of the San Pedro River include Walker and Bufkin's (1986) *Historical Atlas of Arizona* and Herbert and Campbell's (1986) timeline and social history of the San Pedro River. Hoffman (1982), Jackson (1987), and Powell (1980) are similar secondary works that reference San Pedro River history. Barnes (1988) and Granger (1984; 1985) contain historical information on place names in Arizona. Fulton (1966), Fulton and Bahre (1967), Tiller (1982), and Varney (1980) have information on the mining and milling towns along the San Pedro.

Di Peso (1953) is the best overview of Native American use of the San Pedro Valley. Other useful sources on the historic Native American occupation of the valley are Basso (1983), Bandelier (1890, 1890-92, 1892), Browning (1982), Ezell (1983), Fontana (1983), Hackenburg (1983), and Ogle (1970).

The Coronado expedition has an extensive bibliography (Bolton 1916, 1949, 1990; Day 1964; Di Peso 1951; Haury 1984; Hodge 1933; Hodge and Lewis 1907; Riley 1985; Sauer 1932, 1937; Schroeder 1955, 1956; Udall 1984, 1987; Undreiner 1947; Winship 1896), but a recent study by the National Park Service (NPS 1991) indicates a great deal of uncertainty about Coronado's Route through the region. Di Peso (1953) is a historical archeaological study of Spanish attempts first to

missionize and then to colonize the San Pedro and is a thorough account of the history of the San Pedro from the late 1600s to 1800. The missionary activities of Father Eusebio Kino are discussed in many books and articles (Bolton 1916, 1936, 1948, 1960; Burrus 1965, 1971; Kessell 1966a; Smith, Kessell, and Fox 1966). Officer's (1987) study of the Spanish and Mexican period in Arizona provides information on the Spanish and Mexican exploration of the area and is a useful source on Mexican land grants. Hammond (1929), Kessell (1966b, 1966b), Mattison (1946), Thomas (1932, 1941), Williams (1986), and Wyllys (1931) contain information on the San Pedro Valley in the Spanish Period.

James Ohio Pattie's (1883) journal is essentially the only firsthand account of early nineteenth-century fur trappers' use of the San Pedro, but given Pattie's tendency to exaggerate, secondary assessments of his writings (for example, Batman 1984) are useful.

During the Mexican War, topographical engineer William H. Emory accompanied Steven Watts Kearny down the Gila and commented on the lower San Pedro (Emory 1848). John S. Griffen, a surgeon with the expedition also mentioned the San Pedro (Griffen 1943). Philip St. George Cooke (1848, 1938, 1964, 1974), commander of the Mormon Battalion on their journey from Fort Leavenworth, Kansas, to San Diego, California, during the Mexican War, provided relevant observations about the conditions of the San Pedro River Valley in the mid-nineteenth century. Other accounts of the Mormon Battalion include Bigler (1932), Bliss (1931), Golder, Bailey and Smith (1928), and Tyler (1881). One of the principal routes for the forty-niners on their way to the gold fields of California ran along the present border between Arizona and Mexico, and the San Pedro was described by a number of chroniclers (Aldrich 1950; Chamberlain 1945; Clarke 1852; Cox 1925; Durivage 1937; Eccleston 1950; Evans 1945; Harris 1960; Hunter n.d.; Pancoast 1930; Powell 1931). In the 1850s, the international boundary between the United States and Mexico was formally surveyed, and the San Pedro was described again (Bartlett 1854; Emory 1857). Still later, surveys for a railroad (Parke 1857) and a wagon road (Hutton 1859; Leach 1858) resulted in descriptions of the area. Other early travelers' descriptions of the San Pedro include Bell (1932), Bell (1869), Gray (1856), Ormsby (1952), and Tevis (1954). The Surgeon General's (1870) evaluation of Camp Grant includes descriptions of the San Pedro River, as do Bourke's (1891) accounts of life at Camp Grant.

A number of early histories and boosters' descriptions of Arizona (Adams 1930; Bancroft 1888; Farish 1915; Hamilton 1884; Hodge 1877; McClintock 1916; Wallace W. Elliot & Co. 1884) might be considered primary sources. For example, Hamilton (1884), Hodge (1877), and Wallace W. Elliot & Co. (1884) are promotional literature that might be expected to publicize navigability of the rivers if it was at all feasible, but none of these volumes does. Hamilton (1884) has 14 pages of advertisements in the back, including ads for stagecoaches, but none for railroads or river transportation. Secondary sources on the history of transportation in the San Pedro Valley include Conkling and Conkling (1947) and Richardson (1925) on the Butterfield Stage and Greever (1957) and Myrick (1968, 1975) on railroads.

Newspapers were the greatest source of accounts of boating on the Salt River, but contained no accounts of boating on the San Pedro. Newspapers are on microfilm at the State Library and

Archives (as well as at the libraries of the University of Arizona and Arizona State University). The State Library and Archives has a listing of all of the newspapers published in the state. Earl Zarbin has examined Arizona newspapers published between 1859 and 1918 and compiled an index of articles relating to water in Arizona (Zarbin n.d.). Mary Lu Moore, historian with the State Attorney General's Office has a copy of this index.

General Land Office maps, located in the State Library and Archives, were made between 1873 and 1918. Maps were not made for national forests, Indian reservations, or land grants. These maps provide information on activities along the river--including Camp Grant, a parade ground, towns, a Mormon settlement, ranches, houses, barns, corrals, acequias, irrigation ditches, fields, roads, stage stations, a railroad, telegraph lines, a telephone line, a pipeline, and other sites--during the period around the time of statehood. The maps showing the San Pedro River did not illustrate any sites associated with boating.

Sanborne Fire Insurance Maps were produced for most of the communities along the river and can be found in the special collections of the Hayden Library at Arizona State University and the Library at Northern Arizona University. Like GLO maps, Sanborn Fire Insurance Maps provide information on activities along the river, but in the case of the San Pedro River did not illustrate any sites associated with navigation.

Many of the museums and libraries around the state maintain collections of photographs. Among the most extensive are those of the libraries of the state universities, the state historical societies, the state library and archives, and the Salt River Project, mentioned above. The Arizona Historical Foundation has a separate catalog of photographs in its collection. According to museum photo-archivist Boyd Nichol, the Bisbee Mining and Historical Museum has a 1908 photograph of a bridge over the San Pedro and photographs of picnics held along the river.

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Appendix D
San Pedro River Oral History

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THIS IS A GENERAL SAMPLE LETTER SENT OUT TO INDIVIDUALS AND INSTITUTIONS. SOME THINGS WERE ADDED AND OTHER THINGS DELETED DEPENDING ON WHO WAS TO GET THE LETTER.

June 15, 1993

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

Dear Ms. Cortner:

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

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

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

Sincerely,

Javier F. Torres
Ethnographer/Archaeologist

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KEY TOPICS AND QUESTIONS FOR INTERVIEWS

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

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

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

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

(5) How has the river changed historically?

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

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

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List of Oral History Contacts

4/16/93

Bisbee Mining and Historical Museum
P.O. Box 14
Bisbee, AZ 85603
Tel: 602-432-7071

The Bisbee Mining and Historical Museum does not have relevant information on river navigation. Museum secretary said that the museum photo-archivist Boyd Nichol found a photo of a bridge over the (San Pedro) river during 1908. In addition, the museum has photos of picnics that were apparently an annual event near the river. The secretary also mentioned that a major earthquake occurred around the turn of the century, maybe 1908, that realigned the water table and most of the river went underground then. She said that it drastically changed the route of the river and water accessibility. Other reasons she mentioned for the change in water accessibility were overgrazing, drought, cattle.

[The actual date of the earthquake was 1887.]

4/14/93

Cochise County Historical and Archaeological Society
P.O. Box 818
Douglas, AZ 85607
Tel: 602-364-5226

The Cochise County Historical and Archaeological Society does not have any information on navigation on the San Pedro River. Cindy Hayostek, contact person, said that Douglas is a valley over from the San Pedro River Valley, but that the Society does have a time-line for the San Pedro River Valley done by Harold E. Herbert. She mentioned a copy of this time-line would be sent to SWCA. She mentioned two references on the time-line, but that these addresses and phone numbers may be old and out of date:

Harold E. Herbert	Eric Campbell
201 Cole Ave., #3	BLM
Bisbee, AZ 85603	Fairbank, AZ
Tel: 602-432-4538	Tel: 602-457-3395

Ms. Hayostek also provided the names of two people who would be good to contact for further information:

Jerry Pratt	Mrs. Eva Moson-Bradshaw
3000 Meadowlark Drive	Y Lightning Ranch
Sierra Vista, AZ	Hereford, AZ
Tel: 602-458-0971	Tel: 602-378-2204

Mr. Pratt is a retired wildlife biologist and is very knowledgeable about the San Pedro. Mrs. Moson-Bradshaw is an elderly resident of the area and may be able to give an eye-witness account of the San Pedro at the time of statehood. Ms. Hayostek said that Mrs. Bradshaw's family was associated with Col. Green. [Although Ms. Hayostek did not elaborate on Col. Green, he was prominent in the establishment of Douglas as a mining town.]

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[The Cochise County Historical and Archaeological Society later sent a copy of the time-line.]

4/15/93

Gila County Historical Museum
P.O. Box 2891
Globe, AZ 85501
Tel: 602-425-7385

Staff person on duty, Bob Rosen, said that he didn't think that the museum had anything on navigation on the rivers in Arizona. He suggested we contact Mammoth or Winkelman because they would better places to check for information. He said that the San Pedro River was bone dry most of the time. It was the gateway into the area from Mexico and that both Father Kino and Coronado used the river as a travel corridor. He also thought that there might be a dam somewhere along it but he didn't know where it was located. He said that there were a couple of mines along the river but he didn't know how they would use the water.

7-29-93

Holy Trinity Monastery
1605 S. Saint Mary's Way
Saint David, Arizona 85630
Tel: 602-720-4642

Talked to Brother Tom of the Monastery. He said that their involvement with the San Pedro has been for conservation of riparian habitat. They don't have any information about the historical use of the river. He suggested calling the Benson Historical Museum (586-3070) or the BLM, which has a department that has collected information on the San Pedro Valley Riparian Area.

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7-26-93

McFarland State Historic Park
P.O. Box 109
Florence, Arizona 85232
Tel: 602-868-5216

Talked to Dan Brown. He didn't know of any pertinent information at the Park for the San Pedro River. He said their information was probably all related to the Gila River.

4-23-93

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

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

4-26-93

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

5-3-93

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

4-21-93

Pinal County Historical Society
P.O. Box 851
Florence, Arizona 85232
Tel: 602-868-4382

The Pinal County Historical Society does not have any information on river navigation in their records. Contacted Della Meadows (602-868-4184), historian for the Society, who said that she has no information on the rivers, knows of no historical use, but then she said she has not had a chance to verify, and will check soon. She mentioned there was farming along the San Pedro River, and that recent work regarding the preservation of the San Pedro has documented some San Pedro history. The Pinal County Museum is only 30-35 years old and has no pictures or any other type of information on mills, dams, reservoirs, etc. The museum has information on irrigation. Other information is through word of mouth. She mentioned the use of a ferry across the Gila River by Florence. The museum has the voter registration records from the late 1880s but that it was incomplete. She said that any information she would have on the river would be fairly recent.

[Ms. Meadows sent a letter on April 30, 1993, which included photographs of the Gila River ferry at Florence, copied from her book *"Where Two or Three Are Gathered": Centennial History, First Presbyterian Church, Florence, Arizona.*]

4-20-93

San Pedro Valley Arts & Historical Society Museum
P.O. Drawer 1090
Benson, AZ 85602
Tel: 602-586-3070

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According to Helen Hume, President, the San Pedro Valley Arts & Historical Society Museum, does not have any information on pre-1912 use of the San Pedro River for navigation. She said that the museum does not have information on pre-statehood use of the river. Regarding early pioneer, trappers, etc. information she said that the museum had no information either. The former museum burned down in 1982, she said, and that a large amount of material was lost, but she is unsure about what is really in the museum's archives. Ms. Hume suggested contacting the monastery in Saint David. She said the monastery had just won an award for riparian conservation along the San Pedro. Address:

Holy Trinity Monastery
1605 S. Saint Mary's Way
Saint David, Arizona 85630
(602) 720-4642

She also mentioned that her neighbor and former museum director by the name of Nedra Sunderland, 602-586-3473, was doing an oral history of the area, and that she should be contacted. Ms. Hume provided the name of one person who might be of help, and who was being interviewed by Nedra as we spoke: Louise Larson, 602-586-2964.

8-25-93

Talked to Rose Land of the San Pedro Valley Arts & Historical Society Museum. She doesn't know of any documentation at the museum that would pertain to navigability. She suggested contacting the BLM office at Fairbank or the San Pedro Riparian Conservation District for information.

4-9-93

Tombstone Courthouse State Historic Park
P.O. Box 216
Tombstone, Arizona 85638
Tel: 602-457-3311

Hollis N. Cook, park manager, sent a letter describing the archival holdings of the Tombstone Courthouse State Historic Park. He mentioned irrigation, dams, and smelters along the San Pedro. He also stated, "We find the notion of the San Pedro being navigable preposterous, however perhaps 'navigable' isn't defined in the obvious way."

7-15-93

Jay Bateman
Florence, Arizona
Tel:602-868-6442

He has lived in the area around the San Pedro all his life. He said that there used to be pretty good swimming holes in some spots along the river but he didn't know of any other recreational or commercial use of the river. His family used to joke to tourists about taking the ferry down the San Pedro and Gila to Yuma.

8-11-93

Carl Black
St. David, Az

DRAFT

602-720-4671

Mr. Black is a board member of the St. David Irrigation District. St. David was founded in 1877 and they started digging an irrigation canal that year. Originally irrigation was done from surface "ponds". The canal was finished in 1878. The District dug a new ditch in 1926; that was the last time that any major work was done by the District. A pump was put in in the early 1950s. The irrigation ditch takes water out of the river about 7 months of the year; water is pumped the rest of the time when the river is dry. The District probably has some records on the river around 1912 but Mr. Black doesn't know where they are. He thought that Lorena Merrill (720-4736), secretary of the Irrigation District, may know where the records are kept. He thinks that the LDS church in St. David probably has a lot of records on the river.

6-14-93

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

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

4-27-93

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

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

6-14-93

Mary Lou Heuett
Cultural and Environmental Systems, Inc.
Tucson, Arizona 85702-2324

DRAFT

(602) 622-2782

Ms. Heuett has done work on the Santa Cruz, Hassayampa and San Pedro, but all of this work has been archaeological. Her research has not uncovered any references on navigation for any of these rivers. She was very brief and to the point. This was all that she mentioned.

4-27-93

Ken Kimsey, Historian
P. O. Box 2549
Prescott National Forest
Prescott, Arizona 86301
Tel: 602-445-1762

Mr. Kimsey didn't feel he was knowledgeable enough regarding rivers, and suggested we consult James Ohio Pattie's journals, because Pattie rafted down the Salt River. He also suggested we talk with Mr. Polzer of the San Xavier del Bac Mission in Tucson for information on the uses of the San Pedro by Spaniards and Mexicans prior to U.S. occupation. He personally didn't think either one of those groups would have used the San Pedro for navigation because of the settlement patterns of these two groups, but that Mr. Polzer would know about specific uses of the river. He didn't have any other information but he wanted more time to think about this issue. Mr. Kimsey said he would call back as soon as he had more information.

7-27 and 28-93

Louise Larson
Benson
Tel: 602-586-2964

She has been a resident of the area for many years. Diversion dams have been built in the San Pedro river to get water for irrigation. When she was a child (she is now in her 70s) she remembers that there was only a small amount of water in the river. Only time now that there is a continual flow is when there is snow in the nearby mountains. Her parents talked about how the river used to be much narrower. When she was in 8th Grade in 1935, she made up a story for her class about taking a boat ride down the river. She said that there has never been much water in the river; irrigation, which is still practiced today, can only be done during particular seasons. A flood in 1926 washed out a diversion dam between St. David and Pomerene. The Benson Canal Company was formed in 1908 (she has some of the original records of that company). Around 1940, there was a tungsten mill on the river at Pomerene. The tungsten was mined from nearby mountains and processes at the mill but she didn't know exactly how the river water was used for the mill.

4-9-93

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

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

DRAFT

6-14-93

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

8-13-93

Dora Ohnesorgen
204 E. Walker
Benson, AZ 85602
Tel: 602-586-2873

Her grandfather had a toll ferry (raft) on the San Pedro, right below Pomerene. He also had a stage coach that ran from Tombstone to Tucson; it lasted about 2 years. Her grandfather came to the area in the 1870s. He told her father stories about beaver in the river. The grandfather had written memoirs with the help of a women named Kit(?) and Mrs. Ohensorgen thought that her brother had a copy of these (Jerry Onhesorgen 586-9135). Also, Tom Peterson who works (possibly retired now) at the Arizona Historical Society in Tucson wrote a thesis or dissertation on the area and had interviewed the Ohnesorgen family. She also mentioned a man named Albert Bernal, who is familiar with the area.

10-13-93

Terry O'Sullivan
Bureau of Land Management
Tel: 602-650-0509

Mr. O'Sullivan was asked about research done by the Bureau of Land Management on suitability of the Hassayampa and the San Pedro for designation as National Wild and Scenic Rivers. Mr. O'Sullivan said that preliminary reports on the suitability of these two rivers had been completed. According to Mr. O'Sullivan, the reports did not contain much history; instead, they focused on resource values, land use, habitat, and so forth. Mr. O'Sullivan did not know of any reference to navigation or boating in either of the reports, but he suggested talking to the authors (Don Ducote [602-722-4289] for the San Pedro and Jack Ragsdale [602-780-8090] for the Hassayampa) to see if they came across anything relating to navigability during the studies. The preliminary determinations were that the Hassayampa was not suitable for inclusion in the National Wild and Scenic Rivers System, while the San Pedro was suitable. Copies of the two reports were supplied to the Arizona State Land Department.

7-15-93

Geoff Parker
Soil Conservation Service
Route 1
Box 226
Douglas, AZ 85607

DRAFT

364-2001

He had no specific information on the historical uses of the San Pedro. He suggested contacting the USGS in Tucson where he feels is a lot of data on this river.

7-19-93

Jerry Pratt
3000 Meadowlark Drive
Sierra Vista, AZ
Tel: 602-458-0971

Jerry Pratt is a retired wildlife biologist. He said that he had heard of early trappers who used to use boats on the San Pedro. Les Goodding, who moved to Bisbee from Kansas in 1906, told Pratt stories that had been related to him and that he had experienced. Pratt said he had heard of beaver dams on the river and that he thought the river had been navigable before the big earthquake, which changed the river. He said that a good source of information was a PhD dissertation: Goode P. Davis (1982) Man and Wildlife in Arizona: The American Exploration Period 1824-1865. Published by the Fish and Wildlife Service in cooperation with the University of Arizona. Pratt also mentioned that James Herrewig, a planner with the City of Sierra Vista, had been involved with some of the historical research done by the BLM along the San Pedro.

7-26-93

Nedra Sunderland
Tel: 602-586-3473

She is active in the local historical society but said that she didn't have much information. She said that the Benson Canal come off of the San Pedro some years ago. She also said that the Ohnesorgen family had information about the river (Doris Ohnesorgen 586-2873, 586-9135). The Ohnesorgen's grandfather had a ferry across the San Pedro.

4-27-93

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

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

DRAFT

7-19-93

Dean Young
Chief Hydrologist
Arizona State Attorney General's Office
Tucson, Arizona
Tel: 602-628-8447

His experience has been with the fluvial geomorphology of the River. He doesn't have any historical data. He suggested contacting Mary Lu Moore, Research Historian for the Water Resource Adjudication Team (WRAT). Her number is 542-1401.

6-14-93 and 7-5-93

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

Mr. Zarbin sent two letters providing references to boating, ferries, and fish. These references pertained essentially to the Salt and Verde rivers. He also mentioned boating on Walnut Grove Reservoir on the Hassayampa. He did not know of any accounts of boating on the San Pedro.

DRAFT

Appendix E
San Pedro River Hydraulic Rating Curves

DRAFT

Appendix F
Arizona Climatic Variation

DRAFT

Appendix H
San Pedro River GIS

DRAFT

San Pedro River GIS Plots

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

DRAFT

Appendix H.1: Data Formats

INFO (PAT) FILE FORMAT

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

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

OWN_CODE = COUNTY+BOOK+MAP+PARCEL

RELATE FILE FORMAT (Privately owned and some agency lands)

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

SALTP PAT FORMAT (UNREVISED GIS)

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

DRAFT

RVG AND TNK PAT FORMAT

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

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

STR PAT FORMAT

TYPE	13 C
QUAD	4 C

SPVEG PAT FORMAT

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

*Identical to items in ALRIS NATVEG layer.

Land Use Categories and Codes

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

DRAFT

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

DRAFT

Appendix H.2: Data Inventory

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

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

Relate Files:

Verde:	VE_OWN
San Pedro:	SP_OWN
Hassayampa:	HA_OWN

Riparian Data

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

SALTP PAT FORMAT (UNREVISED GIS)

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

DRAFT

Appendix G
Boating on Arizona Rivers

DRAFT

Appendix I
Photographs of the Modern San Pedro River

DRAFT

Appendix J
Public Comment

DRAFT

TAB 12

96-004-008
San Pedro
River

Arizona Stream Navigability Study for the San Pedro River:

Gila River Confluence to the Mexican Border

RECEIVED 9-4-97

ORIGINAL

Prepared by

CH2M HILL

SWCA Environmental Consultants

Arizona Geological Survey

Draft Final Report
(November, 1993)

Revised By:

JE Fuller/ Hydrology & Geomorphology, Inc.

Arizona State Land Department

September 1997

Preface

This report was prepared under contract to the Arizona State Land Department Drainage & Engineering Section. The report summarizes factualinformation relating to the navigability of the San Pedro River as of the time of statehood, from its confluence with the Gila River to the Mexico border. Information presented in this report is intended to provide data to the Arizona Navigable Stream Adjudication Commission (ANSAC)from which ANSAC will make a recommendation to the Arizona Legislature regarding the navigability of the San Pedro River. This report does not make a recommendation or conclusion regarding title navigability of the San Pedro River.

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

The San Pedro River Stream Navigability Study was performed by CH2M HILL, Inc. and SWCA Environmental Consultants, Inc., in cooperation with the Arizona Geological Survey (AZGS). The study was completed under contracts #A3-0061 and #A3-0061-001 for the Arizona State Land Department on behalf of ANSAC. Project staff included V. Ottosawa-Chatupron, P.E., Ph.D., Arizona State Land Department, Project Manager; J. Fuller, CH2M HILL team leader, hydrologist, and geomorphologist; R. Borkan, SWCA team leader; D. Gilpin, SWCA, historian; M. Cederholm, SWCA, GIS specialist; P. Pearthree, AZGS team leader; G. Huckleberry, geomorphologist. Data summarized in this study were obtained from numerous agencies, libraries, and collections named in the appendixes of this report. Use of this document is governed by the Arizona State Land Department and the Arizona Navigable Stream Adjudication Commission. Revisions to the CH2M HILL report were completed by JEFuller/ Hydrology & Geomorphology, Inc.under contract #97-NROE0002 with the ASLD.

Executive Summary

CH2M HILL, in cooperation with SWCA Environmental Consultants and the Arizona Geological Survey (AZGS), was retained by the Arizona State Land Department (ASLD) to provide information to the Arizona Stream Navigability Adjudication Commission (ANSAC). JEFuller/ Hydrology & Geomorphology, Inc. was retained to revise the CH2M HILL report following amendments made to streambed legislation in 1994. ANSAC will use information provided in this report, in conjunction with information presented by others, to make recommendations of navigability or non-navigability for the Salt River to the Arizona Legislature. This report provides information on the San Pedro River between the Gila River confluence and the Mexico border.

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

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

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

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

The literature search focused on five subject areas: (1) Archaeology, (2) History, (3) Hydrology, (4) Hydraulics, and (5) Geomorphology. Archaeological data augment the historical record of potential river uses at statehood by providing an extended record of river conditions, use of river water, climatic variability, and cultural history along the rivers. Historical data provide information on actual river uses at the time of statehood, but also provide information on whether river conditions could have supported certain types of navigation. SWCA historians prepared a report summarizing use of the river and adjacent area in historic times, with special emphasis on the establishment, growth, and development of towns, irrigation systems, commercial activities, and developments. The hydrologic/hydraulic data are the primary source of information regarding susceptibility to navigation. These data

include estimates of flow depths, width, velocity, and average flow conditions at statehood, based on the historical streamflow estimates, and available modern records for natural stream conditions at statehood, as well as for existing stream conditions. Geomorphic data provide information relating to river stability, river conditions at statehood, and the nature of changes to the river since the time of statehood.

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

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

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

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

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

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

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

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

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

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

ARS 37-1128 mandates a presumption of non-navigability if certain criteria apply to the river reach. Data from this study can be summarized according to the following criteria established by HB 2589:

- **Commercial Trade and Travel**. As of the time of statehood, the San Pedro River probably was not susceptible to any forms of commercial trade and travel on water, with the possible exception of opportunistic shallow water boating during brief periods of seasonal high flow. The hydrologic record shows that there was insufficient water in the river to allow use of most types of boats during nearly all of the year.

- **Flow Regime**. As of the time of statehood, the hydrologic record shows that much of the San Pedro River was ephemeral or intermittent, with significant flows occurring only in direct response to precipitation.

- **Sustained Trade and Travel Upstream and Downstream**. There is no evidence that sustained trade and travel ever occurred on the San Pedro River. Hydraulic rating curves indicate that boat travel would have been difficult.

- **Profitable Commercial Enterprise**. There is no documented historical evidence that any profitable commercial enterprises were conducted using the San Pedro River for trade and travel as the time of statehood.

- **Types of Vessels**. The historical record indicates a ferry may have been used near Pomerene prior to (but not at or after) statehood. Since that time, only canoes and kayaks have been used on the San Pedro River. There is no evidence that keelboats, steamboats or powered barges were ever used on the San Pedro River. The hydraulic rating curves prepared for the study reach indicate that keelboats, steamboats or powered barges could not have been used during the low flow conditions that existed in 1912. During high flow conditions, high velocities and river conditions may have made use of these boats hazardous. Canoes and other highly maneuverable low-draft boats possibly could have been used with some difficulty on certain discontinuous reaches during low flow conditions in the remaining perennial reaches in 1912.

- **Diversions**. Numerous irrigation diversions existed along portions of the San Pedro River as of 1912. It is unclear whether any of the irrigated lands were covered under the Desert Land Act of 1877, although some lands are located within the San Carlos Indian Reservation.
- **Recreational Boating**. All but one (undocumented) account of boating on the San Pedro River was for recreational purposes.

- **Regular Flotation of Logs**. Logs or other material could not have been floated through the entire San Pedro River study reach as of the time of statehood..

- **Impediments to Navigation**. There were several irrigation diversion structures in 1912 that would be considered impediments to any type of boat traffic. Dry reaches of river would have been the most significant impediment to navigation.

- **Customary Modes of Transportation**. The customary mode of transportation in the region near the San Pedro River was not by boat. By 1912, alternatives to boat travel included foot, horse, mule train, wagon, and train.

- **Rivers and Harbors Act of 1899.** The San Pedro River is not one of the streams listed in the Rivers and Harbors Act of 1899.

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Chapter 1
Introduction

CH2M HILL, in cooperation with SWCA Environmental Consultants and the Arizona Geological Survey (AZGS), was retained by the Arizona State Land Department (ASLD) to provide information to the Arizona Stream Navigability Adjudication Commission (ANSAC). ANSAC will use information provided by the CH2M HILL team to make a recommendation to the Arizona Legislature on whether the San Pedro River should be classified as navigable or non-navigable.

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

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

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

Project Background

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

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

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

under the provisions of HB 2594.

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

Definition of Navigability

HB. 2594 established a definition of navigability for use in the streambed program. The data collection effort for this study attempts to provide information that would enable ANSAC to determine if a given river meets the criteria of the State's definition. The State's definition is:

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

HB 2589 specified additional criteria to be used by ANSAC when making a recommendation regarding the navigability or non-navigability of specific watercourses. ANSAC was directed to presume that a stream was non-navigable unless: (1) the watercourse was used, or was susceptible for use, for *both* commercial trade and travel, or (2)the watercourse flowed only in response to precipitation, and was otherwise dry. Furthermore, all Arizona streams are presumed non-navigable if any of the following conditions apply[2]:

- No *sustained* trade and travel occurred in *both the upstream and downstream* direction.
- No *profitable, commercial* enterprise was conducted by using the stream for trade and travel.
- Vessels typically used for commerce in 1912, such as keel boats, steamboats, or powered barges, were not used on the stream.
- *Diversions* were made from the stream to irrigate or reclaim land or to provide water to lands that are included in a Federal reclamation project or Indian Reservation that would have been inconsistent with, or would have impeded, navigation.
- Any boating or fishing was for *recreational* purposes, rather than commercial purposes.
- Any flotation of logs or other material that occurred, or was possible, could not have been *regularly* conducted for *commercial* purposes.
- There were bridges, fords, dikes, man-made water conveyance systems or other structures

[2]Emphasis added.

constructed in or across the watercourse that would have been *inconsistent with* or *impediments to navigation*.

- *Transportation* in proximity to the watercourse was *usually* accomplished by methods other than by boat.
- The United States did not regulate the watercourse under the *Rivers and Harbors Act* of 1899.

In addition, HB 2589 precludes the following types of evidence from consideration as evidence of navigability by ANSAC:

- Waters that had been appropriated for beneficial uses before the time of statehood.
- The use of ferries to cross a watercourse.
- Fishing from the banks of a river.
- Uses of the watercourse under flood conditions.

Finally, HB 2589 defines the "ordinary and natural condition" of a watercourse to include the affects of any dams, diversions, or other human impacts that existed as of the time of statehood. Also, determinations of non-navigability in a public proceeding render the entire watercourse non-navigable, unless evidence is presented to the contrary. The limits of the State's claim for any stream found to have been navigable were changed from the portion of the watercourse between the ordinary *high* water marks to the portion of the streambed between the ordinary *low* water marks.

Limit of Study

The report presents evidence of past and existing river conditions and uses for the San Pedro River from the confluence with the Gila River to the Mexican border (Figure 1-1). This report provides factual information for the study area collected from existing data sources. Where necessary or relevant, information from outside the study limits was considered as a supplement to the existing data base. No new analyses or technical evaluations were completed as part of this study. Furthermore, no interpretation of the data collect was made with respect to the title navigability of the San Pedro River. A recommendation regarding title navigability is not presented in this report, nor was it part of the scope of services for the investigation.

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

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

The objective of agency contact and the literature search was to obtain already existing information pertaining to stream navigability. These tasks included contact with various federal, state, local government and private agencies, and review of literature in public and private collections.

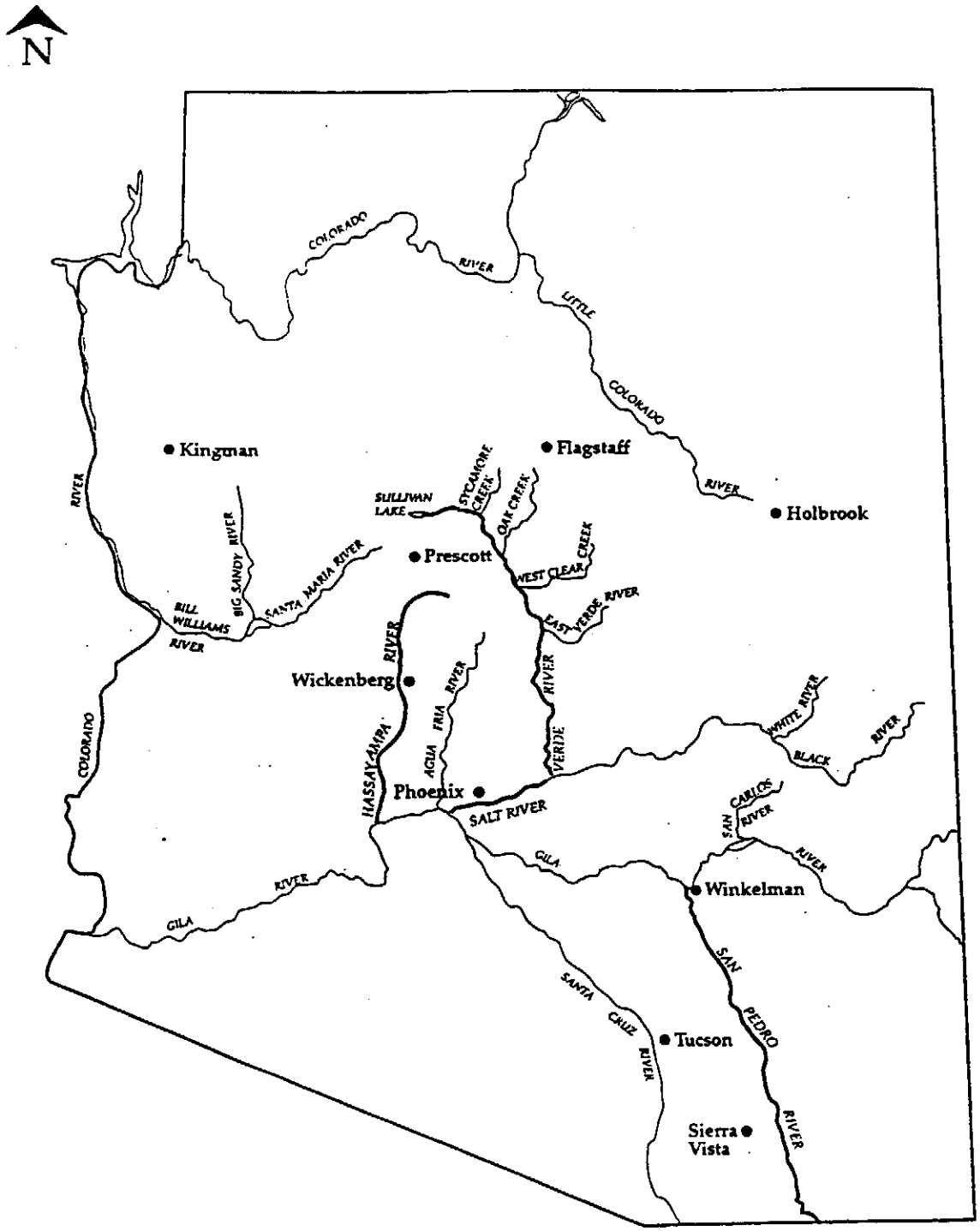

Figure 1-1

General Location Map for Arizona Stream Navigability Studies

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Information obtained during the first two tasks was then reviewed and summarized to provide information on stream conditions and activities as of the time of statehood. A database of public and private land use information was collected for use by ASLD and ANSAC in later phases of the adjudication process.

Methodology

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

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

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

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

Agency Contact

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

Historians, librarians and archivists from public and private museums, libraries, and other collections were also contacted. Letters requesting summaries of information pertaining to historical stream uses or conditions were sent to each institution, with follow-up telephone contact. Other contacts included letter and telephone requests for information to clubs,

professional organizations, special interest groups, and environmental groups. Finally, attorneys involved with previous litigation or investigations of stream navigability in Arizona were contacted to obtain information. In most cases, contacts led to other persons thought to have information pertinent to the study. Several hundred persons were contacted as part of this task (See Appendix A: List of Agency Contacts).

Literature Search

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

- Archaeology
- History
- Hydrology
- Hydraulics
- Geomorphology

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

Data Summaries

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

Archaeology

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

History

Historical data provide information on actual river uses at the time of statehood, and also provide information on whether river conditions could have supported navigation. SWCA historians prepared a report summarizing use of the river and adjacent area in historic times, with special emphasis on the establishment, growth, and development of towns, irrigation systems, commercial activities, and developments. In addition, bibliographical essays were prepared, listing those institutions that have collections relating to the history of navigability and river use, and describing the relevant collections of these institutions. Historical information on the San Pedro River is summarized in Chapter 3 and Appendixes B, C,, H and I.

Oral History

Ethnographic data, or the recollections of individuals with personal knowledge of historical conditions, supplement formal historical and archaeological records. SWCA ethnographers conducted interviews with long-time residents, professional historians, avocational historians, and professional land managers who were knowledgeable about the San Pedro River. Names of potential interviewees were obtained from historical societies, public agencies, and private organizations contacted during the agency contact task. A total of 25 interviews were conducted for the San Pedro River, and are summarized in Chapter 4 and Appendix D.

Hydrology/Hydraulics

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

Geomorphology

Geomorphic data provide information on river stability, river conditions at statehood, and the nature of river changes since statehood. A summary of the geology and geomorphology of the San Pedro River was prepared. These summaries were based on literature and other information collected during agency contact and the literature search. The objectives of these summaries were to estimate channel positions at the time of statehood, assess the possibility of and mechanism for historical

channel movement from its current position, provide evidence of geologic control of flow rates. and to estimate the location of the ordinary high water mark. A summary of geologic information is presented in Chapter 5.

Land Use

Land use data were compiled for the San Pedro River and entered in a GIS database. Land use data included existing title owner records from county assessors offices, and state and federal land leasing records from ASLD, the Bureau of Land Management, and the US Forest Service. Existing improvements, commercial activities, and present use of lands were identified from land use mapping and reports, aerial photographs, and in some cases, by field visits. Other data collected for the San Pedro River, such as ordinary high water mark limits, floodplain limits, and hydrologic data were also entered into the GIS. The GIS/Land Use task results are summarized in Chapter 6 and Appendix G.

Conclusion

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

Chapter 2
Archaeology of the San Pedro Valley

Introduction

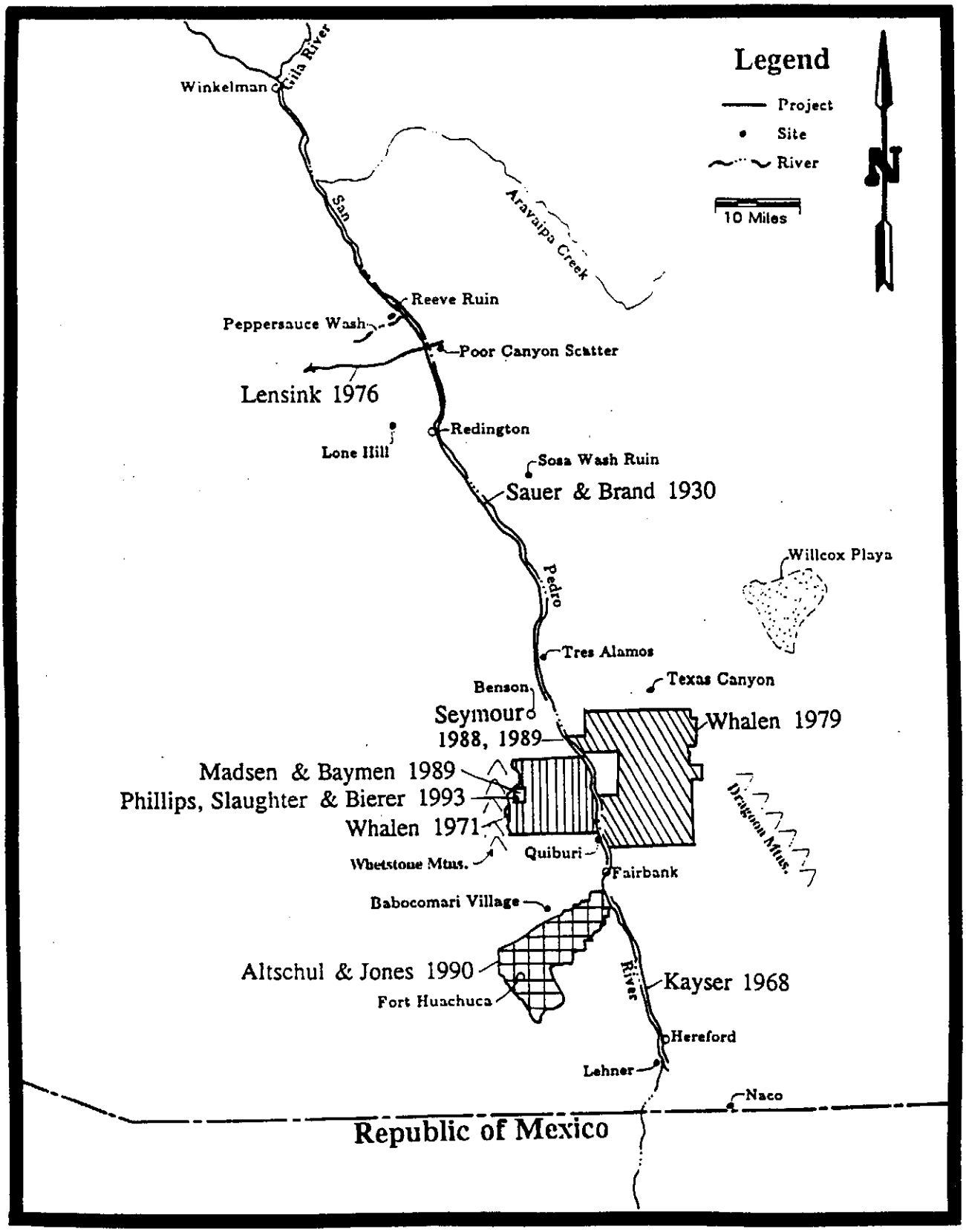
The San Pedro River Valley is divided environmentally and archaeologically into two segments: the lower San Pedro River, from the mouth of the river near Winkelman to approximately the town of Benson; and the upper San Pedro River, from the Benson area to the headwaters of the river. This division is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

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

Archaeological Projects

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

The earliest site descriptions were provided in the 1930's by Trischka (1933) and Fulton (1934) on Texas Canyon. The Amerind Foundation sponsored excavations at major sites such as Tres Alamos (Tuthill 1947), Babocomari Village (DiPeso 1951), and Reeve Ruin (DiPeso 1958) in efforts to learn more about the Dragoon (Tuthill 1950) and Babocomari cultures, and to establish spatial and temporal boundaries for San Pedro Valley prehistory and history (Bronitsky and Merritt 1986:48).



San Pedro River Archaeological Site Map

Figure 2-1

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

Sponsor	Type of Project	Areal Extent	No. of Sites	Reference
Archaeological Institute of America	Reconnaissance (judgmental)	Southwest U.S.	?	Bandelier 1892
University of California, Berkeley	Survey and Collection	San Pedro Valley+	?	Sauer and Brand 1930
Amerind Foundation	Excavation	Excavation (Tres Alamos)	1	Tuthill 1947
Amerind Foundation	Excavation	Excavation (Babocomari Village)	1	DiPeso 1951
Amerind Foundation	Excavation	Excavation (Reeve Ruin)	1	DiPeso 1958
Private Citizens	Excavation	Excavation (Naco)	1	Haury 1953
Arizona State Museum	Excavation	Excavation (Lehner)	1	Haury, Sayles, and Wasley 1959
Arizona State Highway Department	Excavation	Excavation (Peppersauce Wash)	4	Hammack 1971
El Paso Natural Gas Company	Survey	?	2	Lensink 1976
El Paso Natural Gas Company	Collection and Recording	Poor Canyon Scatter	1	Ferg 1977
Arizona Department of Transportation	Excavation	Excavation (Second Canyon Ruin)	1	Franklin 1980
Unknown	Excavation	Excavation (Lone Hill Site)	1	Agenbroad 1970
University of Arizona	Survey	100 square miles	90	Whalen 1971
Organized Research Committee of Southwest Texas State University	Systematic reconnaissance	180 square miles (16½ square miles actually surveyed)	293	Whalen 1979
Trico Electric Cooperative, Inc.	Survey	15.8 miles (Santa Catalina Mountains east across San Pedro River)	7	Bretemitz 1978
Bureau of Land Management; Rio Rico Properties; Nature Conservancy; University of Arizona; Arizona State Parks; Mariah Associates, Inc.; Arizona Archaeological and Historical Society	Survey	Between Fairbank and Benson	501	Seymour 1988, 1989, 1993
Arizona State Parks	Survey	Approximately 3,000 acres (Kartchner Caverns State Park)	13	Madsen and Bayman 1989
Arizona State Parks	Excavation	Excavation (AZ EE:3:28', ASM)	1	Phillips, Slaughter, and Bierer 1993
Army Corps of Engineers	Sample survey	8,600 acres (Fort Huachuca)	84	Altschul and Jones 1990
National Park Service	Survey	51 square miles (near Charleston)	126	Kayser 1968
U.S. Bureau of Land Management	Survey	Winkelman Bureau of Land Management Administrative Unit	56	Teague 1974

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

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

Investigations into Archaic period sites began relatively late along the San Pedro River (Agenbroad 1966, 1970, 1978). The temporal sequence and characterization of each stage was fostered by work initiated by Gila Pueblo (Sayles 1983:1). Archaic period settlement patterns along the upper San Pedro River took great strides when Whalen (1971, 1979) conducted surveys of large areas on either side of the river. Between 1966 and 1969 he surveyed a 100 square mile area on the west side of the valley between the Whetstone Mountains and the river. Ninety sites were located, only four of which postdated the Archaic period. Later, a systematic sample survey was conducted on the east side of the valley between the river and the Dragoon Mountains (Whalen 1979) that covered 16 ½ square mile, or 9% of a 180-square-mile area. The survey documented 293 prehistoric sites dating from 3000 B.C. to A.D. 1450.

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

cultural resources of southeast Arizona, including both government and private lands. The study unit embraced a much larger area than the San Pedro Valley and was conducted to assist in the management of cultural resources in that area.

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

Culture History

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

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

Hill site (Agenbroad 1966, 1970, 1978), Benson:8:3(GP) (Sayles 1945:1), and Benson:5:10(GP), the San Pedro stage type site.

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

Lower San Pedro River

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

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

By A.D. 1200, there was a marked population decline along the lower San Pedro River and many sites were abandoned. By A.D. 1250, a new influence, the Salado Culture, was felt in this area and was accompanied by an increase in occupation and a change in architectural style, pottery, and other cultural traits. Hohokam traits that were retained originated from the Tucson Basin rather than from the Gila and Salt basins. The Salado Culture is defined as a late branch of the Mogollon that is centered below the Mogollon Rim to the north (Gladwin and Gladwin 1935). It was influential in the lower San Pedro Valley from approximately A.D. 1250-1400. The Salado Culture has been interpreted either as an indigenous Hohokam development (Schroeder 1953) or as an immigration of people (DePeso 1958; Franklin and Masse 1976).

Villages ranged in size from 1-2 rooms to over 100 rooms, based on surface remains (Franklin and Masse 1976:50-51), and appear to have been continuous in distribution along the river, from its mouth to around the town of Benson. Sites include Reeve Ruin (DiPeso 1958), Davis Site (Gerald 1975), and Second Canyon Ruin (Franklin 1980). Second Canyon Ruin, typical of this period, contained 21 contiguous, boulder-reinforced adobe rooms that were grouped around large plazas with an encircling compound wall (Franklin 1980:13, 43). House size varied, with houses that contained the most artifacts averaging 266 ft^2 in floor area (Franklin 1980:16). At Reeve Ruin, average room size was 128 ft^2, with a range of 53-203 ft^2, the smaller rooms serving as storage areas; ramadas (n=3) were an average of 217 ft^2 in area (DiPeso 1958:41-77).

Upper San Pedro River

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

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

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

Prehistoric Use of the San Pedro River

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

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

Environmental Reconstruction

Environmental information for the San Pedro Valley is more prevalent for the pre-ceramic period of prehistory than for the later ceramic period occupation. Geoarchaeological investigations have been carried out at Paleo-Indian sites along the river (Haynes 1981, 1982) and at Archaic period sites east of the river valley (Eddy and Cooley 1983; Sayles 1983; Waters 1986). Pollen data from Willcox Playa to the east indicate that there was much greater effective moisture around 22,000 BP (20,050 B.C.) than at present (Hevley and Martin 1961). Between 11,500-7000 BP (9550-5050 B.C.), there was a long-term

fluctuating trend toward decreased effective moisture throughout the Southwest, with a moist episode between 11,500-11,000 BP (9550-9050 B.C.) (Irwin-Williams 1979:31) that probably expanded the grasslands, allowing the development of the Clovis horizon (Bronitsky and Merritt 1986:29). The alluvial stratigraphy at the Murray Springs and Lehner sites shows numerous depositional episodes (Table 2-2) prior to 7000 BP, after which there are periods of arroyo cutting and filling until approximately 100 BP (Haynes 1981).

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

Conclusion

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

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

Table 2-2 Correlation of Environmental Palynological Data

CHRONOLOGY	PALYNOLOGY[1]	ALLUVIAL SEQUENCE[2]
	Increasing effective moisture	
1000		
A.D. / B.C.	Lehner Murray Spgs.	3 cycles of arroyo cutting & filling
1000	Lehner	
2000	Murray Spgs	
3000		Arroyo cutting & filling
4000		
5000	Lehner Tule Spgs.	Eolian deposition
6000	Double Adobe Tule Spgs.	Stream deposition
7000		
8000	Lehner Tule Spgs. Panamint	Cienega deposition
9000	Lehner	Stream deposition
10,000		
11,000	Tule Spgs.	Marl deposition

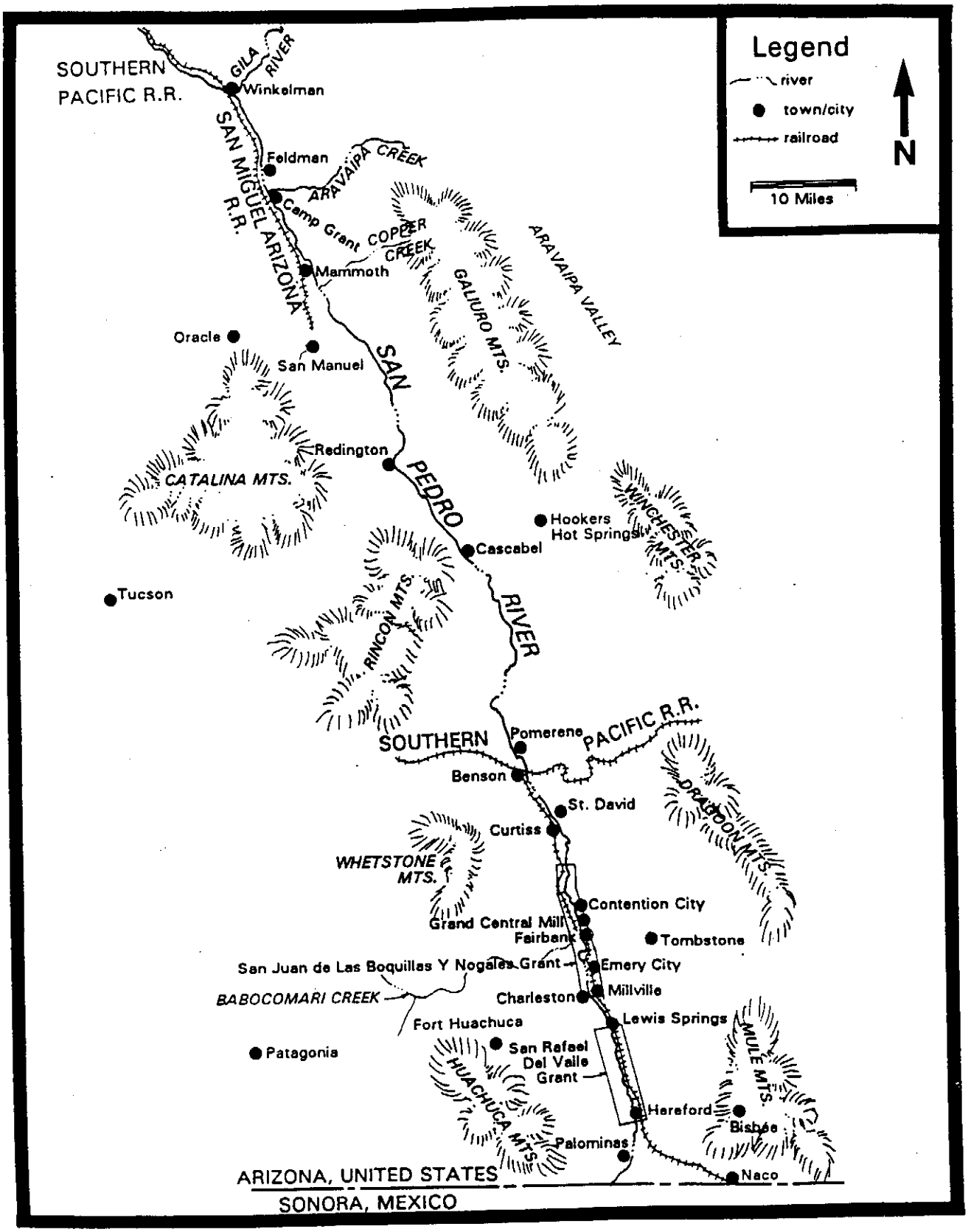
[1]From Irwin-Williams 1979, after Mehringer 1967. [2]From Waters 1986, after Haynes 1981.

Chapter 3
History of the San Pedro River

Introduction

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

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



San Pedro River: Sites of Historical Significance

Figure 3-1

Table 3-1. San Pedro River Chronology	
1500-1600's	Known as the "oldest river trail"--used by the early Spanish (Powell 1980:5).
1540	Called the Rio Nexpa by the 1540 Coronado Expedition (Granger 1984:471). Francisco Vazquez de Coronado marched his army up the San Pedro Valley as his avenue of exploration into the U.S. Southwest (Walker and Bufkin 1986:13; Hoffman 1982:40).
1542	Coronado returned to Mexico by the same route (Walker and Bufkin 1986:13).
1691-1702	Father Eusebio Kino. Jesuit missionary, traveled in the area bounded by the San Pedro and Gila Rivers (Walker and Bufkin 1986:13).
1692	Lieutenant Alférez Juan Mateo Ramirez traveled down the San Pedro to Benson in search of horses stolen from a Sonoran Mission (Walker and Bufkin 1986:13). Fr. Eusebio Kino in September clearly records the name as Rio de San Joseph de Terrenate (Granger 1984:471).
1696	Kino "extended his ministry into the San Pedro Valley" Sobaipuris (upland Pimas) living there (Officer 1987:32).
1697	Fr. Kino traveled along the river (Adams 1930:71; Walker and Bufkin 1986:13; Hastings & Turner 1965:26). He found Indians living there who practiced irrigation (Hastings & Turner 1965:26).
1732	Father Ignacio Keller with Captain Juan Bautista de Anza "visited six mission visitas (missions without resident priests) which serviced 1,800 people along the San Pedro" (Hadley et al. 1991:39).
1737	Father Keller--German Jesuit missionary--followed San Pedro to the Gila--no mention of how (Wagoner 1975:99). At this time found that the Apaches had forced out most of the Sobaipuris (Hadley et al. 1991:39).
1762	Interim Governor Joseph Tienda de Cuervo transferred Sopaipuri Indians to Santa Cruz (Officer 1987:40).
1763	Sobaipuri Indians lived along banks, the river was called Sobahipuris (*sic*) (Granger 1984:471).
1763	Sobaipuris moved to Tucson; Apaches (numbering approximately 1000) moved into San Pedro Valley (Officer 1987:39-40).
1775	Captain Juan Bautista de Anza visits Chichilticale (Yaqui for Red House), a prehistoric ruin with standing walls of adobe and masonry, first visited by Coronado (Hadley et al. 1991:37-38, citing Haury 1984:14-19).
1775-1780	Santa Cruz de Terrenate, a presidio, was located on the west side of the San Pedro, north of the present town of Fairbank (Officer 1987:8; Williams 1986)
pre-1800's	"The creek seeped through a rank growth of marsh grass and can hardly be said to have a course." (Hastings & Turner 1965:36)
1800's	During the Spanish and Mexican Periods, "Tucson settlers planted and harvested crops on the San Pedro River at Tres Alamos" on the east side of the river north of present-day Benson. "Because of the Apache menace, they were escorted to and from their fields by presidial soldiers" (Officer 1987:15). In the 1800's, "peaceful Apaches, protected by fifteen or more soldiers" from the Tucson presidio, farmed the San Pedro floodplain at Tres Alamos, and supplied the Tucson presidio with farm products (Officer 1987:89).
1808	Spanish grazing stock in San Pedro Valley (Officer 1987:88).
1821	Mexican independence.
1824-5	James Ohio Pattie and company trap beaver on the river (Davis 1982; Wagoner 1975:99).
1827	San Ignacio del Babocómari land grant, from modern-day Elgin to the San Pedro, awarded (Officer 1987:109). San Rafael de Valles land grant applied for. Awarded 1828 (Officer 1987:109). Elías González family petitioned for land grant on the San Pedro. Awarded 1833 (Officer 1987:108-110).
1827-8	James Ohio Pattie and company trap beaver on the river (Davis 1982; Wagoner 1975:99).
1828	San Rafael de Valles grant paid for (Officer 1987:109).
1830	Lieutenant Antonio Comaduran left Tucson presidio, traveled to Tres Alamos (north of present-day Benson) on the San Pedro, then proceeded toward the Sierra de Santa Teresa to Cajon de Agua Caliente (Hooker Hot Springs) and then to the Aravaipa Valley (Hadley et al. 1991:41, citing Dobyns 1981:16-26).
1830's	People from Tucson farming Tres Alamos, guarded by troops from Tucson presidio (Officer 1987:148).
1831	Tres Alamos land grant (Officer 1987:109-110).
1832	San Rafael del Valle--sold to Rafael Elías Gonzales for $240 as a stock farm (McClintock 1916:531).
1833	San Juan de la Boquillas y Nogales land grant awarded to Elías González family (Officer 1987:108-110).
1836	Pinaleno and Aravaipa bands of the Western Apache agree to settle at the junction of the Aravaipa and the San Pedro (Hadley et al. 1991:41).

Table 3-1. San Pedro River Chronology	
1846	Mormon Battalion described their camp in the San Pedro River Valley "in a marshy bottom with plenty of grass and water" and the stream as a "beautiful little river." (Tyler 1881, cited in Jackson 1987:21). Lt. Col. Philip St. George Cooke called the river by the name Jose Pedro River (Granger 1984:471). "The San Pedro River...was described in 1846 as a river 'an active man could jump across.'" (Mann 1963:4).
1846?	Captain Philip St. George Cooke marched his battalion up the river to the present site of Benson (Walker and Bufkin 1986:18).
1846-48	San Pedro Valley traversed by the Army of the West under General Kearny, and the Mormon Battalion traverses it on its way from Santa Fe, New Mexico to San Diego, California (Clarke 1961 and Golder 1928 cited in Hoffman 1982:40).
1848	Treaty of Guadelupe Hidalgo.
1849	Cooke's Road went along the river (Walker and Bufkin 1986:40).
1853	Boquillas grant (17,355 acres)--title given to Ignacio Elías Gonzales and Nepomuceno Felix for sale price of $240. Was confirmed to the possession of George Hearst and Janet G. Howard (McClintock 1916:531).
1854	Gadsden Purchase (from the Gila River to the present international border).
1854-55	San Pedro Valley traversed by Major William Emory during his survey of the international U.S.-Mexico border established by the Gadsden Purchase of 1853 (Emory 1848 cited in Hoffman 1982:40).
1855-1865	Farms along the river were targets for the Apaches (McClintock 1916:182).
1857	Major W.H. Emory describes the San Pedro River not having a great amount of water, and backed by a series of large pools by beaver dams and full of fishes (Emory 1857 cited in Jackson 1987:22).
1857	James B. Leach and N.H. Hutton surveyed wagon road from El Paso to Fort Yuma. (Hutton 1859:88, as cited by Hadley et al. 1991:57).
1857	"Captain" James H. Tevis and Mose Carson hunting and trapping on Aravaipa, Gila, and San Pedro. Trapped beaver on the San Pedro near the junction of the Aravaipa (Hadley et al. 1991:57).
1857-9	Leach's Wagon Road--Followed the river north almost to the Gila River junction (Walker and Bufkin 1986:40).
1857	Benson established as a stage stop at the San Pedro River crossing of the Overland and Butterfield Trail. Later the town became a railroad center to serve the mining areas that developed in the San Pedro River Valley (Arizona Office of Economic Planning and Development [AOEPD] 1977:3). [The date is incorrect; the Butterfield Trail dates from 1858 to 1861.
1858-1861	Butterfield Stage Route in operation.
1859	Fort Arivaypa [sic] established at the junction of the Aravaipa and San Pedro (Hadley et al. 1991:45).
1860	Fort Arivaypa renamed Fort Breckenridge and then abandoned (Hadley et al. 1991:45).
pre-1861	San Pedro Mine discovered and located about 1/2 mile from east side of river (Adams 1930:140).
1862	Military post re-established at junction of Arivaipa and San Pedro and named Fort Stanford (Hadley et al. 1991:45).
1863	Silver-lead ore discovered in Copper Creek in Galiuro Mountains above the San Pedro River (Hadley et al. 1991:114).
1865	Fort Stanford renamed Camp Grant (Hadley et al. 1991:45, citing Granger 1985:295).
1867	William A. Bell surveyed route for Kansas Pacific Railroad (Bell 1869, as cited by Hadley et al. 1991:58).
1868	Irrigation in use on the river (Farish 1915:207).
1870	"the valley of the San Pedro 'had a shallow grassy bed and banks covered with luxuriant vegetation.'" (Mann 1963:4).
1871	Camp Grant named reservation for Aravaipa and Pinaleno bands of the Western Apache (Hadley et al. 1991:47).
1872	Reservation status for Camp Grant ended (Hadley et al. 1991:47).
1873	Location of Camp Grant moved from junction of Aravaipa and San Pedro to west side of Pinaleno Mountains near present-day Bonita, Arizona (Hadley et al. 1991:43). Indians removed to San Carlos Reservation (Hadley et al. 1991:47).
1873-4	Wet years (Hadley et al. 1991:144-145).
1874	San Rafael del Valle--claimed under mortgage by Camou Brothers of Sonora who eventually gained title

Table 3-1. San Pedro River Chronology	
	(McClintock 1916:531).
1875	Reddington settled by brothers Henry and Lem Redfield (Barnes 1988:358).
1877	copper mine established at Bisbee (Barnes 1988:48).
1878	mine established at Tombstone (Barnes 1988:446).
1879	Charleston Post Office established (Barnes 1988:88).
1880	Charleston established--mill town for reduction for Tombstone Milling & Mining Company--"wild river camp" (Granger 1985:33).
1881	Mammoth Mine established (Barnes 1988:262).
1881	San Manuel Mine began production. Prior to this the Mammoth and Mohawk mines were chief producers in the area (San Manuel Copper Corporation [SMCC] 1955:1). Neptune Mining Co. of Bisbee built a smelter at Hereford (Myrick 1975:179).
1881	St. David Post Office established at Mormon settlement on spur line of EP&SW Railroad (Barnes 1988:374).
1881-2	New Mexico & Arizona Railroad built between Benson and Fairbank. The haul from Bisbee to Fairbank was accomplished by teams of 18 and 20 horses and mules (Myrick 1975:179). Atchinson, Topeka & Santa Fe Railroad built the New Mexico & Arizona Railroad from Benson to Nogales (Walker and Bufkin 1986:47).
1882	Fairbank established on EP&SW Railroad (Barnes 1988:150).
ca. 1884	River description: The San Pedro rises near the lone between Arizona and Sonora, and runs in a general northerly course a distance of over one hundred miles, and enters the Gila River at the foot of Gila Cañon, in Pinal County. It has a number of small tributaries, among them Arivaypai, which enters near its mouth, after passing through Grass Valley for five miles. On the western side is a tributary called Babacomari, rising in the Huachuca Mountains (Wallace W. Elliot & Co. 1884:90).
1884	"It is a sluggish, narrow stream, but carrying sufficient water to irrigate the rich bottom-lands through which it flows." (Hamilton 1884:48). Cited river as being "capable of irrigating vast stretches of land" (Hamilton 1884:361).
1885-1903	Drought years (Hadley et al. 1991:144-145).
1886	Flooding (Hastings & Turner 1965:42).
1887	More flooding (Hastings & Turner 1965:42).
1888	More flooding (Hastings & Turner 1965:42).
1889	More flooding (Hastings & Turner 1965:42).
1889	Lewis Springs established on EP&SW Railroad (Barnes 1988:246).
1890	More flooding (Hastings & Turner 1965:42).
1890	"Where the San Pedro River of southeastern Arizona formerly wound its sluggish course northward through a marshy, largely unchanneled valley, in August, 1890, it began carving a steep-walled trench through which it thereafter emptied rapidly and torrentially into the Gila. Where it formerly ran more or less consistently throughout the year, after 1890 its flow became intermittent, leaving the new channel dry over much of its length for most of the time." (Hastings & Turner 1965:3)
1891	Stamp mill for Mammoth Mine built at Mammoth (Granger 1985:298).
1894	Arizona Southeastern Railroad Company--"Near Fairbank the track was washed for 100 feet, and 11 miles down the line a 45-foot bridge and 1-1/2 miles of track were knocked out. Mail from Bisbee was carried on horseback during the week the railroad was being repaired." (Myrick 1975:191)
9/26/1894	Arizona Southeastern Railroad track between Benson and Fairbank completed (Myrick 1975:192).
1899	Naco Post Office established on railroad to mines at Nacozori, Mexico (Barnes 1988:294).
1900	Three railroads serve the San Pedro River Valley area, and Benson is known as The Hub City (AOEPD 1977:3).
1904-5	Wet years (Hadley et al. 1991:144-145).
1905	Arizona Eastern Railroad line completed from Phoenix to junction of Gila and San Pedro at Winkelman (Hadley et al. 1991:112).
1915	Pomerene Post Office established (Barnes 1988:342).
1916	Cascabel Post Office established (Barnes 1988:80).

Table 3-1. San Pedro River Chronology	
1917-21	Drought (Hadley et al. 1991:144-145).
1920's	The Arizona Southeastern Railroad along the river was in use at least through the 1920's (Myrick 1975).
1933-4	Drought (Hadley et al. 1991:144-145).
1945	San Manuel Copper Corporation incorporated (SMCC 1955:1).

Historical Overview/Chronology

Historic Indian Use of the San Pedro Valley

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

Spanish Exploration

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

Spanish Colonization

Father Eusebio Kino arrived in Pimería Alta in 1687, and in 1691 was invited by the Pimas to establish missions in what is now southern Arizona. By the time of his death in 1711, Kino had founded a chain of missions throughout Pimería Alta. In conjunction with these missions, military presidios were established. Spanish missionaries introduced herds of cattle to the Pimas and by 1694, "100,000 cattle ranged the grasslands around the headwaters of the San Pedro River and Bavispe Rivers" (Bolton 1948: map, as cited by Hastings and Turner 1965:31). The missionary activities of Father Eusebio Kino are discussed in many books and articles (Bolton 1936, 1960; Burrus 1965, 1971; Kessell 1966a; Smith, Kessell, and Fox 1966) that contain information on the San Pedro Valley in the Spanish Period. Figure 3-2 shows the locations of Spanish-Period sites mentioned in the text.

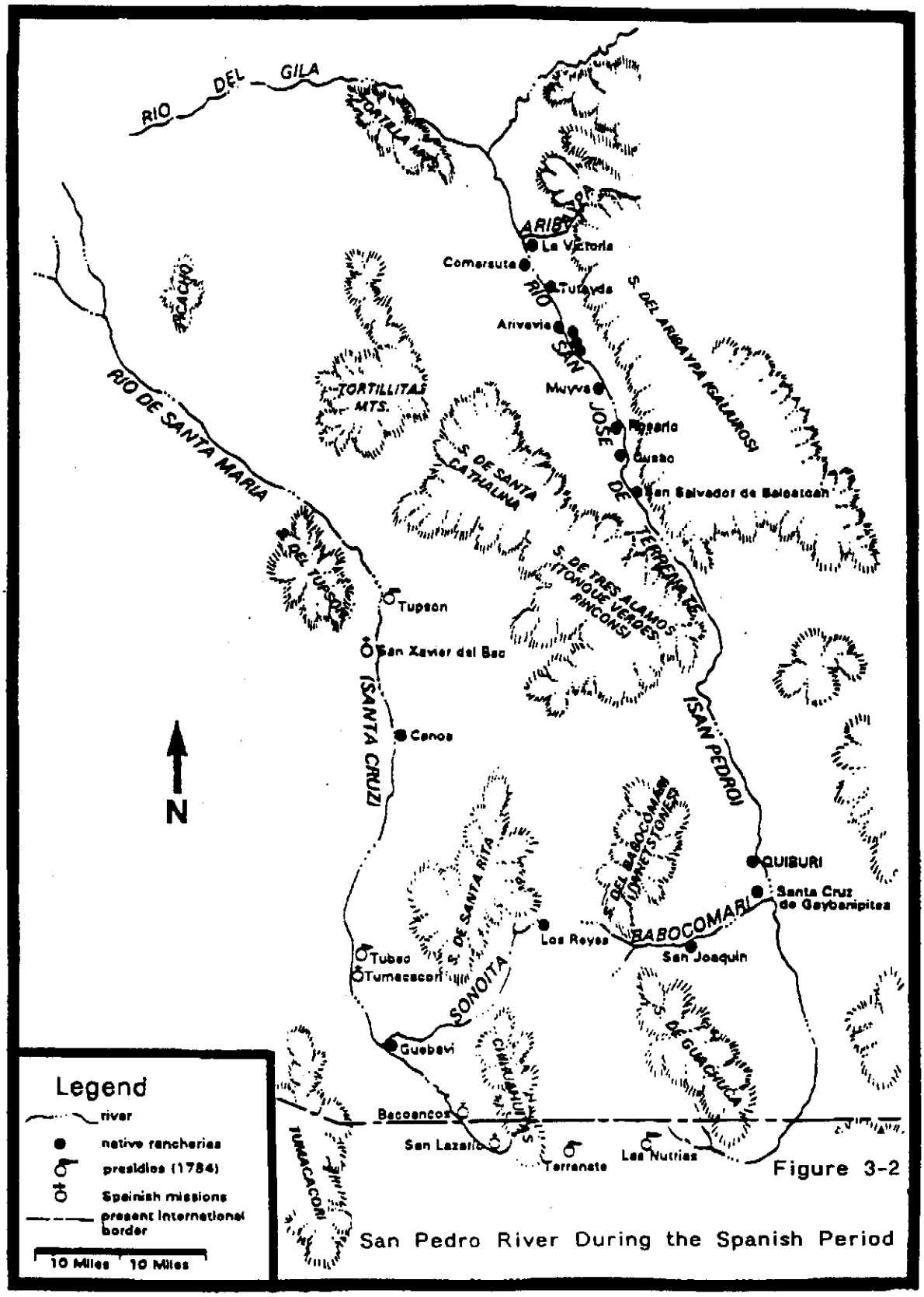


Figure 3-2

San Pedro River During the Spanish Period

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

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

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

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

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

Mexican Colonization

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

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

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

Exploration by United States Citizens

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

During the Mexican War, three expeditions traveled through southern Arizona. The first was Stephen Watts Kearny's, which (upon the advice of Kit Carson) left its wagons behind and followed the Rio Grande to below present-day Elephant Butte Reservoir, then went west over the mountains to the headwaters of the Gila River, and followed the Gila River to its mouth. Kearny was accompanied by William Hensley Emory of the Corps of Topographical Engineers who prepared a map and description of the route (Emory 1848). In late 1846, Philip St. George Cooke brought Kearny's wagons over a more southerly route along the present

international border and followed the San Pedro River for about 50 miles before turning west to Tucson (Cooke 1848, 1938, 1964). From September of 1848 to January of 1849, after the signing of the Treaty of Guadalupe Hidalgo, Major Lawrence P. Graham led the Second Dragoons from Chihuahua to California staying south of the present international boundary until he reached the Altar Valley and leaving a trail of dead livestock, abandoned wagons, and other debris that would be followed by later travelers.

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

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

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

United States Colonization

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

Mining in the lower San Pedro River began in 1863, when silver-lead ore was discovered in Copper Creek in the Galiuro Mountains above the San Pedro River. Mining continued in the 1870's and 1880's (Hadley et al. 1991). The mines at Bisbee were established in 1877 (Barnes 1988:48), those at Tombstone in 1878 (Barnes 1988:446). Mining began at the Mammoth Mine and San Manuel in 1881 (Barnes 1988:262; San Manuel Copper

Corporation 1955:1). Six mining and milling towns were established along the San Pedro River: Contention, Grand Central, Fairbank, Emory City, Charleston, and Millville (Fulton 1966:9).

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

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

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

The transcontinental railroad arrived in Tucson in 1880, and over the next 25 years, the San Pedro River Valley became laced with a network of railroads. In 1881, a railroad route linking Benson, Arizona, with Guaymas, Sonora, was completed (Greever 1957, as cited by Hastings and Turner 1965:40). According to Walker and Bufkin (1986: map 28), St. David (a Mormon settlement) was established in 1877. The St. David Post Office was established in 1881 when a spur line of the EP&SW Railroad reached the town (Barnes 1988:374). Fairbank was established in 1882 on the EP&SW Railroad (Barnes 1988:150). Lewis Springs was established in 1889 on the EP&SW Railroad (Barnes 1988:246). The Naco Post Office was established in 1899 on the railroad to the mines at Nacozori, Mexico (Barnes 1988:294). The Arizona Eastern Railroad was completed from Globe to Winkelman in 1905 (Myrick 1984, as cited by Hadley et al. 1991:118).

Historical Descriptions of the River[1]

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

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

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

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

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

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

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

Philip St. George Cooke (1848, 1938, 1964, 1974), commander of the Mormon Battalion on their journey from Fort Leavenworth, Kansas, to San Diego, California, during the Mexican War, provided relevant observations about the conditions of the San Pedro River Valley in the mid-nineteenth century. On December 9, 1846, Cooke first saw the San Pedro Valley from the mountains to the east, but saw "no other appearance of a stream than a few ash trees in the midst.... On we pushed, and finally, when twenty paces off, saw a fine bold stream! There was the San Pedro we had so long and anxiously pursued." Cooke followed the San Pedro River for the next five days, traveling approximately 55 miles through the San Pedro Valley as far north as present-day Benson. On December 9, Cooke stated that "The San Pedro was frozen over in places this morning" (Cooke 1974:141). On December 10, he reported, "Fish are abundant in this pretty stream.. Salmon trout are caught by the men in great numbers; I have seen them eighteen inches long" (Cooke 1974:142). On December 11, he said "An abundance of fine fish are caught, some that are three feet

long; they are said to be salmon trout (Cooke 1974:144)."[2] On December 12, he wrote that the valley floors were, on average, more than a mile wide and covered with grass so tall that it was sometimes difficult to pass through it (Cooke 1974:145). On December 13, he described the valley as being one to two miles wide, with a plain and mesquite bosques on each side, "the mesquite in places taking the exact resemblance of orchards" (Cooke 1974:146). They passed a ruined ranch, which Cooke thought was probably "the true San Pedro." On December 13, they camped again on the San Pedro River, and on the 14th left the valley to travel west to Tucson. From Tucson, Cooke traveled down the Santa Cruz River to the Gila River, which he described as "a rapid stream of clear water, in places three or four feet deep, and here about one hundred and fifty yards wide." Cooke felt that the Gila River might be substantial enough to be boated.

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

One of the principal routes for the forty-niners on their way to the gold fields of California ran along the present border between Arizona and Mexico, although at the time, the route lay in Mexican territory (Aldrich 1950; Chamberlain 1945; Cox 1925; Durivage 1937; Eccleston 1950; Evans 1945; Harris 1960; Hunter n.d.; Pancoast 1930; Powell 1931). The Evans (1945) and Harris (1960) accounts do not mention the San Pedro River, although they were favorably impressed by the Santa Cruz River. Cox (1925:141) stated only that on August 22 "arrived at our present camp ground which we suppose to be on the River San Pedro." From September 26 through 28, H.M.T. Powell traveled through the upper San Pedro Valley, probably southeast of the Huachuca Mountains, but could not find Cooke's trail and was never able to identify the San Pedro River for certain. Instead he crossed a number of small streams. On September 27, he (Powell 1931:130) wrote:

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

The next day, Powell (1931:131) "passed a little clear stream, running East, a tributary of the San Pedro, I suppose. ... A short distance from where we crossed the stream we saw the ruins of a number of adobe houses. The ground became swampy and heavy. In about a Mile we recrossed the same creek, which now ran

[2] In fact, they were probably squawfish.

southerly." On October 30, Powell's group converted their wagons into boats and also built rafts and flatboats, all of which they floated down the Gila River (Powell 1931:162). Of the Gila River, Powell (1931:174) stated, "The navigation is laborious, but perfectly practicable for flat boats properly built, Colonel Cooke to the contrary notwithstanding."

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

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

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

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

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

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

> *"The valley of the San Pedro River near our camp was any thing but luxuriant. It consists of loam, which if irrigated might be productive; but as the banks are not less than eight or ten feet high, irrigation is impracticable, except by digging a canal a very long distance. The grass of the vicinity is miserably thin and poor, growing merely in tufts beneath the mezquit bushes which constitute the only shrubbery, and in some places attain a height of ten or twelve feet .... In order to cross the river,*

it was necessary to level the banks on both sides, and let the wagon down by hand (Bartlett 1854 [I]:379-81).

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

On September 12, 1858, Leach stated:

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

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

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

In 1870, the Surgeon General prepared a report on conditions at military posts, including Camp Grant located on the lower San Pedro River at the junction of the Aravaipa (U.S. War Department, Surgeon General's Office 1870). The post "was originally built immediately on the bank of the San Pedro River, but in 1866 twenty out of twenty-six adobe buildings, composing the post, were swept away by the flooding of the stream." The post was then moved to the top of a flat knoll between the junction of the two streams. "The valley of the San Pedro varies in width from one-half to four miles. Many parts of the valley can be cultivated by irrigation. Several attempts have been made to reclaim the ground in the immediate neighborhood of the camp, but without success" (Surgeon General 1870:465). "...the main supply [of

vegetables] is from the company gardens in the river bottom" (Surgeon General 1870:466). Water for cooking and drinking came from a well. "The water of the San Pedro is used only by the quartermaster animals and for washing. It is pleasant enough to the taste, and turbid only during heavy rains, but coming as it does, through swampy country above the post, may be impregnated with malaria" (Surgeon General 1870:466). "The prevailing winds are from the southeast down the course of the San Pedro, carrying with them the malaria from the marshes along its banks, and exposing the troops stationed on the knoll to its deleterious influence" (Surgeon General 1870:465). Mail was dispatched to the post weekly from Tucson. "But well-escorted trains and travelers may proceed from Maricopa Wells direct, without circling southward by Tucson, as there is a good road along the Gila River between the two places" (Surgeon General 1870:465).

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

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

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

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

> *"In 1886 "the water in the San Pedro River was...higher than it was ever known to be. Between Contention and Benson there was four feet of water on the side of the [railroad] tracks" (Arizona Daily Star, August 30, 1886). At its junction with the Gila River, "an avalanche of water swept down...like a wave, 6' high" (Arizona Weekly Enterprise,* August 14, 1886).

"During the following year, 1887, the San Pedro River again had "higher water than ... ever ... known before" (Arizona Weekly Enterprise, Sept. 17, 1887). "For nearly the entire length of the river from Benson down to the Gila the crops with the exception of hay ... [were] destroyed" (Arizona Weekly Enterprise, Sept. 3, 1887). At Charleston the flood carried away the dam (Arizona Weekly Enterprise, July 16, 1887; Arizona Daily Star, July 17, 1887)." (Hastings and Turner 1965:42)

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

"Of the country down the San Pedro, from Tres Alamos to the Gila [Captain Van Alstine] ... says, "all of it is gone, destroyed, torn up, 'vamosed' down with high water. He never saw such a destruction in all his life. ... The San Pedro never was as high as it was this time, and will probably not be for the next ten years. The losses sustained by the people will reach into the thousands (Arizona Daily Star, August 14, 1890)." (Hastings and Turner 1965:42, their ellipsis and inserts)

"At Dudleyville, near the mouth of the San Pedro the river "caved within 15' of Cook's [store]" (Arizona Weekly Enterprise, Sept. 6, 1890), and upstream at Mammoth flood washed the soil out in places thirty feet deep, exposing archaeological relics" (*Arizona Daily Star*, Oct. 2, 1890). (Hastings and Turner 1965:42-43, their ellipsis and inserts)

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

"Where the San Pedro River of southeastern Arizona formerly wound its sluggish course northward through a marshy, largely unchanneled valley, in August, 1890, it began carving a steep-walled trench through which it thereafter emptied rapidly and torrentially into the Gila River. Where it formerly ran more or less consistently throughout the year, after 1890 its flow became intermittent, leaving the new channel dry over much of its length for most of the time" (Hastings 1959).

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

Historical Uses of the River

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

Farming

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

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

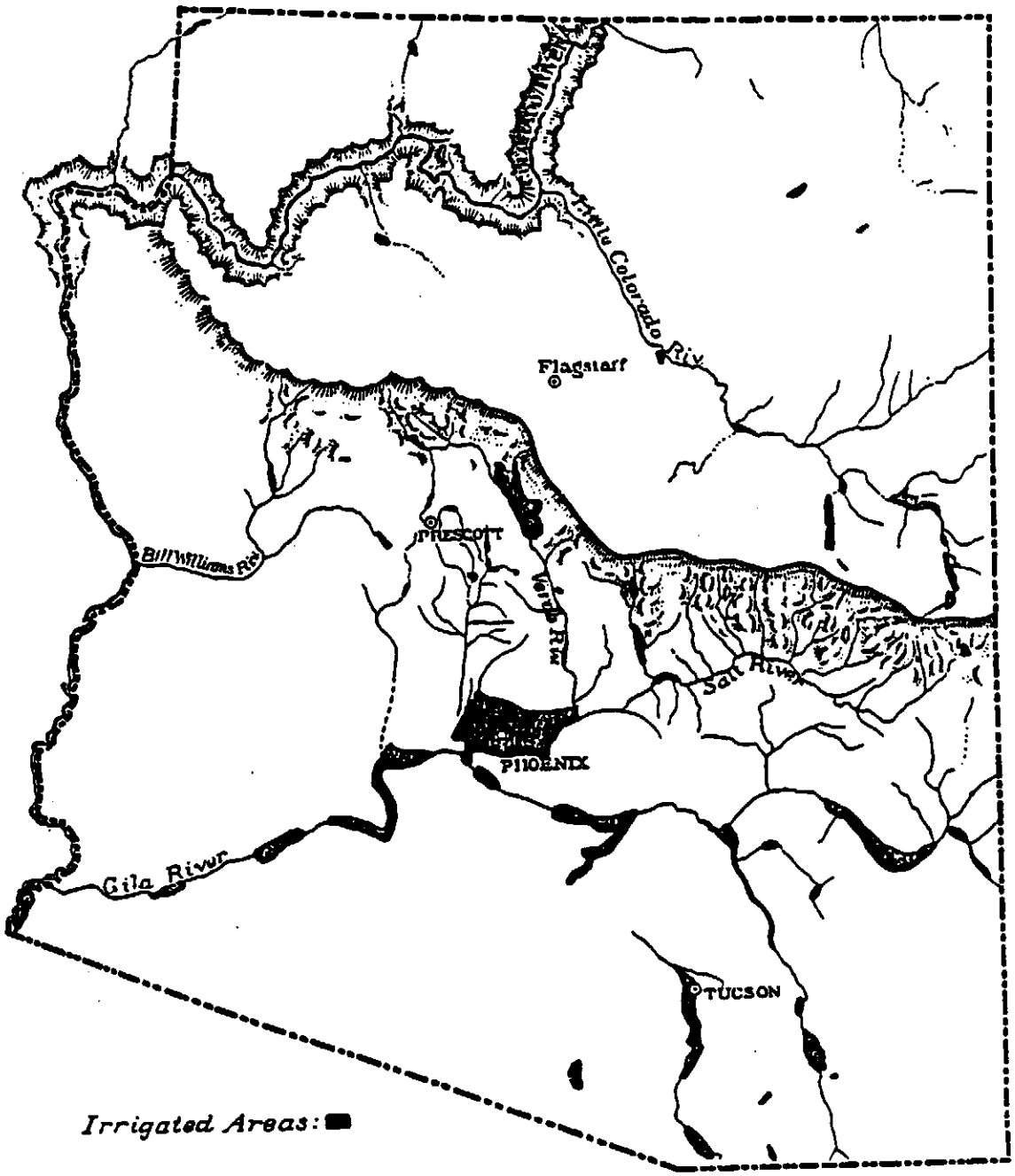
Hodge (1877:47) wrote that the San Pedro Valley contained 50,000 acres "of good farming land, most of which can be successfully cultivated. At Tres Alimos, in this valley, are some well cultivated farms and one choice dairy farm, that of H.C. Hooker, Esq." GLO maps dated to 1873, 1878, 1880, 1882, 1901,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

Fishing

Fish species found in the San Pedro River historically included some very large fish such as squawfish (aka Salt River Salmon, Colorado River Salmon) some of which grow to over three feet long, razorback sucker, and flannelmouth sucker. Historical accounts of fishing are centered on early explorer routes and settlements, as cited earlier in this chapter. There are numerous accounts of "salmon" runs (actually squawfish) on the San Pedro River, fish clogging canals on the San Pedro River, and catching fish with pitchforks for use as fertilizer on irrigated fields. A commercial operation reportedly harvested razorback suckers from the San Pedro River between 1870 and 1910 near Tombstone.

Mining

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



From Census Bulletin No. 6, July 25 1901

Figure 3-3

Map of Irrigation in Arizona, 1900

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

Regional Transportation

The primary means of transportation along the San Pedro River has always been overland. Spanish missionaries and military expeditions, as well as the trappers of the 1820's, traveled on horseback. Kearny traveled by horseback in 1846, not even attempting to haul wagons. Later U.S. military expeditions did use wagons, as did the forty-niners. All of these groups followed expedient trails (Figure 3-4).

The Butterfield Stage Route, which crossed the San Pedro River at the present location of Benson, was in operation from 1858 to 1861, and in 1859, a bridge was constructed across the San Pedro River (Conkling and Conkling 1947:149; Eaton 1933:176). The military was responsible for surveying and constructing a number of formal roads in the region. In 1858, the Leach Wagon Road, which ran down the San Pedro River, was surveyed but never became popular because it bypassed Tucson. By 1870, a road ran up the Gila River to Camp Grant.

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

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

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

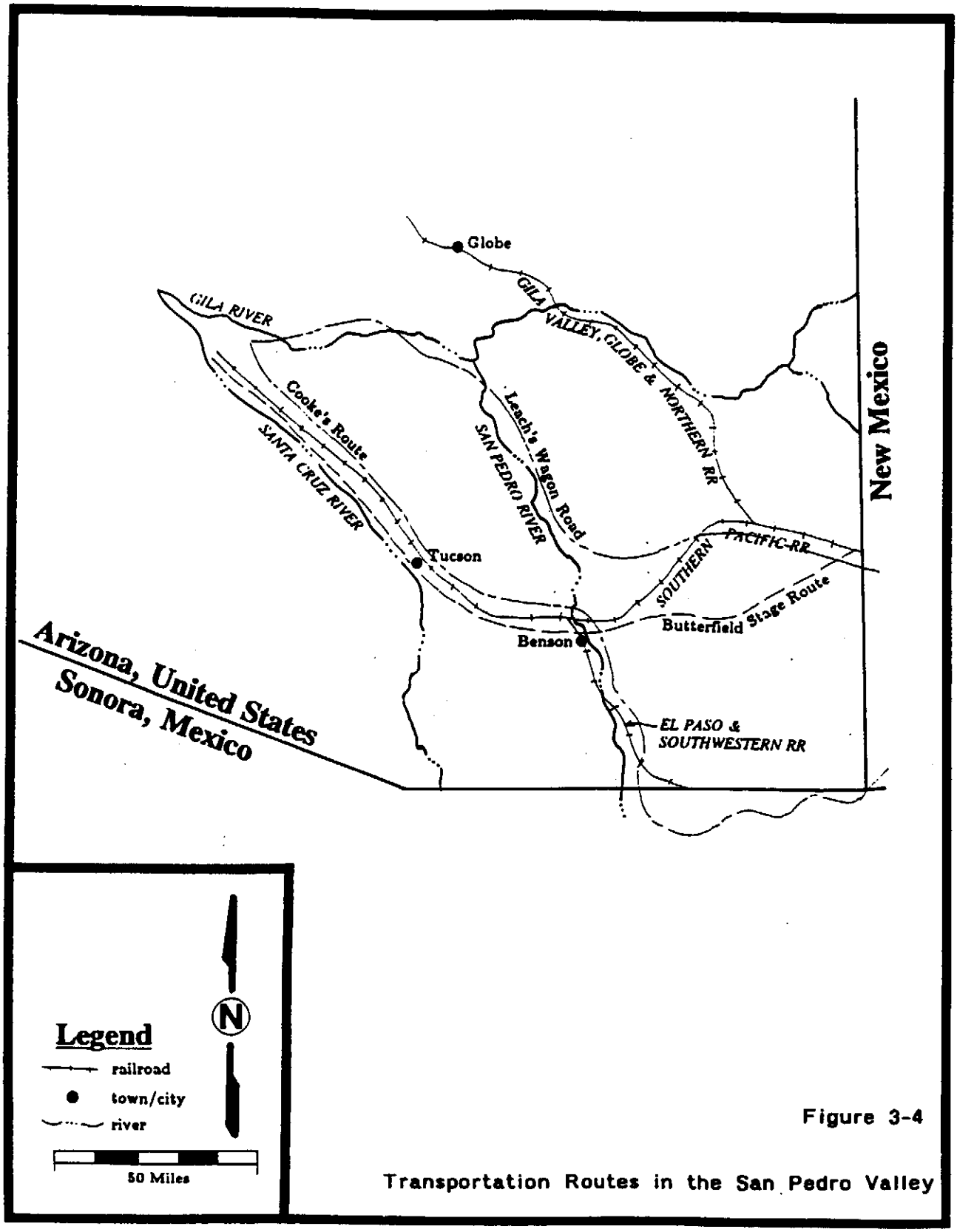


Figure 3-4

Transportation Routes in the San Pedro Valley

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

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

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

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

Summary

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

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

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

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

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

Given the criteria established by HB 2589, the historical record for the San Pedro River indicates the following:

- Portions, but not all of the San Pedro River were perennial, with an average depth of about one foot and a width of about 10 to 15 feet during the early period of Anglo settlement. By the time of statehood, the river channel had become more arroyo-like. Portions may have been dry due to irrigation diversions or because changes in historical flow rates.
- There is no documented record of trade or travel on the river during the period leading up to, or after, the time of statehood. The San Pedro River Valley served as an overland travel route during the historical period, in part because of reliable water along the river.
- No record of episodic or sustained trade and travel in the upstream (or downstream) direction on the San Pedro River was found.
- No evidence of profitable commercial enterprises based on flotation of goods on the river was identified.
- Diversions were made from the San Pedro River to irrigate farm land, some of which was located within Indian reservations. Many of these diversions were appropriated prior to the time of statehood.
- There is no evidence that flotation of logs could have been regularly conducted for commercial purposes.
- There were several bridges and diversion dams on the San Pedro River that could have created an impediment to certain types of navigation. The most significant impediment to navigation, according to historical descriptions of the river, was shallow water or a dry riverbed.

- Transportation in the area near the San Pedro River was primarily accomplished by methods other than by boat. Several alternatives to transportation of goods by boat, including train, wagon, and pack mule, existed by the time of statehood.
- The San Pedro River is not listed as one of the streams regulated in the Rivers and Harbors Act of 1899.

Chapter 4
Oral History

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

In general, individuals who were questioned during the initial and subsequent contacts might be characterized as falling into one of four groups: (1) professional land managers; (2) professional historians, archaeologists, and museum curators; (3) avocational historians; and (4) longtime residents along the rivers. For the San Pedro River, three professional land managers, nine professional historians, eight avocational historians, and five local residents provided information or were interviewed.

Professional land managers interviewed included Geoff Parker (Soil Conservation Service) and Terry O'Sullivan (Bureau of Land Management), who were interviewed, and Hollis N. Cook (Tombstone Courthouse State Historic Park), who sent a letter. Professional historians, archaeologists, and museum curators who were interviewed included Julio Betancourt (United States Geological Survey), Dan Brown (McFarland State Historic Park), Don Bufkin (Arizona Historical Society), Suzanne Dewberry (National Archives, Federal Records Center, Laguna Niguel, California), Mary Lou Heuett (Cultural and Environmental Systems, Inc.), Ken Kimsey (Prescott National Forest), Mary Lu Moore (Arizona State Attorney General's Office), Bob Trennert (Arizona State University), and Angie Vandereedt (National Archives of the Old Coast Guard). Avocational historians who were interviewed included Brother Tom of the Holy Trinity Monastery at St. David, Cindy Hayostek (Cochise County Historical and Archaeological Society), Helen Hume (San Pedro Valley Arts and Historical Society Museum), Rose Land (San Pedro Valley Arts and Historical Society Museum), Della Meadows (Pinal County Historical Society), Bob Rosen (Gila County Historical Museum), Nedra Sunderland (San Pedro Valley Arts and Historical Society Museum), and the secretary of the Bisbee Mining and Historical Museum. Local residents who were interviewed included Jay Bateman (Florence), Carl Black (St. David), Louise Larson (Benson), Dora Ohnesorgen (Benson), and Jerry Pratt (Sierra Vista). Earl Zarbin, a retired Phoenix newspaperman, has written extensively on water issues in Arizona and has compiled an index of articles on water in Arizona from Arizona newspapers published between 1859 and 1918 (Zarbin n.d.).

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

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

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

A number of people mentioned the changes that had occurred along the San Pedro River in historic times. Hollis Cook (Tombstone Courthouse State Historic Park) and Dora Ohnesorgen cited the presence of beavers in the San Pedro River. Louise Larson recalled that even when she was a child (in the 1920's), there was only a small amount of water in the river; now it rarely flows. Jerry Pratt, a retired wildlife biologist in Sierra Vista, thought that early fur trappers might have used boats on the San Pedro River and that the river might have been navigable before the 1887 earthquake. The secretary of the Bisbee Mining and Historical Museum also suggested that the earthquake, grazing, and drought might have affected the

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

stream.[2] Dora Ohnesorgen and Nedra Sunderland both recalled that Dora Ohnesorgen's grandfather had operated a ferry across the San Pedro River near Pomerene. Possible operation of this ferry represented the only historical account of boating on the San Pedro River found during this study.

- No accounts of commercial trade or travel, sustained travel upstream or downstream, in any type of vessel, or floatation of logs on the San Pedro River were obtained during the ethnographic interviews. Use of a ferry near Pomerene was recalled by two long-time residents.

- Recollections of the normal flow regime of the San Pedro River, i.e. ephemeral or perennial, were conflicting, perhaps indicative of the variations in flow regime over the length of the study reach.

- Irrigation diversions were a normal use of the river flow as of the time of statehood, much as they continue to be today.

- Local residents and historians did not report any knowledge of recreational boating on the San Pedro River.

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

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

Chapter 5
San Pedro River Geology

Introduction

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

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

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

Stream Reaches

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

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

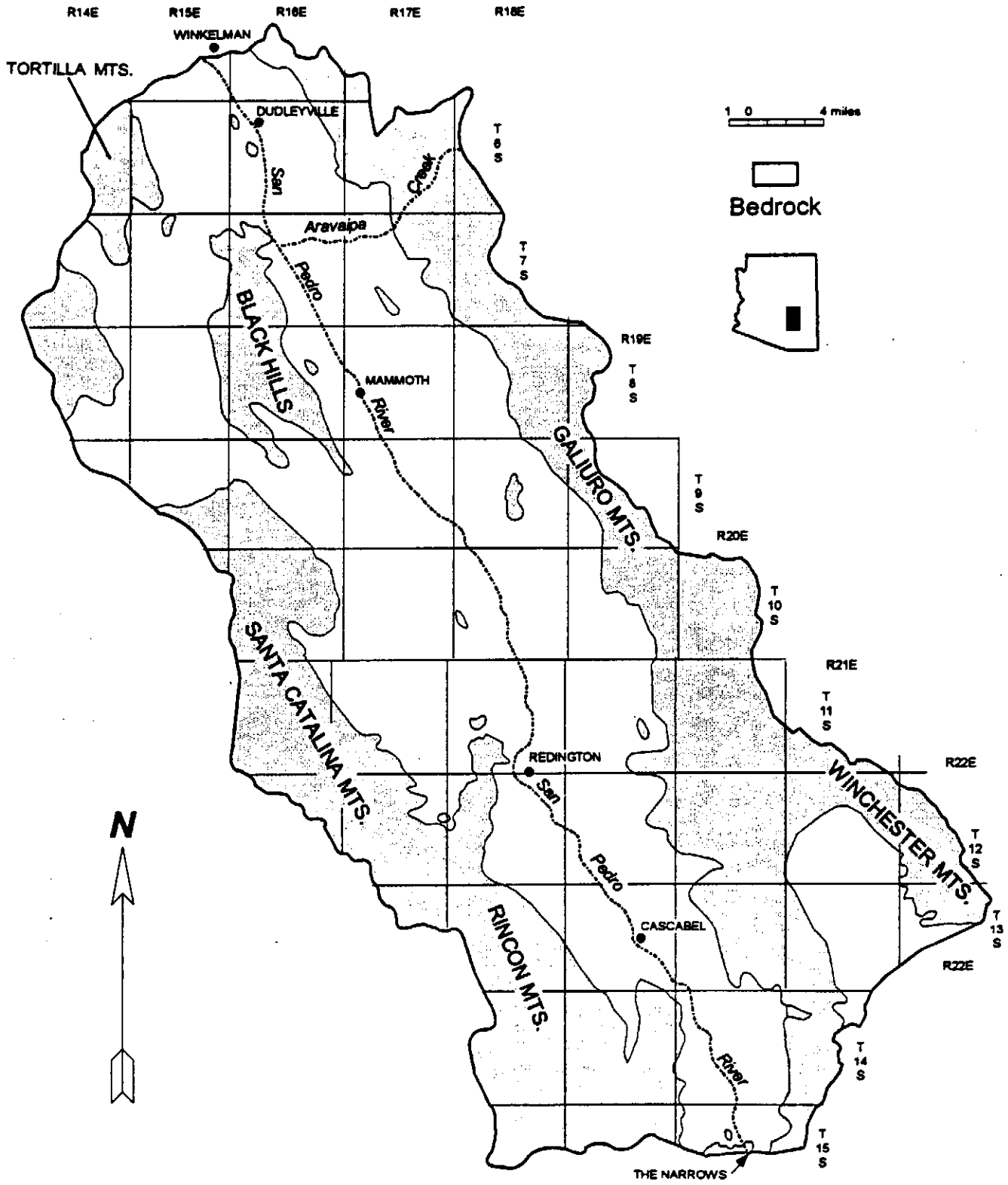

Figure 5-1

Geologic Site Map of Lower San Pedro River

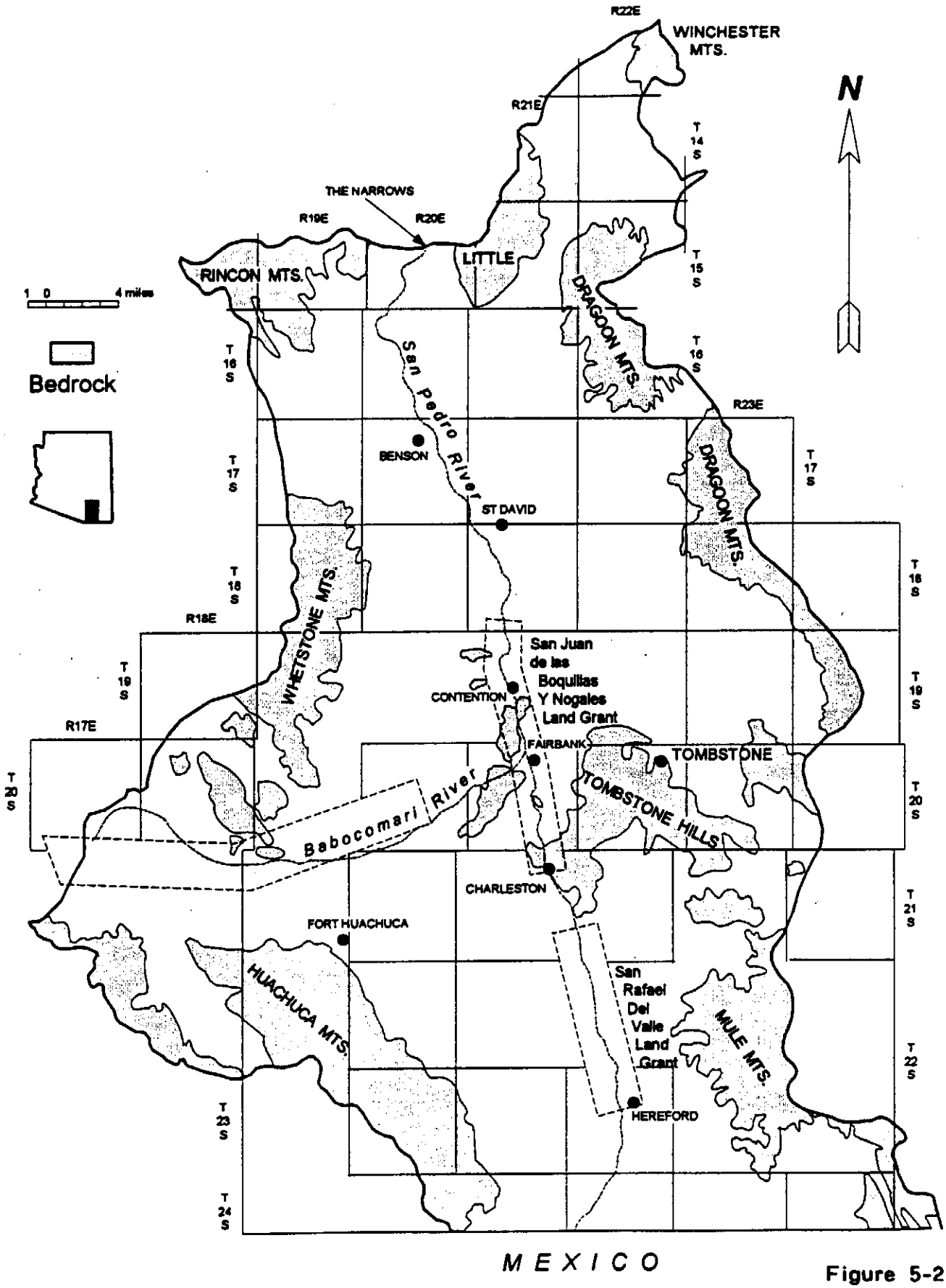

Figure 5-2

Geologic Site Map of Upper San Pedro River

Physical Setting

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

Table 5-1
Major Mountain Ranges Bordering the San Pedro Valley, Arizona

Mountain Range	Highest Elevation (ft)	
Dragoon Mountains	7,519	Jurassic and Tertiary granite
Galiuro Mountains	7,540	Tertiary volcanics
Huachuca Mountains	9,466	Precambrian granite; Jurassic volcanics
Mule Mountains	6,597	Paleozoic limestone
Rincon Mountains	8,666	Tertiary-Cretaceous granite and gneiss
Santa Catalina Mountains	9,157	Tertiary-Cretaceous granite and gneiss
Tortilla Mountains	4,547	Tertiary-Cretaceous granite
Whetstone Mountains	6,628	Paleozoic limestone: Precambrian granite
Winchester Mountains	7,631	Cretaceous-Jurassic sedimentary and volcanic rocks: Precambrian granite

Source: Reynolds (1988)

Climate in the San Pedro River valley varies with elevation. Overall, the valley is semi-arid. The lower San Pedro River valley receives less than 15 inches annually (Bahr, 1991). Some of the higher mountains bounding the valley average greater than 25 inches annually. Mean July maximum temperatures range from 103 °F at Winkelman (2,075 feet above sea level) to 89 °F at Fort Huachuca (4,664 feet above sea level; Sellers and Hill, 1974). Despite its lower elevation, Winkelman has an average January minimum temperature of 29 °F compared to 34 °F for Fort Huachuca. The lower winter minimum temperatur

at Winkelman probably reflect micro environmental effects such as cold-air drainage within the middle Gila River Canyon. Throughout the entire San Pedro Valley, the bulk of precipitation comes primarily during the summer when moisture entering Arizona from the south triggers convective thunderstorms. There is also a lesser rainy season in the winter characterized by regionally extensive, frontal storm systems from the north Pacific. Occasionally during September and October, the San Pedro Valley experiences heavy rains associated with dissipating eastern Pacific tropical storms that commonly result in heavy rain and flooding (Hirschboek, 1985; Webb and Betancourt, 1992; Chapter 7).

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

Late Cenozoic Geologic History

Most elements of the modern topography in the San Pedro Valley can be traced back to the Basin and Range Disturbance (8-15 Ma[2]) (Damon and others, 1984; Menges and Pearthree, 1989; Shafiqullah and others, 1980). Tensional stresses associated with the change from convergent to transform motion on the west coast tectonic plate boundary resulted in a largely north-northwest trending series of alternating basins and mountain blocks separated by steeply dipping normal faults . As the basins dropped, they simultaneously began filling with debris shed from adjacent mountain blocks. Many of the mountain fronts, especially those composed of granite, retreated from the axis of the valley forming broad pediments (Melton, 1965; Morrison, 1985; Tuan, 1962). The upper San Pedro Valley is broader and less dissected with a more gently sloping piedmont than the lower San Pedro Valley (Tuan, 1962). The basin sediments grade from coarse clastics (e.g., boulders, cobbles, and gravels) near the valley margins to finer sediment (sand, silt, and clay) and evaporites in the center (Agenbroad, 1967; Heindl, 1957a,b; Smith, 1963). The upper basin fill stratigraphy is characterized by relatively fine-textured alluvial and lacustrine sediments overlain by coarse-textured fan deposits (Johnson and others, 1975; Melton, 1965; Smith, 1964). The thickness of the basin deposits vary. Geophysical data indicate maximum depths of 4,800 to 6,400 feet in the upper San Pedro River Valley between the Huachuca and Mule Mountains and 3,200 to 4,800 feet in the lower San Pedro River Valley between the Santa Catalina and Galiuro Mountains (Oppenheimer and Sumner, 1980).

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

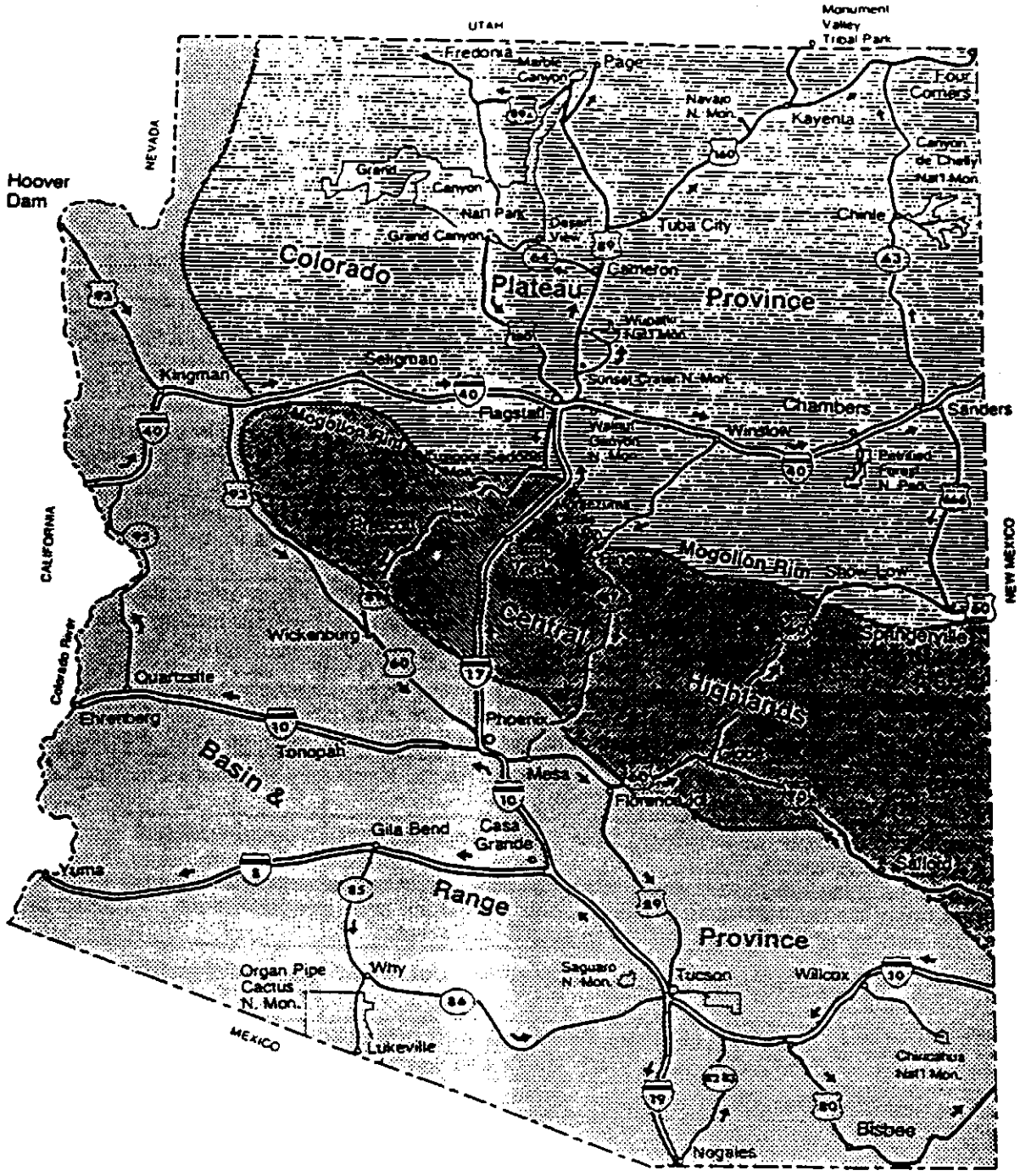

Figure 5-3 Physiographic Provinces of Arizona

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

Modern Channel Characteristics

Upper San Pedro River

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

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

Lower San Pedro River

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

Historical Channel Changes

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

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

Because of academic interest in the arroyo phenomenon, historical channel changes on the San Pedro River are well documented (e.g., Cooke and Reeves, 1976; Hereford and Betancourt, 1993). Most of the historical descriptions of the San Pedro River are from the upper reach; most geological investigations of channel change have been focused on the reach south of The Narrows. Therefore, historical channel changes on the lower San Pedro River are less well defined. Channel changes on the upper reach need not necessarily be in tandem with those of the lower reach since bedrock constrictions

present local base level controls and basin morphometry varies between the two reaches. Because of geomorphological contrasts between the upper and lower reaches, historical channel changes are reviewed for both reaches separately.

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

Upper San Pedro River

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

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

1871-1933. The first cadastral survey by the U.S. General Land Office (now the BLM) was performed within the upper San Pedro River Valley in 1873 (survey notes on file at the BLM in Phoenix). All of the section lines within townships crossed by the upper San Pedro River had been surveyed by 1901 with

the exception of the original Mexican Land Grants (see Cooke and Reeves, 1976: Figure II.6). The survey notes and plat maps provide systematic descriptions of channel dimensions, particularly width and location. However, the survey notes are often cryptic and can be easily misinterpreted (see Bahr, 1991; Betancourt, 1990). For example, measurements of channel width are recorded, but these measurements were made normal to cadastral lines and thus usually do not represent true channel width. Also, whereas the G.L.O. plats are the first scaled maps showing channel location, the position of the channel is only surveyed where it crosses cadastral lines; channel locations between cadastral lines are interpolated. Nonetheless, the G.L.O. survey notes are the first systematic measurements of the San Pedro River and provide a base for analyzing historical channel change.

The first townships in the upper San Pedro River Valley to be surveyed were Townships T. 15, 16, and 17 S., R. 20 E., by Theodore White in 1873. He later surveyed Township T. 18 S., R. 21 E. in 1881. Very few channel measurements are provided for Townships T. 19, 20, and 21 S., R. 21 E. and Townships T. 21 and 22 S., R. 22 E. due to the private land grants, and Townships T. 23 and 24 S., R. 22 E. were not surveyed until 1901 by Phillip Contzen. Following the procedure of Burkham (1972), measurements of channel width (normal to cadastral lines) were compiled (Appendix E) and averaged for each Township (Table 5-2). Between St. David and The Narrows, the channel width in 1873 averaged less than 36 feet. Between the San Juan de las Boquillas y Nogales land grant and St. David, the channel width in 1881 averaged approximately 60 feet. This agrees with historical descriptions of a relatively narrow channel (Hastings, 1959; Hereford and Betancourt, 1993).

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

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

increasing runoff and gullying (Carpenter and Bransford, 1921; Cooke and Reeves, 1976; Dobyns, 1981).

Table 5-2
Mean Channel Widths for the Upper San Pedro River (ft)

Township	Year	Mean
T15S R20E	1873[1] 1935[9]	35 266
T16S R20E	1873[2] 1935[9]	27 238
T17S R20E	1873[3] 1935[9]	28 285
T18S R21E	1881[4] 1935[9]	58 367
T19S R21E	-	-
T20S R21E	-	-
T21S R21E	1901[5] 1935[9]	73 492
T21S R22E	1909[6] 1935[9]	261 246
T22S R22E	-	-
T23S R22E	1901[7] 1935[9]	85 303
T24S R22E	1901[8] 1935[9]	137 321

[1] White; Book 811 [2] White; Book 804 [3] White; Book 845 [4] White; Book 889
[5] Contzen; Book 935 [6] Wright; Book 2167 [7] Contzen; Book 983 [8] Contzen; Book 989
[9] Measured from 1:62.500 scale aerial photography

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

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

Lower San Pedro River

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

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

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

Beginning in 1890, the lower San Pedro River started to change. A series of large floods in 1890, 1893,

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

> *"About 12 years ago the [lower] San Pedro Valley consisted of a narrow strip of subirrigated and very fertile lands. Beaver dams checked the flow of water and prevented the cutting of a channel. Trappers exterminated the beavers, and less grass on the hillsides permitted greater erosion, so that within four or five years a channel varying in depth from 3 to 20 feet was cut almost the whole length of the river. Every year freshets are carrying away new portions of the bottom lands."*

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

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

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

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

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

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

Channel Conditions in 1912

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

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

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

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

Ordinary High Watermark

Where channel conditions have not significantly changed since statehood, the limits of the ordinary high watermark as of the time of statehood can be mapped using the current USGS topographic maps for

the river. Where changes have occurred, and are not due to avulsions or are not man-made, any potential claim of streambed ownership will follow the existing channel geometry. Therefore, the ordinary high watermark was identified by topographic characteristics indicated on USGS topographic maps, such as slope changes at the channel margin, and by vegetation changes visible on aerial photographs. For the upper San Pedro River, the lateral extent of the ordinary high watermark is very similar to the lateral extent of the floodplain due to historic entrenchment of the river. In the lower San Pedro River, ordinary high watermarks are not necessarily similar to floodplain limits. The USGS maps were used a base map to map the ordinary high water limits entered into the San Pedro River GIS.

Ordinary Low Watermark

HB 2589 limited the state's claim to navigable watercourses to the land between the ordinary low watermark. The ordinary low watermark is defined in HB 2589 as:

> *"...the line on the banks of a watercourse created when the water recedes at its regularly recurring lowest stage in normal years without reference to unusual droughts."*

In practice, the ordinary low watermark may be difficult to identify on Arizona rivers, but is generally identified in conjunction with delineation of the high watermark, or is defined on the basis of site-specific or hydrologic characteristics. Unlike high watermarks, low watermarks are more ephemeral and may be erased by subsequent high flows. Case histories for application of a low watermark standard in Arizona are lacking.

Delineation of the ordinary low watermark was not within the scope of the original investigation for the San Pedro River. However, the following general statements can be made in regard to delineation of the ordinary low watermark for the San Pedro River:

- For existing conditions, parts of the San Pedro River are ephemeral or intermittent. Therefore, the intermittent reaches have no ordinary low watermark (or a low watermark of zero width), and the State's ordinary low water mark definition cannot be applied. Stated another way, there is no land area between the ordinary low water mark for the portions of the study reach that are normally dry during seasonal periods of low flow.
- For the remaining perennial reaches, the ordinary low watermark is controlled by the normal low flow condition of the river. Seasonal flows can be less than 10 cfs in the perennial reaches, which would result in a very narrow, poorly defined strip of land between the ordinary low watermarks.

Regardless of whether the ordinary low watermark is delineated for existing (1997) conditions or for conditions as of the time of statehood (1912), it is likely that portions of the San Pedro River were not dry in their ordinary and natural condition, as defined by HB 2589. These reaches would require additional study and data collection to identify the ordinary low watermark, should the San Pedro

River be found to have been navigable as of the time of statehood.

Summary

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

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

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

Chapter 6
San Pedro River Land Use

Introduction

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

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

Data Sources

The primary data sources for San Pedro River land ownership, land use, and improvements was information obtained from county assessors' offices, and other public agencies as described below. Leasing data was collected from ASLD (mining and other uses), BLM (agriculture and mining), and the U.S. Forest Service (grazing). Wildlife, riparian, and recreational classifications were obtained from Arizona Game and Fish Department and the U.S. Fish and Wildlife Service.

Methodology

The primary work product for the land use assessment is a GIS for the San Pedro River study reach. Geographical Information Systems combine the spatial characteristics of digital mapping with the resource information library capabilities of a database. Through a GIS, information such as land ownership (title), biological and hydrologic characteristics, land use, or other descriptive information can be tied to specific parcels or river reaches. The San Pedro GIS was constructed from assessor records from Pima County, Pinal County, and Cochise County, and other information from a GIS being constructed by ALRIS, an inter-agency group funded by the State of Arizona, and information from the BLM. However, parcel datasets for portions of the San Pedro received from Pima FCD, Cochise FCD, and BLM, but were found to be incompatible with ALRIS coordinates, and the parcels were digitized from the assessor maps.

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

as delineated on the assessor maps, though USGS maps and ALRIS's HYDRO layer were consulted as well. Where "meander lines" were delineated on assessor maps, all parcels within that area were digitized.

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

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

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

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

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

- Land Ownership
- Ordinary High Watermark
- Land Use

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

Land Use and Ownership

Land ownership, or current title, and land use information obtained from assessors' records and other sources are shown in Tables 6-1 and 6-2. The largest percentage of land in the reach is privately held.

The BLM and the State are the next largest land holders. Land uses in the river valley include grazing, agricultural (orchards/crops/miscellaneous), residential, and undeveloped. The San Pedro River reach includes three land grant parcels, the San Pedro Riparian Preserve, and several Nature Conservancy holdings. The San Carlos Indian Community also claims a portion of the reach.

Table 6-1
San Pedro River Land Ownership.

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

Table 6-2
San Pedro River Land Use.

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

Riparian Information

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

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

Chapter 7
Hydrology of the San Pedro River

Introduction

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

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

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

Stream Reaches

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

Data Sources

Hydrologic data were derived primarily from published stream gage records of the U.S. Geological Survey (cf. USGS, 1954; 1991), historical accounts of the San Pedro River (cf. Dobyns, 1981; Davis,

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

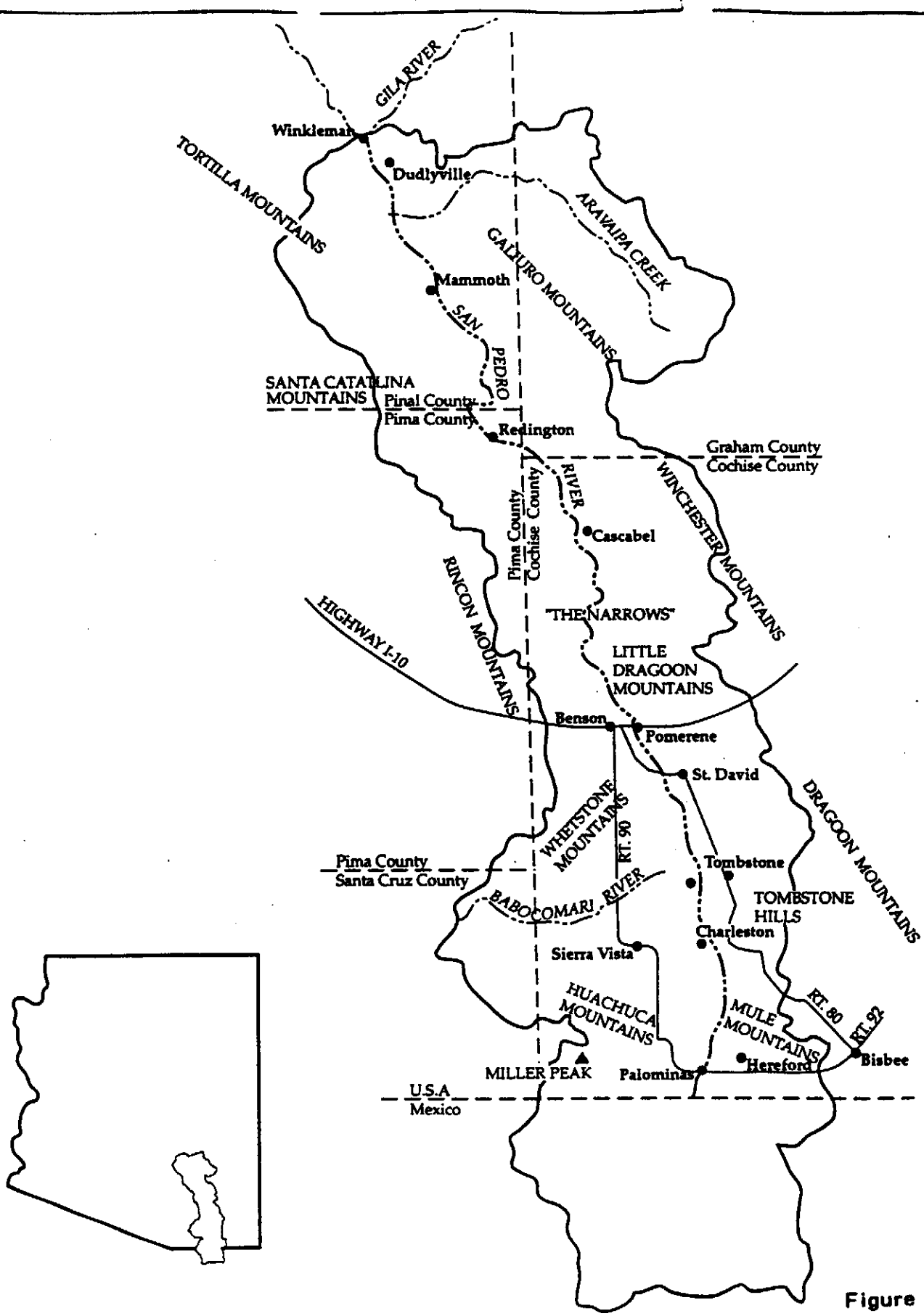

Figure 7-1

San Pedro River Watershed Map

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1981), and other reports on the hydrology of the San Pedro River (cf. ADWR, 1991). More detailed descriptions of archeological and historical records, stream geology and geomorphology, and boating and navigability criteria for the San Pedro River basin are summarized elsewhere.

Hydrologic Setting

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

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

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

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

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

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

SOURCE: Sellers et al, 1989

Vegetation along the San Pedro River is predominantly Sonoran desert scrub in the lower reaches, with Chihuahuan desert scrub in the upper reaches. Historically, the upper San Pedro Valley was Chihuahuan desert grassland but has since been invaded by woody shrubs and other species (Huckleberry, 1993). Since the late 1800's, riparian vegetation such as cottonwood, willow, tamarisk, and mesquite have populated the river corridor (Hastings and Turner, 1965). At higher elevations oak woodland and mixed conifer species are found.

The hydrology of the San Pedro River is also impacted by irrigation diversions, ground water pumping, evapotranspiration (cf. ADWR, 1991), ground water-surface water interactions (cf Stetson, 1987), and watershed impacts including grazing, timber, and fire (Dobyns, 1978).

Statehood/Pre-Statehood Hydrology

Hydrologic data for the San Pedro River for the period preceding statehood is derived primarily from historical accounts of early explorers and settlers. Although the San Pedro River is one of the most thoroughly studied rivers in the southwest, systematic collection of hydrologic data

generally did not begin until after 1912.

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

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

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

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

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

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

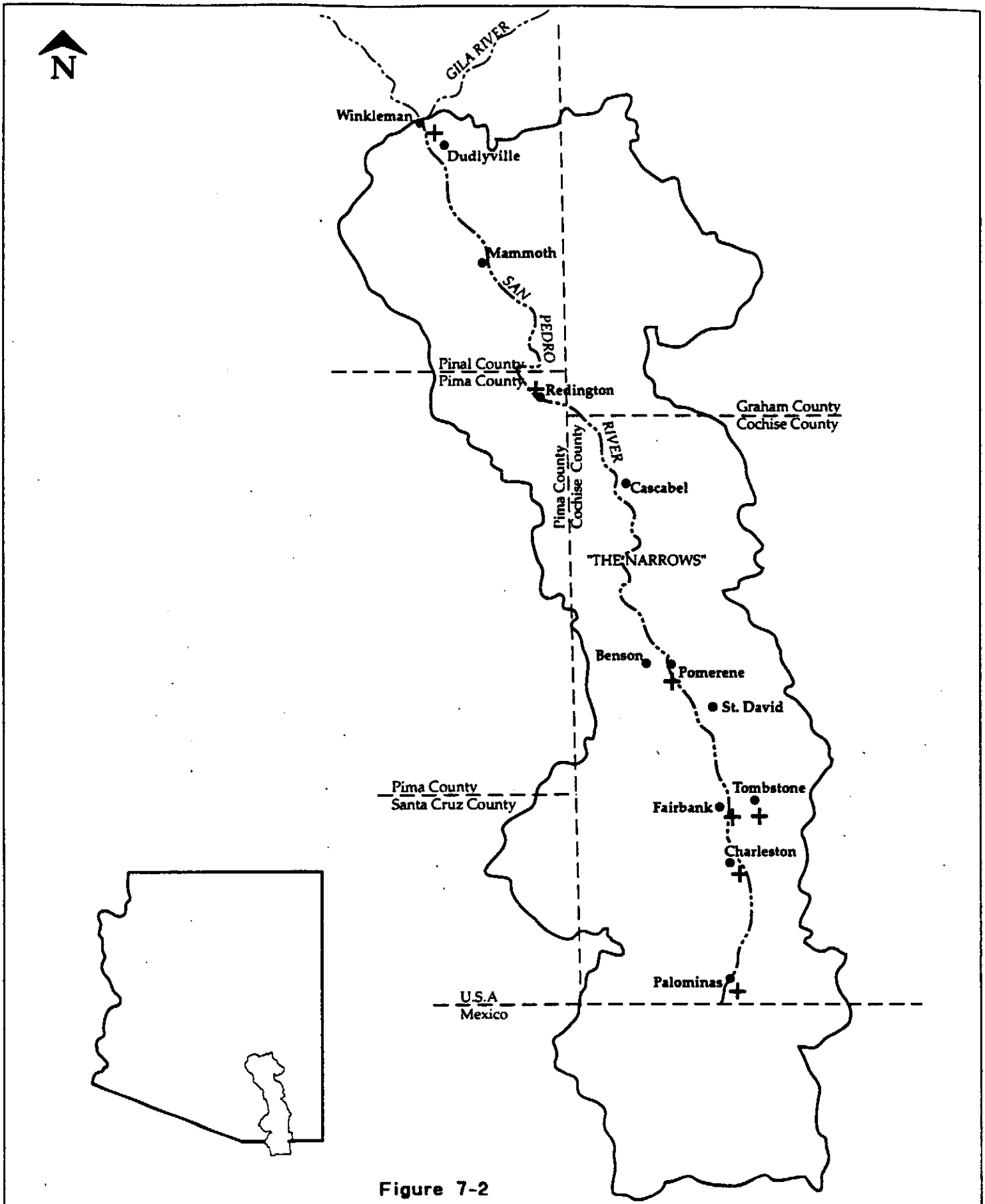

Figure 7-2

Location of San Pedro River Stream Gage Sites and Rating Curve Reaches

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

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

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

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

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

Post-Statehood Hydrology

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

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

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

Table 7-3
San Pedro River USGS Streamflow Gaging Stations

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

Sources: USGS, 1914; 1954; 1991

Flow Duration Curves. A flow-duration curve shows the percentage of time (frequency) during some time period studied that a specified rate of flow was equaled or exceeded. The curve also provides a useful method for analyzing the availability and variability of streamflow. That is, the slope of a flow-duration curve is a good indication of the capacity of a basin to store water. Storage of water in alluvium or bedrock aquifers tends to lower the variability of the flow by reducing the peak flows and spreading the same volume of runoff over a longer time period. A steeply sloping flow duration curve indicates high variability in flow rates and small amounts of natural storage, and gently sloping curve indicates a low variability, which is characteristic of a consistent component of base flow per unit drainage area (Owen-Joyce and Bell, 1983). The station at Palominas and the stations from Benson downstream have steeply sloping flow duration curves. These stations correspond to the intermittent reaches of the river. The Charleston and Tombstone station have less steeply sloped flow duration curves, though they are steep compared to other perennial rivers in Arizona such as the Verde River. Flow frequency estimates for all of the San Pedro River stations converge for low frequency events (less than 20%), indicating a similar flood hydrology for the entire river.

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

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

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

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

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

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

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

- Most of the San Pedro River between Hereford and the St. David Irrigation ditch is perennial. Only about four miles of the river downstream of St. David is perennial.

- The few springs in the study area discharge at rates of only a few gallons per minute (0.002 cfs).

- Ground water in the San Pedro River basin flows toward or into the San Pedro River.

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

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

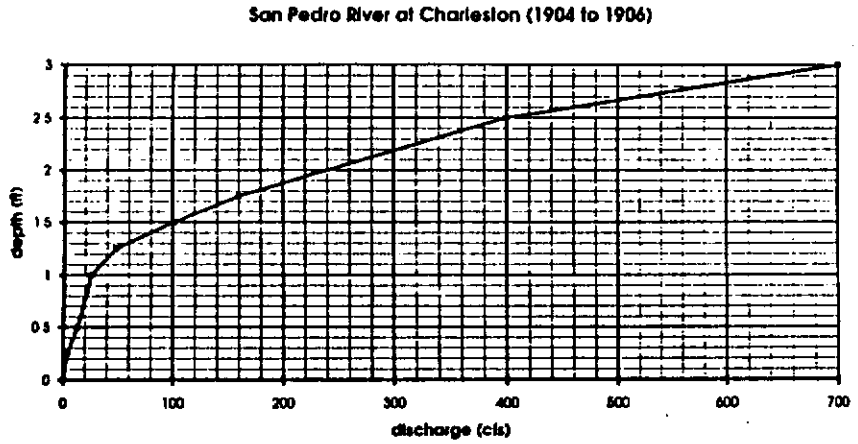
- Average streamflow rates have declined since the 1920's at some stations on the San Pedro River.

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

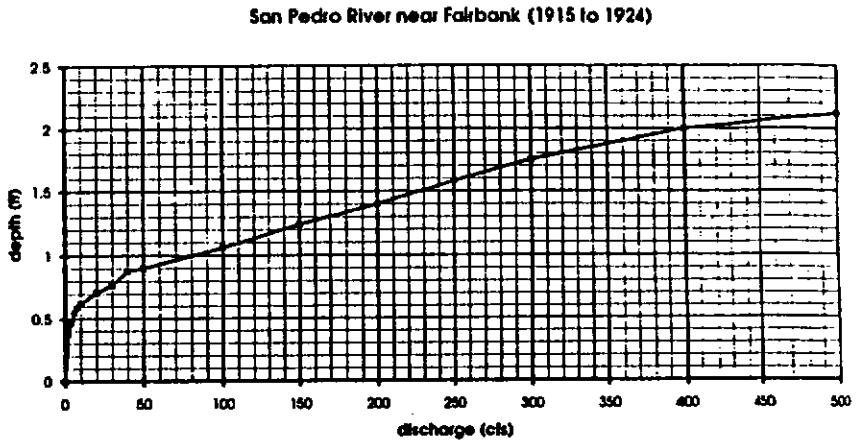
Comparison of Modern and Historical Record. No systematic data exist by which to compare post-statehood flow rates with flow rates at the time of statehood. Secondary sources such as tree-ring data (Smith and Stockton, 1981) and precipitation analyses (Cooke and Reeves, 1976) indicate that the period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

Hydraulic Rating Curves

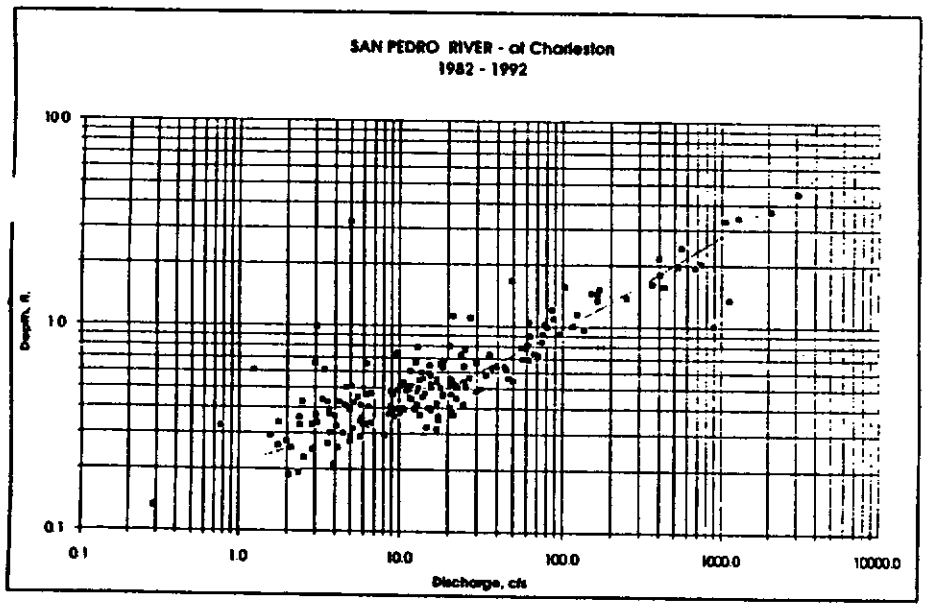
Hydraulic rating curves relate stream discharge to flow depth, width, and velocity. Two sources of information were used to develop rating curves for the San Pedro River: (1) historical measurements of stream stage, velocity, and discharge taken around the time of statehood by the USGS; and (2) recent streamflow characteristics recorded by USGS field personnel working at stream gage stations still in operation. A typical rating curve for the San Pedro River is shown in Figure 7-3; locations of San Pedro stream gages are shown in Figure 7-2; documentation on rating curves is attached in Appendix F.



A



B



C

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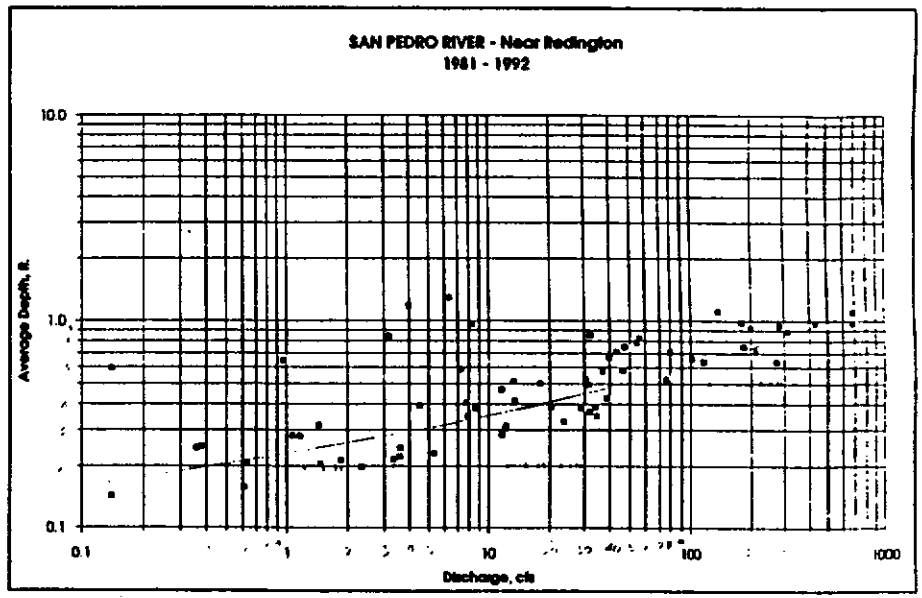

Typical Hydraulic Rating Curve for Upper and Lower San Pedro River

Figure 7-3

Historical streamflow data were available from the Charleston (1904-1906), and (near) Fairbank (1915-1924), stations. To reconstruct rating curves, published stage, velocity, and discharge readings from the period of record closest to statehood were tabulated. Stream stage was then related to average stream depth. Finally, other streamflow parameters such as topwidth and velocity were estimated using Manning's equation[4], assuming a rectangular channel. Rating curves were then developed and compared to monthly and annual streamflow statistics, as illustrated below.

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

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

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

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

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

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

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

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

NOTE: Discharges from entire gage record: 1904-1991

Table 7-6b
San Pedro River at Charleston, 1904 to 1906
Flow Duration Hydraulic Characteristics

Flow Period	Flow Rate (cfs)	Average Depth (ft)	Velocity (ft/sec)	Topwidth (ft)
Average Annual Flow	59	1.3	4.3	10
90% Flow	77	1.4	4.4	12
50% Flow	14	0.5	3.0	5
10% Flow	4	0.2	2.5	3

Table 7-7a
San Pedro River at Charleston Gage #09471000
Average Hydraulic Characteristics

Month	Flow Rate (cfs)	Average Depth (ft)	Velocity (ft/sec)	Topwidth (ft)
January	38	0.7	1.7	37
February	28	0.6	1.5	33
March	24	0.5	1.4	31
April	13	0.4	1.2	23
May	9	0.4	1.1	19
June	3	0.3	0.9	10
July	148	1.2	2.3	60
August	233	1.4	2.7	69
September	91	0.9	2.1	50
October	40	0.7	1.7	38
November	18	0.5	1.3	28
December	50	0.7	1.8	41
Annual	59	0.8	1.9	43

NOTE: Discharges from entire gage record: 1904-1991

Table 7-7b
San Pedro River at Charleston, Gage #09471000
Flow Duration Hydraulic Characteristics

Flow Period	Flow Rate (cfs)	Average Depth (ft)	Velocity (ft/sec)	Topwidth (ft)
Average Annual Flow	59	0.79	1.9	43
90% Flow	77	.88	2.0	48
50% Flow	14	.44	1.3	24
10% Flow	4	.30	0.95	12

Table 7-8a
San Pedro River at Fairbank, 1915 to 1924
Average Hydraulic Characteristics

Month	Flow Rate (cfs)	Average Depth (ft)	Velocity (ft/sec)	Topwidth (ft)
January	56	0.9	3.0	20
February	45	0.9	2.9	17
March	37	0.9	2.8	15
April	15	0.7	2.4	9
May	8	0.5	2.2	6
June	4	0.5	2.0	5
July	104	1.1	3.3	29
August	160	1.3	3.7	34
September	58	0.9	3.0	20
October	95	1.0	3.2	28
November	16	0.7	2.4	9
December	63	1.0	3.0	22
Annual	56	0.9	3.0	20

NOTE: Discharges derived from San Pedro near Tombstone gage.

Table 7-8b
San Pedro River near Fairbanks, 1915 to 1924
Flow Duration Hydraulic Characteristics

Flow Period	Flow Rate (cfs)	Average Depth (ft)	Velocity (ft/sec)	Topwidth (ft)
Average Annual Flow	56	0.9	3.0	20
90% Flow	82	1.0	3.2	25
50% Flow	13	0.7	2.4	9
10% Flow	0	0	0	0

Table 7-9a
San Pedro River: Near Tombstone, Gage 09471550
Average Hydraulic Characteristics

Month	Flow Rate (cfs)	Average Depth (ft)	Velocity (ft/sec)	Topwidth (ft)
January	56	0.5	1.9	58
February	45	0.5	1.8	53
March	37	0.5	1.7	48
April	15	0.4	1.4	28
May	8	0.3	1.3	16
June	4	0.3	1.2	9
July	104	0.6	2.1	72
August	160	0.8	2.4	84
September	58	0.5	1.9	59
October	95	0.6	2.1	70
November	16	0.4	1.5	29
December	63	0.5	1.9	61
Annual	56	0.5	1.9	58

Table 7-9b
San Pedro River: Near Tombstone, Gage 09471550
Flow Duration Hydraulic Characteristics

Flow Period	Flow Rate (cfs)	Average Depth (ft)	Velocity (ft/sec)	Topwidth (ft)
Average Annual Flow	56	0.5	1.9	58
90% Flow	82	0.6	2.0	66
50% Flow	13	0.4	1.4	24
10% Flow	0	0	0	0

Table 7-10a
San Pedro River: Near Redington, Gage 09472000
Average Hydraulic Characteristics

Month	Flow Rate (cfs)	Average Depth (ft)	Velocity (ft/sec)	Topwidth (ft)
January	33	0.5	2.2	27
February	22	0.4	1.9	21
March	16	0.4	1.7	18
April	4	0.3	1.1	8.5
May	1	0.3	0.8	5.7
June	2	0.3	0.9	6.0
July	103	0.6	3.1	50
August	215	0.8	3.6	74
September	50	0.5	2.6	33
October	51	0.5	2.6	33
November	4	0.3	1.1	8
December	36	0.5	2.3	28
Annual	45	0.5	2.5	31

Table 7-10b
San Pedro River: Near Redington, Gage 09472000
Flow Duration Hydraulic Characteristics

Flow Period	Flow Rate (cfs)	Average Depth (ft)	Velocity (ft/sec)	Topwidth (ft)
Average Annual Flow	45	0.50	2.5	31
90% Flow	55	0.5	2.6	35
50% Flow	0.6	0.2	0.6	4
10% Flow	0	0	0	0

Rating curves of depth vs. discharge for high flow conditions have been developed by the BLM (1987) for seven locations between Hereford and St. David. BLM rating curves are based application of Mannings' equation to surveyed cross section information. These rating curves probably have little applicability to navigability on "ordinary and natural" conditions, since flows in excess of 1,000 cfs occur less than one percent of the time, according to flow duration statistics, and because no flow velocities are given. In general, the BLM curves agree with the low flow rating

curve data summarized in Tables 7-6 to 7-10, in that low flows are about two feet deep or less. The BLM cross section data also predict flow depths of 5 to 10 feet for the 2-year flood. BLM cross section plots are attached in Appendix E.

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

Floods

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

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

Table 7-12
Summary of San Pedro River Flood Frequency Discharges (cfs)

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

Source: FEMA, 1989; 1990; USGS, 1991

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

Table 7-12
Dates and Discharges of Large San Pedro River Floods (cfs)

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

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

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

velocities do not exceed federal maximum recommended velocities for floating-type boats such as canoes. However, other river conditions during floods, such as floating debris, could indeed making boating in flood waters hazardous.

Irrigation

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

Table 7-13
San Pedro River Surface Water Irrigation Diversions

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

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

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

Summary. Although irrigation was practiced in the San Pedro River valley, irrigation was not as

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

extensive as for other Arizona rivers such as the Salt, Gila, and Verde Rivers. Limited streamflow and channel cutting may have prevented more extensive irrigation in the watershed. On average, about 14 cfs of surface water is currently diverted from the entire San Pedro River for use on about 3,300 acres, most of which must be supplemented by ground water (ADWR, 1991). Around the time of statehood, about 2,500 acres were irrigated (ADWR, 1991), with much of the water supply derived from wells. The increased number of canals during the pre-statehood period, particularly in the lower San Pedro River, may indicate higher flow rates in the lower reach at that time.

Summary

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

Given the criteria for navigability established by HB 2589, the hydrologic record for the San Pedro River indicates the following:

- The Upper San Pedro River about St. David was perennial at of the time of statehood, with an average annual flow rate of about 50 cfs, and a median (50%) flow rate of about 10 cfs. These flow rates correspond to flow depths, widths, and velocities of about 1 feet, 30 feet, and 3 feet per second, for the average annual rate, and about 0.5 feet, 10 feet, and 2 feet per second, for the median flow rate , respectively. The natural average flow rate during the month of February was about 40 cfs.
- The remaining reaches of the San Pedro River were mostly intermittent, with a few local ephemeral or perennial reaches of limited extent. In these reaches, such as near Redington, the average annual flow rate is about 45 cfs, but the median (50%) flow rate is less than 1 cfs. Both the average annual and median flow rates are associated with flow depths of less than 0.5 feet, and velocities of less than 3 feet per second.
- Few data are available for the year, month or day of Arizona statehood for the San Pedro River.
- By the time of statehood, the portions of the San Pedro River were periodically dry or experienced low flows due to irrigation diversions.

- Diversions were made from the San Pedro River to irrigate and reclaim land, including possible diversions to Indian lands. Many of these diversions were appropriated prior to the time of statehood.
- There were diversion dams and other man-made hydraulic structures in the San Pedro River that could have created an impediment to certain types of navigation. The most common impediment to navigation was absence of flow during early summer months, or shallow water during typical flow conditions.

Chapter 8
Boating on the San Pedro River

Introduction

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

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

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

Federal Criteria for Navigability

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

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

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

Source: US Fish and Wildlife, 1978

Table 8-2
Minimum and Maximum Conditions for Recreational Water Boating

Type of Boat	Minimum Condition			Maximum Condition		
	Width	Depth	Velocity	Width	Depth	Velocity
Canoe, Kayak	25 ft.	3-6 in.	5 fps	-	-	15 fps
Raft, Drift Boat	50 ft.	1 ft.	5 fps	-	-	15 fps
Low Power Boating	25 ft.	1 ft.	-	-	-	10 fps
Tube	25 ft.	1 ft.	1 fps	-	-	10 fps

Source: Cortell and Associates, 1977

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

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

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

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

Historical Accounts of Boating

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

- Travel
- Ferries
- Recreation
- Mail Delivery
- Flood Rescues

- Transport of Goods

Several accounts of floating logs down other Arizona rivers are also documented. Review of historical records of boating gives the general impression is that there was no shortage of boats in certain parts of Arizona as of the time of statehood. Whenever a boat was needed to cross a flooded river, even during the period of early exploration, boats were borrowed from local residents, used and returned, or simply constructed on the spot.

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

Historical Accounts of Fish

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

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

Modern Accounts of Boating

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

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

modern use of a river reach by canoes probably indicates that canoes could have been used as of the time of statehood.

The Central Arizona Paddlers Club (CAPC), an organization of boaters, recently conducted a survey of their members to determine what rivers had been boated. With 20 percent of members responding, the survey indicated that the San Pedro from Palominas to Hereford Road has been boated in recent years (Central Arizona Paddlers Club, 1992). CH2M HILL informally polled CAPC members willing to be interviewed to determine flow conditions at the time the San Pedro River was boated. Data collected in this poll reveal that all of the San Pedro River except the reach from Mammoth to Aravaipa Creek, and from Curtis to I-10 have been boated at least once. A brief summary of the CAPC poll showing reaches and flow data is presented in Table 8-3 (Also see Appendix G).

Although the San Pedro River has been boated, Arizona State Parks Department classified the river as a hiking or general recreation area, rather than a boating stream (1989). Some boaters who have traveled on the San Pedro River described driving to the reach and waiting for summer monsoons to occur before being able to float the stream. Others have attempted to float some reaches merely on base flow. All but one of the modern, documented boating excursions on the San Pedro River occurred in the month of August, during the monsoon season. A boating guide to the southwest does not list the San Pedro River (Anderson and Hopkinson, 1982).

Table 8-3
Central Arizona Boaters Club
Survey Results: Selected San Pedro Reaches Boated

River	Reach	Date mo-yr	Flow (cfs)	Depth (ft)	Width (ft)	Craft	Portage (%)
San Pedro	Mexican Border to Palominas	8-92	n.a.	< 1	< 15	Kayak	50
	Palominas to Hereford Rd.	8-92	12	< 1	< 10	Kayak	50
	Hereford to Highway 90	1-93	n.a.	< 5	< 40	Rubber Raft	0
	San Pedro Preserve	8?-92	n.a.	n.a.	n.a.	Canoe	n.a.
	I-10 to Mammoth	8-73	200	> 0.5	< 20	Small Raft	5
	Aravaipa Ck. to Hayden	3-79	1,000	1.5	< 120	Canoe	0

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

Table 8-4 Flow Requirements for Pre-1940 Canoeing	
Boat Type	**Depth**
Flat Bottomed (Wood or Canvas)	4 in.
Round Bottomed (Wood or Canvas)	6 in.
Source: Slingluff, J., 1987	

Navigability Decisions

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

Summary

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

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

Given the navigability criteria established by HB 2589, the record of historical and modern boating on the San Pedro River indicate the following:

- Only certain reaches of the San Pedro River have been boated. These reaches were floated by low-draft boats such as kayaks, rafts and canoes during the monsoon season.
- No records of historical boat use was identified for the San Pedro River.
- No record of episodic and/or sustained trade and travel in the upstream direction on the San Pedro River was found.
- The only recorded accounts of boating on the San Pedro River were for recreational, rather than commercial purposes.
- Flow conditions suggest that flotation of logs probably could not have been regularly

conducted for commercial purposes.

- There are or were diversion dams and other man-made structures in the San Pedro River that created impediments to certain types of navigation.

Chapter 9
Conclusions

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

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

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

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

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

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

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

generally occur during floods or brief periods of higher flow.

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

ARS 37-1128 mandates a presumption of non-navigability if certain criteria apply to the river reach. Data from this study can be summarized according to the following criteria established by HB 2589:

- **Commercial Trade and Travel**. As of the time of statehood, the San Pedro River probably was not susceptible to any forms of commercial trade and travel on water, with the possible exception of uses based on opportunistic shallow -water boating during brief periods of seasonal high flow. The hydrologic record shows that there was insufficient water in the river to allow use of most types of boats during nearly all of the year.

- **Flow Regime**. As of the time of statehood, the hydrologic record shows that much of the San Pedro River was ephemeral or intermittent, with significant flows occurring only in direct response to precipitation.

- **Sustained Trade and Travel Upstream and Downstream**. There is no evidence that sustained trade and travel ever occurred on the San Pedro River. Hydraulic rating curves indicate that boat travel would have been difficult.

- **Profitable Commercial Enterprise**. There is no documented historical evidence that any profitable commercial enterprises were conducted using the San Pedro River for trade and travel as the time of statehood.

- **Types of Vessels**. The historical record indicates a ferry may have been used near Pomerene prior to (but not at or after) statehood. Since that time, only canoes and kayaks have been used on the San Pedro River. There is no evidence that keel boats, steamboats or powered barges were ever used on the San Pedro River. The hydraulic rating curves prepared for the study reach indicate that keelboats, steamboats or powered barges could not have been used during the low flow conditions that existed in 1912. During high flow conditions, high velocities and river conditions may have made use of these boats hazardous. Canoes and other highly maneuverable low-draft boats possibly could have been used with some difficulty on certain discontinuous reaches during low flow conditions in the remaining

perennial reaches in 1912.

- **Diversions**. Numerous irrigation diversions existed along portions of the San Pedro River as of 1912. It is unclear whether any of the irrigated lands were covered under the Desert Land Act of 1877, although some lands are located within the San Carlos Indian Reservation.

- **Recreational Boating**. All but one (undocumented) account of boating on the San Pedro River was for recreational purposes.

- **Regular Flotation of Logs**. Logs or other material could not have been floated through the entire San Pedro River study reach as of the time of statehood..

- **Impediments to Navigation**. There were several irrigation diversion structures in 1912 that would be considered impediments to any type of boat traffic. Dry reaches of river would have been the most significant impediment to navigation.

- **Customary Modes of Transportation**. The customary mode of transportation in the region near the San Pedro River was not by boat. By 1912, alternatives to boat travel included foot, horse, mule train, wagon, and train.

- **Rivers and Harbors Act of 1899.** The San Pedro River is not one of the streams listed in the Rivers and Harbors Act of 1899.

No documented record of use of the San Pedro River for navigation on water was found. It is unlikely that the river would be, or was, susceptible to most types of boating, under median flow conditions during most months of the year, though hydraulic ratings of the channel indicate that limited types of shallow-water boating could occur in some reaches during portions of some years.

Chapter 10
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1966 Preliminary Report on a Desert Culture Site: San Pedro Valley, Arizona. Ms. on file, Arizona State Museum Library, University of Arizona, Tucson.

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

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

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

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1976 The San Pedro Salado: A Case of Prehistoric Migration. *The Kiva* 42:47-56.

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

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

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

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

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

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

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1961 Geochronology of Pluvial Lake Cochise, Southern Arizona: Pollen Analysis of Shore Deposits. *Journal of the Arizona Academy of Science* 32:168-185.

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

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

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

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1993 *Archaeological Studies at Kartchner Caverns State Park, Cochise County, Arizona*. SWCA Archaeological Report No. 93-26. SWCA, Inc., Tucson. Submitted to Arizona State Parks, Phoenix.

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1930 *Pueblo Sites in Southeastern Arizona*. University of California Publications in Geography Vol. 7, No. 3.

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

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

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

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

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

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

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

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

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

Main theme: History of Arizona prior to 1930.

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

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

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

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

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

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

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

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

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1988 *Arizona Place Names.* University of Arizona Press, Tucson.

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

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

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

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

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

Bell, William A.
1869 *New Trails in North America.* Vols. 1 and 2. Chapman and Hall, London.
Main theme: Bell followed Graham's route south of the international border, but he did report on the headwaters of the San Pedro.

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

Main theme: Journal of member of the Mormon Battalion.

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

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

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

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

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

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

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

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

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

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

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

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

Main theme: Chamberlain was a forty-niner who followed the Kearny-Emory route, leaving the Rio Grande at San Antonio (south of Socorro) and going straight over the mountains to the headwaters of the Gila, then following the Gila to the Colorado, and not traveling along the San Pedro.

Clarke, Asa B.

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

Clarke, Dwight L.

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

Conkling, Roscoe P., and Margaret B. Conkling

1947 *The Butterfield Overland Mail, 1857-1869.* 3 vols. Arthur H. Clark Co., Glendale.

Cooke, Philip St. George

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

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

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

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

Cox, Cornelius C.

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

Main theme: The history of Arizona comprising eight volumes.

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

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

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

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

Graham, J.D.
1852 Report of the Secretary of War, Communicating, in Compliance with a Resolution of the Senate, the Report of Lieutenant Colonel Graham on the Subject of the Boundary Line between the United

States and Mexico. U.S. 32nd Congress, 1st Sess., Sen. Exec. Doc. 121. A. Boyd Hamilton, Washington, D.C.

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

Hinton, R.J.
1878 Handbook of Arizona.

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

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

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

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

Main theme: Intention of the book is to encourage people to move to Arizona. Title page reads, "To the inhabitants of Arizona and to all others who take an interest in the development and prosperity of that wonderful country." There is a chapter on rivers of Arizona but there is no reference to their use.

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

Main theme: This is a technical report on the role of intermittent streams and rivers in the Wild a Scenic River System. It touches on rivers in Arizona in chapters 6-7. Rivers and streams covered are the Gila, Eagle Creek-San Francisco-Tonto Creek, Little Colorado and San Pedro. There is no mention of navigability on any of these waterways. It focuses a lot on biology and hydrology, and culture historical sequence is described.

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

Main theme: Concerns the Missouri Company of Capt. Samuel W. Berry.

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

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

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

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

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

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

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

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

Main Theme: Treatise of the conflicts over control of water in Arizona.

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

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

Main theme: History of Arizona.

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

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

Main theme: Historical information on the railroads of southern Arizona.

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

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

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

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

Main theme: account of the only through passenger on the first Butterfield Stage west.

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

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

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

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

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

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

Main theme: Book is a narrative on particular rivers as of 1980 as seen through the eyes of the author.

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

Main theme: Butterfield stage line through Texas. Richardson recommends reading the St. Louis and San Francisco newspapers, especially the St. Louis *Missouri Republican*, 1858-1859, for accounts of the early trips. Newspaper reporters waited at the stations and reported passenger lists as well as descriptions of the trip.

Riley, Carroll L.
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Appendix C
Note on Historical Sources

A Note on Historical Sources for San Pedro River

The primary libraries for historical research in Arizona are (1) the Arizona State Library and Archives, (2) the Arizona Historical Society libraries in Tucson and Phoenix, (3) the University of Arizona Library, especially the special collections, (4) the Hayden Library at Arizona State University, especially the special collections and the Arizona Historical Foundation, which maintains an office in the Hayden Library. The Salt River Project maintains archives that are important in documenting the history of the San Pedro and other rivers. The Cline Library at Northern Arizona University and the library of the Museum of Northern Arizona have secondary sources, but with regard to the San Pedro River, duplicate the holdings of the libraries at the University of Arizona and Arizona State University. It should be noted that the computerized card catalog at the Cline Library at NAU can access the collections of the other university libraries in Arizona.

The San Pedro River and Valley are one of the key case studies in Hastings and Turner's (1965) *The Changing Mile*, a study of environmental changes in southern Arizona during historic times. Hastings and Turner reviewed virtually all of the historical descriptions of the San Pedro and rephotographed historic views of southern Arizona landscapes to document arroyo cutting and changes in vegetation. Dobyns (1981), Hastings (1959b), and Hereford and Betancourt (1993) also explore the theme of environmental changes along Sonoran Desert rivers. A similar study by Davis (1982) documents wildlife observed by American explorers in Arizona, and contains numerous and extensive accounts of the San Pedro. Hadley, Warshall, and Bufkin (1991) prepared a history of the ecology of Aravaipa Creek, a major tributary of the San Pedro. This volume deals tangentially with the San Pedro from prehistoric times to the present, and is especially useful in discussing the history of Camp Grant, which is located at the junction of the Aravaipa and the San Pedro.

Other secondary sources that provide general overviews on the history of the San Pedro River include Walker and Bufkin's (1986) *Historical Atlas of Arizona* and Herbert and Campbell's (1986) timeline and social history of the San Pedro River. Hoffman (1982), Jackson (1987), and Powell (1980) are similar secondary works that reference San Pedro River history. Barnes (1988) and Granger (1984; 1985) contain historical information on place names in Arizona. Fulton (1966), Fulton and Bahre (1967), Tiller (1982), and Varney (1980) have information on the mining and milling towns along the San Pedro.

Di Peso (1953) is the best overview of Native American use of the San Pedro Valley. Other useful sources on the historic Native American occupation of the valley are Basso (1983), Bandelier (1890, 1890-92, 1892), Browning (1982), Ezell (1983), Fontana (1983), Hackenburg (1983), and Ogle (1970).

The Coronado expedition has an extensive bibliography (Bolton 1916, 1949, 1990; Day 1964; Di Peso 1951; Haury 1984; Hodge 1933; Hodge and Lewis 1907; Riley 1985; Sauer 1932, 1937; Schroeder 1955, 1956; Udall 1984, 1987; Undreiner 1947; Winship 1896), but a recent study by the National Park Service (NPS 1991) indicates a great deal of uncertainty about Coronado's Route through the region. Di Peso (1953) is a historical archeaological study of Spanish attempts first to missionize and then to colonize the San Pedro and is a thorough account of the history of the San Pedro from the late 1600s to 1800. The missionary activities of Father Eusebio Kino are discussed in many books and articles (Bolton 1916, 1936, 1948, 1960;

Burrus 1965, 1971; Kessell 1966a; Smith, Kessell, and Fox 1966). Officer's (1987) study of the Spanish and Mexican period in Arizona provides information on the Spanish and Mexican exploration of the area and is a useful source on Mexican land grants. Hammond (1929), Kessell (1966b, 1966b), Mattison (1946), Thomas (1932, 1941), Williams (1986), and Wyllys (1931) contain information on the San Pedro Valley in the Spanish Period.

James Ohio Pattie's (1883) journal is essentially the only firsthand account of early nineteenth-century fur trappers' use of the San Pedro, but given Pattie's tendency to exaggerate, secondary assessments of his writings (for example, Batman 1984) are useful.

During the Mexican War, topographical engineer William H. Emory accompanied Steven Watts Kearny down the Gila and commented on the lower San Pedro (Emory 1848). John S. Griffen, a surgeon with the expedition also mentioned the San Pedro (Griffen 1943). Philip St. George Cooke (1848, 1938, 1964, 1974), commander of the Mormon Battalion on their journey from Fort Leavenworth, Kansas, to San Diego, California, during the Mexican War, provided relevant observations about the conditions of the San Pedro River Valley in the mid-nineteenth century. Other accounts of the Mormon Battalion include Bigler (1932), Bliss (1931), Golder, Bailey and Smith (1928), and Tyler (1881). One of the principal routes for the forty-niners on their way to the gold fields of California ran along the present border between Arizona and Mexico, and the San Pedro was described by a number of chroniclers (Aldrich 1950; Chamberlain 1945; Clarke 1852; Cox 1925; Durivage 1937; Eccleston 1950; Evans 1945; Harris 1960; Hunter n.d.; Pancoast 1930; Powell 1931). In the 1850s, the international boundary between the United States and Mexico was formally surveyed, and the San Pedro was described again (Bartlett 1854; Emory 1857). Still later, surveys for a railroad (Parke 1857) and a wagon road (Hutton 1859; Leach 1858) resulted in descriptions of the area. Other early travelers' descriptions of the San Pedro include Bell (1932), Bell (1869), Gray (1856), Ormsby (1952), and Tevis (1954). The Surgeon General's (1870) evaluation of Camp Grant includes descriptions of the San Pedro River, as do Bourke's (1891) accounts of life at Camp Grant.

A number of early histories and boosters' descriptions of Arizona (Adams 1930; Bancroft 1888; Farish 1915; Hamilton 1884; Hodge 1877; McClintock 1916; Wallace W. Elliot & Co. 1884) might be considered primary sources. For example, Hamilton (1884), Hodge (1877), and Wallace W. Elliot & Co. (1884) are promotional literature that might be expected to publicize navigability of the rivers if it was at all feasible, but none of these volumes does. Hamilton (1884) has 14 pages of advertisements in the back, including ads for stagecoaches, but none for railroads or river transportation. Secondary sources on the history of transportation in the San Pedro Valley include Conkling and Conkling (1947) and Richardson (1925) on the Butterfield Stage and Greever (1957) and Myrick (1968, 1975) on railroads.

Newspapers were the greatest source of accounts of boating on the Salt River, but contained no accounts of boating on the San Pedro. Newspapers are on microfilm at the State Library and Archives (as well as at the libraries of the University of Arizona and Arizona State University). The State Library and Archives has a listing of all of the newspapers published in the state. Earl Zarbin has examined Arizona newspapers published between 1859 and 1918 and compiled an index of articles relating to water in Arizona (Zarbin n.d.). Mary Lu Moore, historian with the State Attorney General's Office has a copy of this index.

General Land Office maps, located in the State Library and Archives, were made between 1873 and 1918. Maps were not made for national forests, Indian reservations, or land grants. These maps provide information on activities along the river--including Camp Grant, a parade ground, towns, a Mormon settlement, ranches, houses, barns, corrals, acequias, irrigation ditches, fields, roads, stage stations, a railroad, telegraph lines, a telephone line, a pipeline, and other sites--during the period around the time of statehood. The maps showing the San Pedro River did not illustrate any sites associated with boating.

Sanborne Fire Insurance Maps were produced for most of the communities along the river and can be found in the special collections of the Hayden Library at Arizona State University and the Library at Northern Arizona University. Like GLO maps, Sanborn Fire Insurance Maps provide information on activities along the river, but in the case of the San Pedro River did not illustrate any sites associated with navigation.

Many of the museums and libraries around the state maintain collections of photographs. Among the most extensive are those of the libraries of the state universities, the state historical societies, the state library and archives, and the Salt River Project, mentioned above. The Arizona Historical Foundation has a separate catalog of photographs in its collection. According to museum photo-archivist Boyd Nichol, the Bisbee Mining and Historical Museum has a 1908 photograph of a bridge over the San Pedro and photographs of picnics held along the river.

Appendix D
San Pedro River Oral History

THIS IS A GENERAL SAMPLE LETTER SENT OUT TO INDIVIDUALS AND INSTITUTIONS. SOME THINGS WERE ADDED AND OTHER THINGS DELETED DEPENDING ON WHO WAS TO GET THE LETTER.

June 15, 1993

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

Dear Ms. Cortner:

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

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

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

Sincerely,

Javier F. Torres
Ethnographer/Archaeologist

KEY TOPICS AND QUESTIONS FOR INTERVIEWS

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

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

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

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

(5) How has the river changed historically?

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

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

List of Oral History Contacts

4/16/93

Bisbee Mining and Historical Museum
P.O. Box 14
Bisbee, AZ 85603
Tel: 602-432-7071

The Bisbee Mining and Historical Museum does not have relevant information on river navigation. Museum secretary said that the museum photo-archivist Boyd Nichol found a photo of a bridge over the (San Pedro) river during 1908. In addition, the museum has photos of picnics that were apparently an annual event near the river. The secretary also mentioned that a major earthquake occurred around the turn of the century, maybe 1908, that realigned the water table and most of the river went underground then. She said that it drastically changed the route of the river and water accessibility. Other reasons she mentioned for the change in water accessibility were overgrazing, drought, cattle.

[The actual date of the earthquake was 1887.]

4/14/93

Cochise County Historical and Archaeological Society
P.O. Box 818
Douglas, AZ 85607
Tel: 602-364-5226

The Cochise County Historical and Archaeological Society does not have any information on navigation on the San Pedro River. Cindy Hayostek, contact person, said that Douglas is a valley over from the San Pedro River Valley, but that the Society does have a time-line for the San Pedro River Valley done by Harold E. Herbert. She mentioned a copy of this time-line would be sent to SWCA. She mentioned two references on the time-line, but that these addresses and phone numbers may be old and out of date:

Harold E. Herbert
201 Cole Ave., #3
Bisbee, AZ 85603
Tel: 602-432-4538

Eric Campbell
BLM
Fairbank, AZ
Tel: 602-457-3395

Ms. Hayostek also provided the names of two people who would be good to contact for further information:

Jerry Pratt
3000 Meadowlark Drive
Sierra Vista, AZ
Tel: 602-458-0971

Mrs. Eva Moson-Bradshaw
Y Lightning Ranch
Hereford, AZ
Tel: 602-378-2204

Mr. Pratt is a retired wildlife biologist and is very knowledgeable about the San Pedro. Mrs. Moson-Bradshaw is an elderly resident of the area and may be able to give an eye-witness account of the San Pedro at the time of statehood. Ms. Hayostek said that Mrs. Bradshaw's family was associated with Col. Green. [Although Ms. Hayostek did not elaborate on Col. Green, he was prominent in the establishment of Douglas as a mining town.]

[The Cochise County Historical and Archaeological Society later sent a copy of the time-line.]

4/15/93

Gila County Historical Museum
P.O. Box 2891
Globe, AZ 85501
Tel: 602-425-7385

Staff person on duty, Bob Rosen, said that he didn't think that the museum had anything on navigation on the rivers in Arizona. He suggested we contact Mammoth or Winkelman because they would better places to check for information. He said that the San Pedro River was bone dry most of the time. It was the gateway into the area from Mexico and that both Father Kino and Coronado used the river as a travel corridor. He also thought that there might be a dam somewhere along it but he didn't know where it was located. He said that there were a couple of mines along the river but he didn't know how they would use the water.

7-29-93

Holy Trinity Monastery
1605 S. Saint Mary's Way
Saint David, Arizona 85630
Tel: 602-720-4642

Talked to Brother Tom of the Monastery. He said that their involvement with the San Pedro has been for conservation of riparian habitat. They don't have any information about the historical use of the river. He suggested calling the Benson Historical Museum (586-3070) or the BLM, which has a department that has collected information on the San Pedro Valley Riparian Area.

7-26-93

McFarland State Historic Park
P.O. Box 109
Florence, Arizona 85232
Tel: 602-868-5216

Talked to Dan Brown. He didn't know of any pertinent information at the Park for the San Pedro River. He said their information was probably all related to the Gila River.

4-23-93

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

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

4-26-93

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

5-3-93

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

4-21-93

Pinal County Historical Society
P.O. Box 851
Florence, Arizona 85232
Tel: 602-868-4382

The Pinal County Historical Society does not have any information on river navigation in their records. Contacted Della Meadows (602-868-4184), historian for the Society, who said that she has no information on the rivers, knows of no historical use, but then she said she has not had a chance to verify, and will check soon. She mentioned there was farming along the San Pedro River, and that recent work regarding the preservation of the San Pedro has documented some San Pedro history. The Pinal County Museum is only 30-35 years old and has no pictures or any other type of information on mills, dams, reservoirs, etc. The museum has information on irrigation. Other information is through word of mouth. She mentioned the use of a ferry across the Gila River by Florence. The museum has the voter registration records from the late 1880s but that it was incomplete. She said that any information she would have on the river would be fairly recent.

[Ms. Meadows sent a letter on April 30, 1993, which included photographs of the Gila River ferry at Florence, copied from her book *"Where Two or Three Are Gathered": Centennial History, First Presbyterian Church, Florence, Arizona.*]

4-20-93

San Pedro Valley Arts & Historical Society Museum
P.O. Drawer 1090
Benson, AZ 85602
Tel: 602-586-3070

According to Helen Hume, President, the San Pedro Valley Arts & Historical Society Museum, does not have any information on pre-1912 use of the San Pedro River for navigation. She said that the museum does not have information on pre-statehood use of the river. Regarding early pioneer, trappers, etc. information she said that the museum had no information either. The former museum burned down in 1982, she said, and that a large amount of material was lost, but she is unsure about what is really in the museum's archives. Ms. Hume suggested contacting the monastery in Saint David. She said the monastery had just won an award for riparian conservation along the San Pedro. Address:

Holy Trinity Monastery
1605 S. Saint Mary's Way
Saint David, Arizona 85630
(602) 720-4642

She also mentioned that her neighbor and former museum director by the name of Nedra Sunderland, 602-586-3473, was doing an oral history of the area, and that she should be contacted. Ms. Hume provided the name of one person who might be of help, and who was being interviewed by Nedra as we spoke: Louise Larson, 602-586-2964.

8-25-93

Talked to Rose Land of the San Pedro Valley Arts & Historical Society Museum. She doesn't know of any documentation at the museum that would pertain to navigability. She suggested contacting the BLM office at Fairbank or the San Pedro Riparian Conservation District for information.

4-9-93

Tombstone Courthouse State Historic Park
P.O. Box 216
Tombstone, Arizona 85638
Tel: 602-457-3311

Hollis N. Cook, park manager, sent a letter describing the archival holdings of the Tombstone Courthouse State Historic Park. He mentioned irrigation, dams, and smelters along the San Pedro. He also stated, "We find the notion of the San Pedro being navigable preposterous, however perhaps `navigable' isn't defined in the obvious way."

7-15-93

Jay Bateman
Florence, Arizona
Tel:602-868-6442

He has lived in the area around the San Pedro all his life. He said that there used to be pretty good swimming holes in some spots along the river but he didn't know of any other recreational or commercial use of the river. His family used to joke to tourists about taking the ferry down the San Pedro and Gila to Yuma.

8-11-93

Carl Black
St. David, Az
602-720-4671

Mr. Black is a board member of the St. David Irrigation District. St. David was founded in 1877 and they started digging an irrigation canal that year. Originally irrigation was done from surface "ponds". The canal was finished in 1878. The District dug a new ditch in 1926; that was the last time that any major work was done by the District. A pump was put in in the early 1950s. The irrigation ditch takes water out of the river about 7 months of the year; water is pumped the rest of the time when the river is dry. The District probably has some records on the river around 1912 but Mr. Black doesn't know where they are. He thought that Lorena Merrill (720-4736), secretary of the Irrigation District, may know where the records are kept. He thinks that the LDS church in St. David probably has a lot of records on the river.

6-14-93

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

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

4-27-93

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

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

6-14-93

Mary Lou Heuett
Cultural and Environmental Systems, Inc.
Tucson, Arizona 85702-2324
(602) 622-2782

Ms. Heuett has done work on the Santa Cruz, Hassayampa and San Pedro, but all of this work has been archaeological. Her research has not uncovered any references on navigation for any of these rivers. She was very brief and to the point. This was all that she mentioned.

4-27-93

Ken Kimsey, Historian
P. O. Box 2549
Prescott National Forest
Prescott, Arizona 86301
Tel: 602-445-1762

Mr. Kimsey didn't feel he was knowledgeable enough regarding rivers, and suggested we consult James Ohio Pattie's journals, because Pattie rafted down the Salt River. He also suggested we talk with Mr. Polzer of the San Xavier del Bac Mission in Tucson for information on the uses of the San Pedro by Spaniards and Mexicans prior to U.S. occupation. He personally didn't think either one of those groups would have used the San Pedro for navigation because of the settlement patterns of these two groups, but that Mr. Polzer would know about specific uses of the river. He didn't have any other information but he wanted more time to think about this issue. Mr. Kimsey said he would call back as soon as he had more information.

7-27 and 28-93

Louise Larson
Benson
Tel: 602-586-2964

She has been a resident of the area for many years. Diversion dams have been built in the San Pedro river to get water for irrigation. When she was a child (she is now in her 70s) she remembers that there was only a small amount of water in the river. Only time now that there is a continual flow is when there is snow in the nearby mountains. Her parents talked about how the river used to be much narrower. When she was in 8th Grade in 1935, she made up a story for her class about taking a boat ride down the river. She said that there has never been much water in the river; irrigation, which is still practiced today, can only be done during particular seasons. A flood in 1926 washed out a diversion dam between St. David and Pomerene. The Benson Canal Company was formed in 1908 (she has some of the original records of that company). Around 1940, there was a tungsten mill on the river at Pomerene. The tungsten was mined from nearby mountains and processes at the mill but she didn't know exactly how the river water was used for the mill.

4-9-93

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

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

6-14-93

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

8-13-93

Dora Ohnesorgen
204 E. Walker
Benson, AZ 85602
Tel: 602-586-2873

Her grandfather had a toll ferry (raft) on the San Pedro, right below Pomerene. He also had a stage coach that ran from Tombstone to Tucson; it lasted about 2 years. Her grandfather came to the area in the 1870s. He told her father stories about beaver in the river. The grandfather had written memoirs with the help of a women named Kit(?) and Mrs. Ohensorgen thought that her brother had a copy of these (Jerry Onhesorgen 586-9135). Also, Tom Peterson who works (possibly retired now) at the Arizona Historical Society in Tucson wrote a thesis or dissertation on the area and had interviewed the Ohnesorgen family. She also mentioned a man named Albert Bernal, who is familiar with the area.

10-13-93

Terry O'Sullivan
Bureau of Land Management
Tel: 602-650-0509

Mr. O'Sullivan was asked about research done by the Bureau of Land Management on suitability of the Hassayampa and the San Pedro for designation as National Wild and Scenic Rivers. Mr. O'Sullivan said that preliminary reports on the suitability of these two rivers had been completed. According to Mr. O'Sullivan, the reports did not contain much history; instead, they focused on resource values, land use, habitat, and so forth. Mr. O'Sullivan did not know of any reference to navigation or boating in either of the reports, but he suggested talking to the authors (Don Ducote [602-722-4289] for the San Pedro and Jack Ragsdale [602-780-8090] for the Hassayampa) to see if they came across anything relating to navigability during the studies. The preliminary determinations were that the Hassayampa was not suitable for inclusion in the National Wild and Scenic Rivers System, while the San Pedro was suitable. Copies of the two reports were supplied to the Arizona State Land Department.

7-15-93

Geoff Parker
Soil Conservation Service
Route 1
Box 226
Douglas, AZ 85607
364-2001

He had no specific information on the historical uses of the San Pedro. He suggested contacting the USGS in Tucson where he feels is a lot of data on this river.

7-19-93

Jerry Pratt
3000 Meadowlark Drive
Sierra Vista, AZ
Tel: 602-458-0971

Jerry Pratt is a retired wildlife biologist. He said that he had heard of early trappers who used to use boats on the San Pedro. Les Goodding, who moved to Bisbee from Kansas in 1906, told Pratt stories that had been related to him and that he had experienced. Pratt said he had heard of beaver dams on the river and that he thought the river had been navigable before the big earthquake, which changed the river. He said that a good source of information was a PhD dissertation: Goode P. Davis (1982) Man and Wildlife in Arizona: The American Exploration Period 1824-1865. Published by the Fish and Wildlife Service in cooperation with the University of Arizona. Pratt also mentioned that James Herrewig, a planner with the City of Sierra Vista, had been involved with some of the historical research done by the BLM along the San Pedro.

7-26-93

Nedra Sunderland
Tel: 602-586-3473

She is active in the local historical society but said that she didn't have much information. She said that the Benson Canal come off of the San Pedro some years ago. She also said that the Ohnesorgen family had information about the river (Doris Ohnesorgen 586-2873, 586-9135). The Ohnesorgen's grandfather had a ferry across the San Pedro.

4-27-93

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

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

7-19-93

Dean Young
Chief Hydrologist
Arizona State Attorney General's Office
Tucson, Arizona
Tel: 602-628-8447

His experience has been with the fluvial geomorphology of the River. He doesn't have any historical data. He suggested contacting Mary Lu Moore, Research Historian for the Water Resource Adjudication Team (WRAT). Her number is 542-1401.

6-14-93 and 7-5-93

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

Mr. Zarbin sent two letters providing references to boating, ferries, and fish. These references pertained essentially to the Salt and Verde rivers. He also mentioned boating on Walnut Grove Reservoir on the Hassayampa. He did not know of any accounts of boating on the San Pedro.

Appendix E
San Pedro River Hydraulic Rating Curves

SAN PEDRO RIVER NEAR TOMBSTONE						
1981 - 1986						
Meas #	Width	Area	Velocity	Gage H.	Discharge	Depth
202	2.9	0.65	0.98	2.74	0.64	0.22
203	14	2.34	0.89	2.85	2.08	0.17
204	17.5	5	1.29	2.94	6.44	0.29
205	17	6.2	1.6	2.93	9.89	0.36
206	12.5	6.08	1.86	2.93	11.3	0.49
207	13.5	6.09	1.87	2.94	11.4	0.45
208	12.3	5.42	1.69	2.92	9.16	0.44
209	9.3	3.73	1.01	2.8	3.77	0.40
210	34.2	15.8	1.78	3.02	28.2	0.46
211	8	3.35	0.66	2.52	2.21	0.42
212				7.9	6500	
213	53.5	46	2.46	3.36	113	0.86
214	9	2.96	1.25	2.71	3.7	0.33
215	4.1	1.46	1.23	2.61	1.8	0.36
216	8.5	3.69	1.46	2.74	5.41	0.43
217	24.5	12.3	1.38	3.04	17	0.50
218	25.5	12	1.33	3.05	16	0.47
219	68.8	32.8	1.61	3.24	52.9	0.48
220	39.5	22.7	1.65	3.16	37.5	0.57
221	58.5	31.4	1.79	3.16	56.2	0.54
222	42	30.8	1.71	3.14	52.6	0.73
223	32.4	12.6	1.42	2.87	17.9	0.39
224	8.6	2.66	1.2	2.67	3.2	0.31
225	88	49	1.79	3.37	87.7	0.56
226	36	13.9	1.57	2.82	21.8	0.39
227	52	23	1.23	3.14	38.2	0.44
228	59	19.2	1.51	3.1	28.9	0.33
229	35.5	19	1.6	3.07	30.4	0.54
230	35.5	15.2	1.7	3.05	25.9	0.43
231	56.5	29.2	1.77	3.2	51.8	0.52
232	32	17.4	1.72	3.18	30	0.54
233	24.5	12.4	1.69	3.12	20.9	0.51
234	15.2	7.4	1.45	3.02	10.7	0.49
235	3.8	1.21	1.01	2.9	1.22	0.32
236	55	37	1.75	3.12	64.8	0.67
237	170	399	5.81	5.36	2320	2.35
238	75	43.5	1.93	3.12	84.1	0.58
239	44.5	13.9	1.17	2.92	16.3	0.31
240	34	15.9	1.51	2.89	24	0.47
241	30.4	16.6	1.86	2.95	30.8	0.55
242	80	39.3	1.93	3.25	76	0.49
243	62	50.2	1.98	3.24	99.5	0.81
244	97	169	3.17	4.2	536	1.74

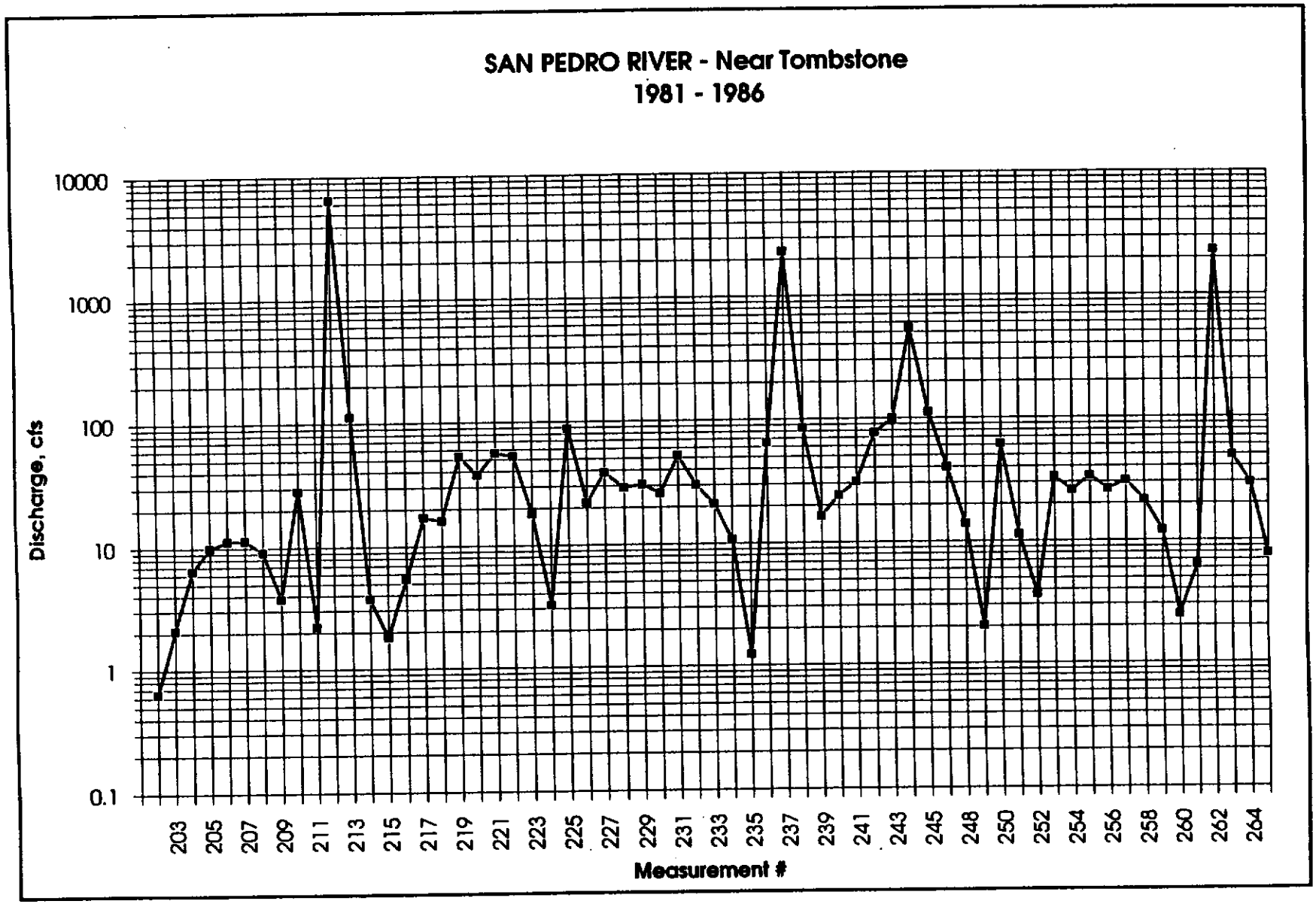
245	80	60.5	1.85	3.38	112	0.76
247	42	24.5	1.62	3.09	39.6	0.58
248	30.4	9.17	1.5	2.85	13.8	0.30
249	7.7	1.76	1.14	2.68	2.01	0.23
250	80	33.8	1.8	3.3	60.9	0.42
251	20	8.3	1.36	2.88	11.3	0.42
252	10.1	3.04	1.18	2.57	3.61	0.30
253	44.8	20.3	1.62	3.01	32.8	0.45
254	35.6	15.4	1.66	2.93	25.6	0.43
255	45	20.3	1.64	3.03	33.3	0.45
256	44	16.6	1.57	2.99	26	0.38
257	44	19.2	1.59	3.04	30.5	0.44
258	36.8	14.9	1.42	3.01	21.1	0.40
259	23.5	8.11	1.48	2.88	12	0.35
260	5.8	1.94	1.27	2.56	2.46	0.33
261	9	4.37	1.43	2.82	6.25	0.49
262	167	405	5.67	5.63	2300	2.43
263	45	28.2	1.72	2.93	48.6	0.63
264	46.5	19.2	1.52	3.13	29.1	0.41
265	12.3	5.62	1.39	2.89	7.82	0.46

SAN PEDRO RIVER NEAR TOMBSTONE

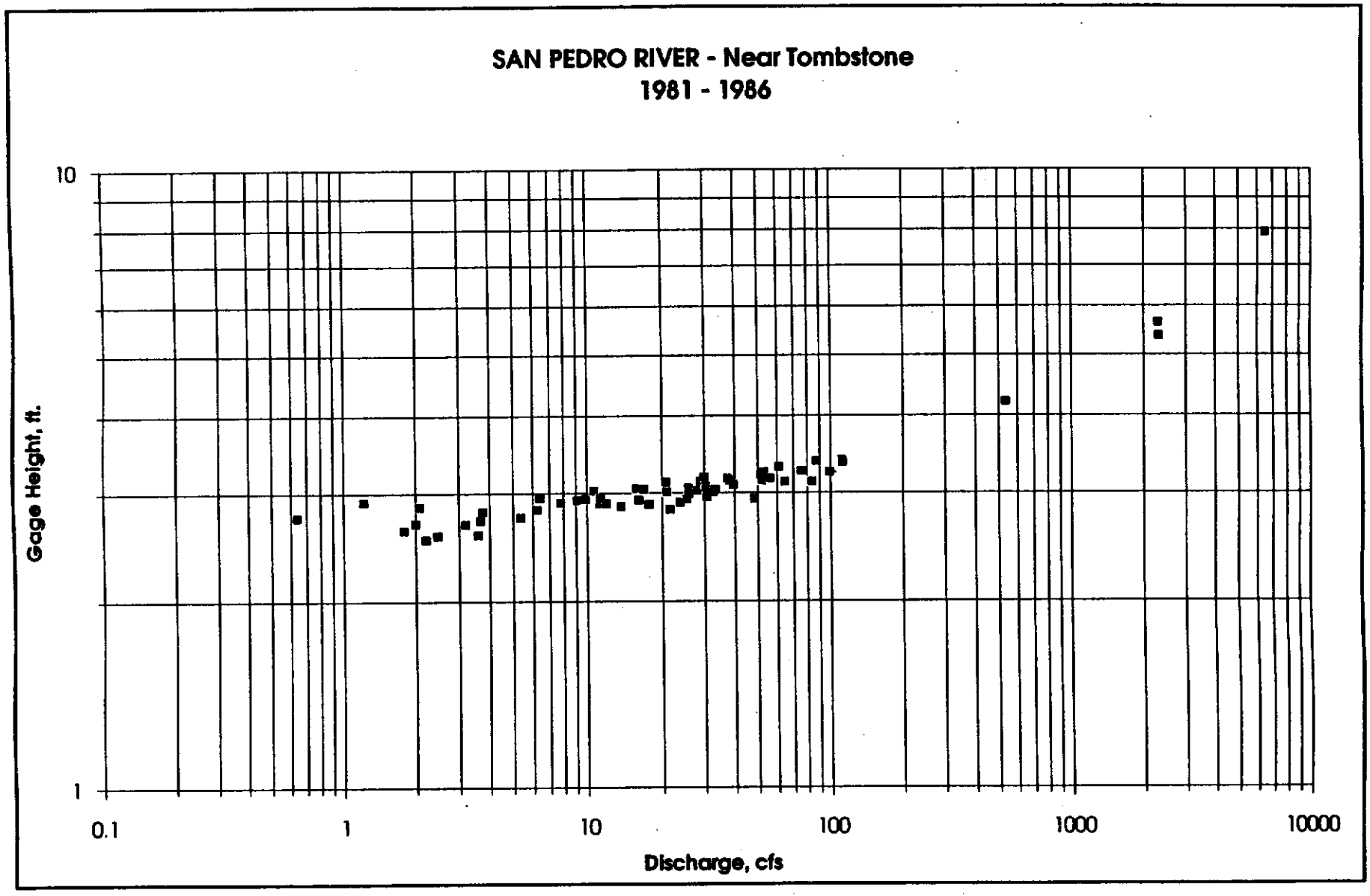
2) Sorted w.r.t. Q

Meas #	Discharge	Width	Area	Velocity	Gage H.	Depth
202	0.64	2.9	0.65	0.98	2.74	0.22
235	1.22	3.8	1.21	1.01	2.9	0.32
215	1.8	4.1	1.46	1.23	2.61	0.36
249	2.01	7.7	1.76	1.14	2.68	0.23
203	2.08	14	2.34	0.89	2.85	0.17
211	2.21	8	3.35	0.66	2.52	0.42
260	2.46	5.8	1.94	1.27	2.56	0.33
224	3.2	8.6	2.66	1.2	2.67	0.31
252	3.61	10.1	3.04	1.18	2.57	0.30
214	3.7	9	2.96	1.25	2.71	0.33
209	3.77	9.3	3.73	1.01	2.8	0.40
216	5.41	8.5	3.69	1.46	2.74	0.43
261	6.25	9	4.37	1.43	2.82	0.49
204	6.44	17.5	5	1.29	2.94	0.29
265	7.82	12.3	5.62	1.39	2.89	0.46
208	9.16	12.3	5.42	1.69	2.92	0.44
205	9.89	17	6.2	1.6	2.93	0.36
234	10.7	15.2	7.4	1.45	3.02	0.49
206	11.3	12.5	6.08	1.86	2.93	0.49
251	11.3	20	8.3	1.36	2.88	0.42
207	11.4	13.5	6.09	1.87	2.94	0.45
259	12	23.5	8.11	1.48	2.88	0.35
248	13.8	30.4	9.17	1.5	2.85	0.30
218	16	25.5	12	1.33	3.05	0.47
239	16.3	44.5	13.9	1.17	2.92	0.31
217	17	24.5	12.3	1.38	3.04	0.50
223	17.9	32.4	12.6	1.42	2.87	0.39
233	20.9	24.5	12.4	1.69	3.12	0.51
258	21.1	36.8	14.9	1.42	3.01	0.40
226	21.8	36	13.9	1.57	2.82	0.39
240	24	34	15.9	1.51	2.89	0.47
254	25.6	35.6	15.4	1.66	2.93	0.43
230	25.9	35.5	15.2	1.7	3.05	0.43
256	26	44	16.6	1.57	2.99	0.38
210	28.2	34.2	15.8	1.78	3.02	0.46
228	28.9	59	19.2	1.51	3.1	0.33
264	29.1	46.5	19.2	1.52	3.13	0.41
232	30	32	17.4	1.72	3.18	0.54
229	30.4	35.5	19	1.6	3.07	0.54
257	30.5	44	19.2	1.59	3.04	0.44
241	30.8	30.4	16.6	1.86	2.95	0.55
253	32.8	44.8	20.3	1.62	3.01	0.45
255	33.3	45	20.3	1.64	3.03	0.45

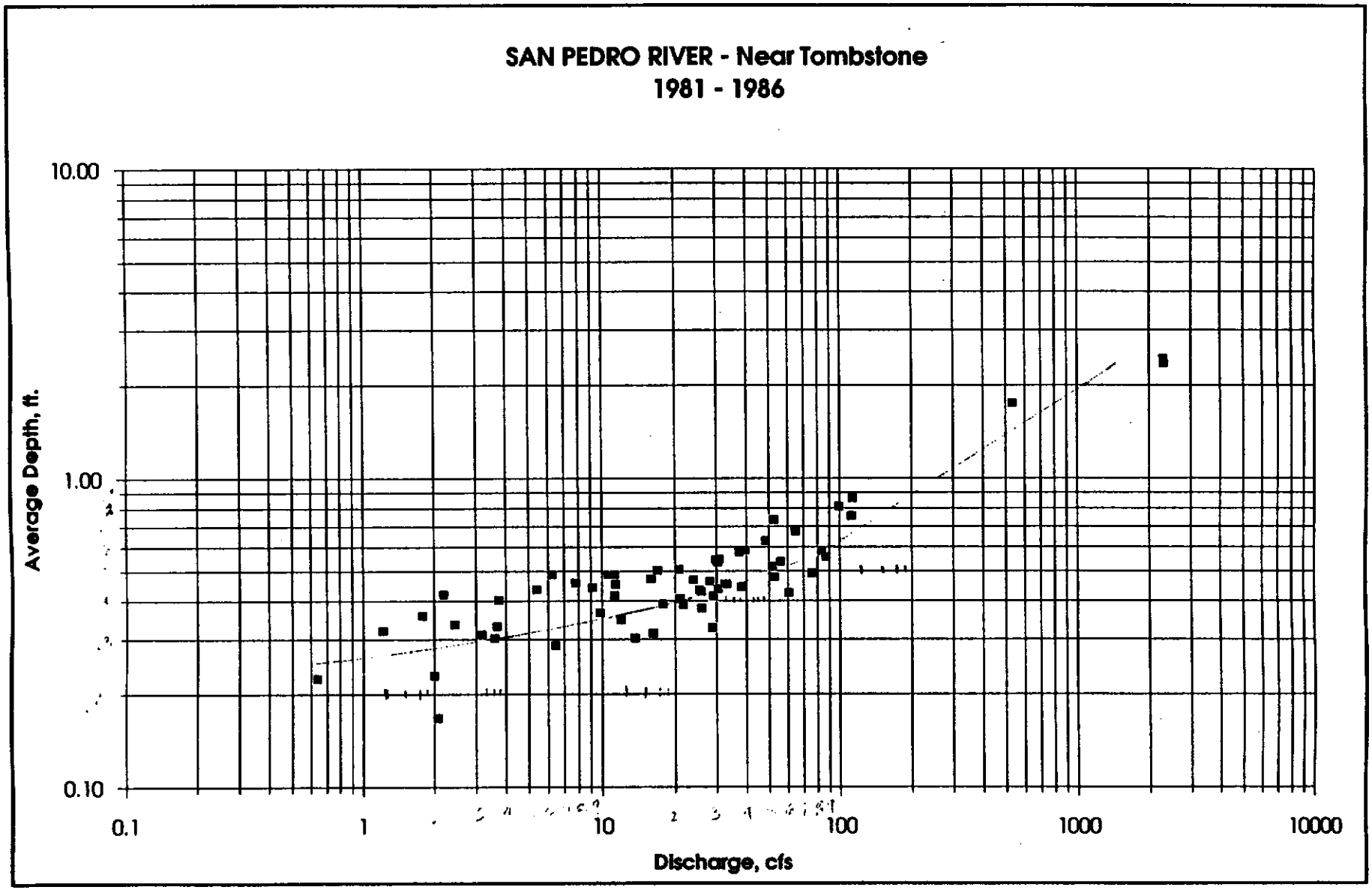
220	37.5	39.5	22.7	1.65	3.16	0.57
227	38.2	52	23	1.23	3.14	0.44
247	39.6	42	24.5	1.62	3.09	0.58
263	48.6	45	28.2	1.72	2.93	0.63
231	51.8	56.5	29.2	1.77	3.2	0.52
222	52.6	42	30.8	1.71	3.14	0.73
219	52.9	68.8	32.8	1.61	3.24	0.48
221	56.2	58.5	31.4	1.79	3.16	0.54
250	60.9	80	33.8	1.8	3.3	0.42
236	64.8	55	37	1.75	3.12	0.67
242	76	80	39.3	1.93	3.25	0.49
238	84.1	75	43.5	1.93	3.12	0.58
225	87.7	88	49	1.79	3.37	0.56
243	99.5	62	50.2	1.98	3.24	0.81
245	112	80	60.5	1.85	3.38	0.76
213	113	53.5	46	2.46	3.36	0.86
244	536	97	169	3.17	4.2	1.74
262	2300	167	405	5.67	5.63	2.43
237	2320	170	399	5.81	5.36	2.35
212	6500				7.9	


SAN PEDRO RIVER - Near Tombstone
1981 - 1986
Discharge, cfs
10000
1000
100
10
1
0.1
203
205
207
209
211
213
215
217
219
221
223
225
227
229
231
233
235
237
239
241
243
245
248
250
252
254
256
258
260
262
264
Measurement #

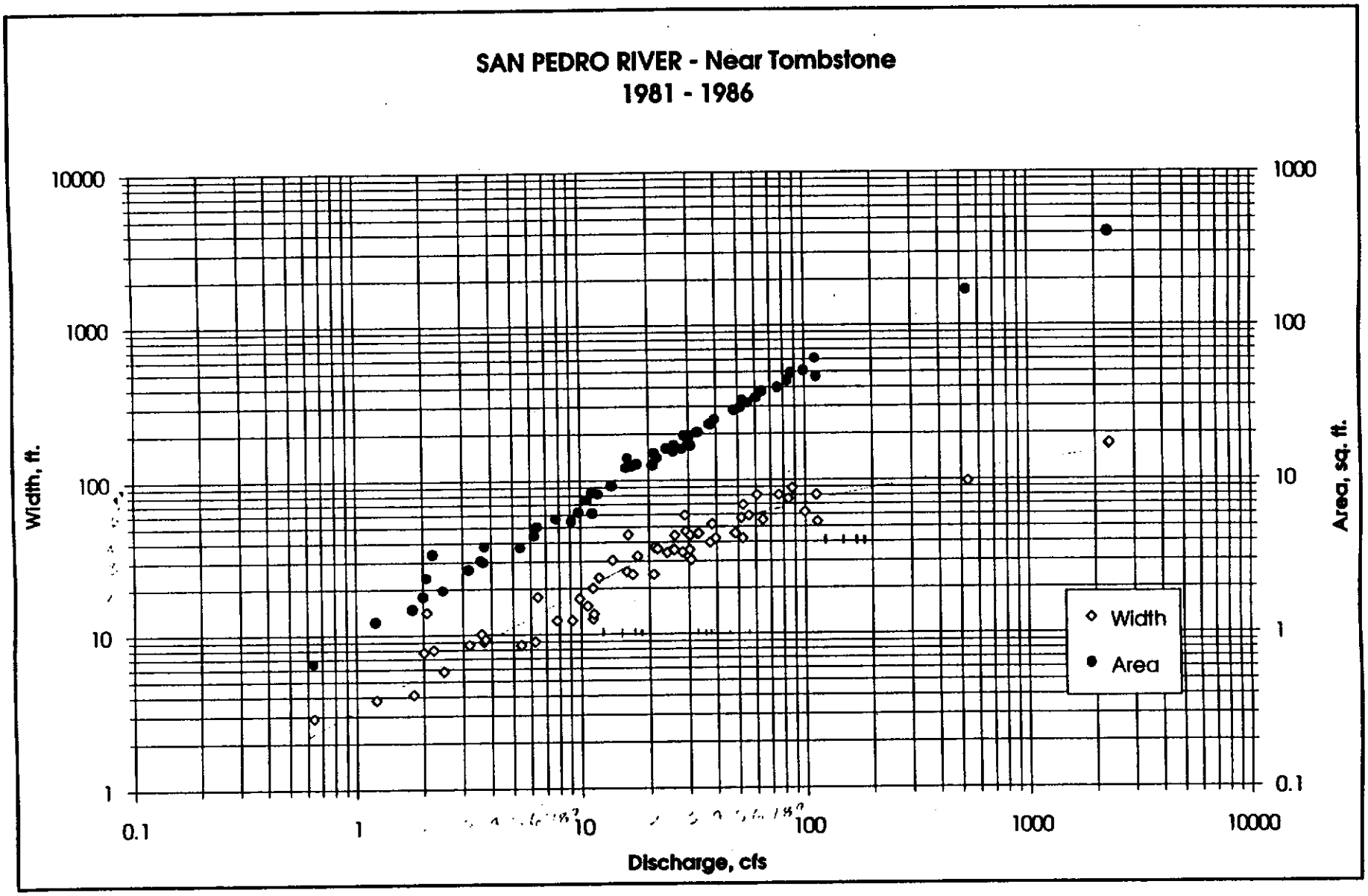
SPT-M-Q.XLC


SAN PEDRO RIVER - Near Tombstone
1981 - 1986
Gage Height, ft.
10
1
0.1
1
10
100
1000
10000
Discharge, cfs

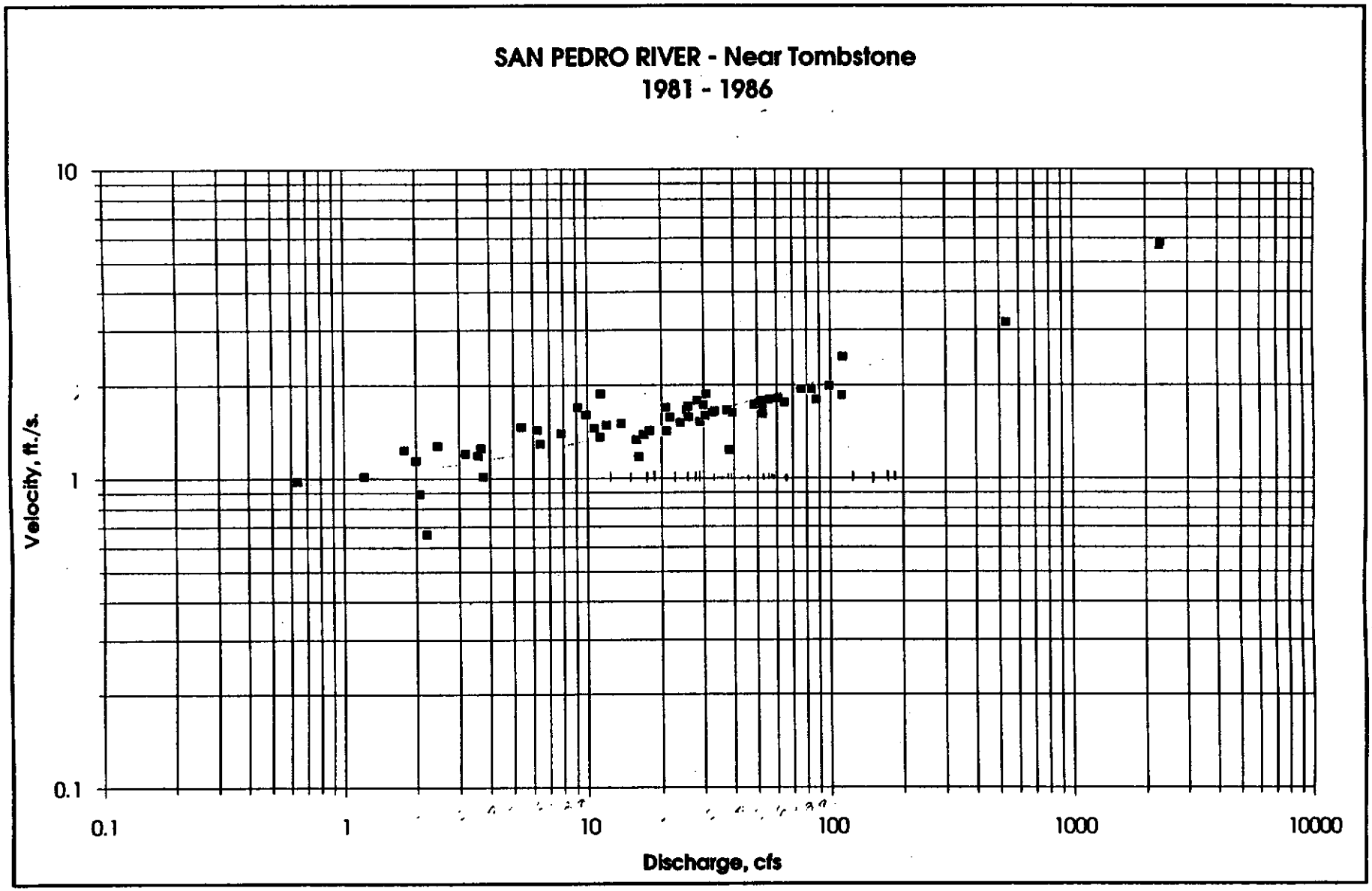
SPT-Q-GH.XLC


SAN PEDRO RIVER - Near Tombstone
1981 - 1986
10.00
1.00
0.10
Average Depth, ft.
0.1
1
10
100
1000
10000
Discharge, cfs

SPT-Q-D.XLC


SAN PEDRO RIVER - Near Tombstone
1981 - 1986
Width, ft.
Area, sq. ft.
Discharge, cfs
10000
1000
100
10
1
0.1
1000
100
10
1
0.1
0.1
1
10
100
1000
10000
Width
Area

SPT-Q-WA.XLC


SAN PEDRO RIVER - Near Tombstone
1981 - 1986
Velocity, ft./s.
10
1
0.1
0.1
1
10
100
1000
10000
Discharge, cfs

SPT-Q-V.XLC

SAN PEDRO AT CHARLESTON

1982 - 1992

1) Original Data

date	width	area	velocity	gage h	discharge	depth
1/25/82	23	8.62	1.05	2.17	10.1	0.4
2/22/82	24	9.58	1.10	2.22	10.5	0.4
3/25/82	23	8.38	1.12	2.25	9.4	0.4
4/26/82	15.2	49	1.05	2.16	5.0	3.2
5/24/82	6	1.97	1.23	1.99	2.4	0.3
6/24/82	2	0.65	1.18	1.95	0.8	0.3
7/26/82	24	19.2	1.07	2.29	20.6	0.8
8/27/82	9.5	3.88	1.22	2.05	4.7	0.4
9/10/82	116	225	3.01	4.66	678.0	1.9
9/10/82	100	157	2.75	4.14	432.0	1.6
9/10/82				8.00	8700.0	
9/14/82	55	60	1.47	2.82	88.2	1.1
9/27/82	13	8.53	0.74	2.08	6.3	0.7
10/25/82	12.8	4.67	0.85	2.16	4.0	0.4
11/22/82	17	6.07	0.98	2.25	5.9	0.4
12/28/82	31.5	17.6	0.97	2.33	17.1	0.6
1/24/83	29	13.7	1.06	2.34	14.5	0.5
2/4/83				5.65	1900.0	
2/15/83	69.7	38.2	1.30	2.71	49.8	0.5
2/20/83	32	23.5	1.53	2.60	35.9	0.7
3/17/83	56.5	31.8	1.48	2.75	47.0	0.6
3/27/83	56	39	1.47	2.82	57.2	0.7
4/26/83	49	15.5	1.10	2.55	17.1	0.3
5/24/83	14.3	4.5	1.17	2.38	5.2	0.3
6/27/83	6.9	1.88	1.06	2.27	2.0	0.3
7/21/83	6.1	2.18	1.10	2.30	2.4	0.4
8/12/83	58	45.4	1.32	2.86	59.8	0.8
8/25/83	8.2	3.51	1.22	2.13	4.3	0.4
9/27/83	33.5	12.4	1.09	2.24	13.5	0.4
10/4/83	87	289	3.70	5.03	1070.0	3.3
10/12/83	54	44	1.39	2.78	61.2	0.8
10/25/83	36.6	19.1	1.34	2.47	25.6	0.5
11/28/83	36	24	1.25	2.69	29.9	0.7
12/29/83	36.2	18.4	1.21	2.64	22.2	0.5
1/25/84	36	23.1	1.71	2.74	39.6	0.6
2/26/84	36	16.1	1.42	2.63	22.8	0.4
3/27/84	20.9	13.5	1.15	2.60	15.5	0.6
4/24/84	11.6	8.58	1.14	2.46	9.8	0.7
5/27/84	5	3.06	1.13	2.20	3.4	0.6
6/25/84	3	2.96	1.20	2.30	3.1	1.0
7/22/84	44	52.9	1.64	2.93	86.6	1.2
8/6/84	85	292	4.45	5.48	1300.0	3.4

8/26/84	47	43.2	1.76	2.98	75.9	0.9
9/24/84	37	11.9	1.25	2.58	14.9	0.3
10/25/84	37	17.3	1.23	2.50	21.2	0.5
11/26/84	36.5	19.3	1.28	2.53	24.8	0.5
12/27/84	37.5	29.6	1.89	2.86	55.9	0.8
1/10/85	45.5	46.7	1.67	2.94	78.1	1.0
1/28/85	67	145	2.77	3.99	401.0	2.2
2/24/85	46.5	46.4	1.74	2.92	80.6	1.0
3/25/85	42	26.4	1.41	2.50	37.3	0.6
4/27/85	29	16.2	1.28	2.32	20.8	0.6
5/23/85	17.2	8.42	1.17	2.02	9.8	0.5
6/14/85	6.2	2.09	1.48	1.76	3.1	0.3
6/23/85	10	3.02	1.24	1.77	3.7	0.3
7/24/85	45	40.4	1.58	2.74	63.7	0.9
8/7/85	39.1	14.3	1.22	2.20	17.5	0.4
8/22/85	25	9.88	1.26	2.17	12.5	0.4
9/25/85	14.5	4.77	1.34	2.03	6.4	0.3
10/27/85	40.8	23.8	1.45	2.48	34.4	0.6
11/25/85	36	19.7	1.09	2.26	21.4	0.5
12/27/85	38	20.4	1.24	2.37	25.3	0.5
1/26/86	36.5	19	1.11	2.26	20.9	0.5
2/23/86	37.9	21.3	1.28	2.37	27.2	0.6
3/27/86	35.4	22.5	0.84	2.33	18.8	0.6
4/23/86	27	13.3	0.87	2.08	11.6	0.5
5/22/86	9.9	4.98	0.95	1.81	4.7	0.5
6/26/86	8	3.42	0.73	1.77	2.5	0.4
7/18/86	78	126	2.89	4.10	364.0	1.6
7/30/86	23.4	9.02	1.18	2.24	10.2	0.4
8/18/86	98	364	5.66	5.94	2090.0	3.7
8/18/86	117	530	5.87	6.75	3110.0	4.5
8/21/86	47	29.2	1.55	2.50	45.4	0.6
9/9/86	42	20.3	1.47	2.59	29.8	0.5
9/29/86	15.3	7.83	1.30	2.34	10.2	0.5
10/28/86	16.1	864	1.24	2.14	10.7	53.7
11/25/86	26	10.2	1.54	2.25	15.8	0.4
12/16/86	33.7	17	1.36	2.36	23.2	0.5
12/29/86	41	15.2	1.48	2.52	22.0	0.4
1/29/87	19	12.7	1.48	2.34	18.8	0.7
2/26/87	20	14.6	1.66	2.36	24.2	0.7
3/27/87	19.5	12.8	1.41	2.22	18.0	0.7
4/28/87	64	88		3.62	250.0	1.4
4/29/87	28.5	18.3	1.38	2.36	25.2	0.6
5/5/87	23.3	9.72	1.33	2.08	13.0	0.4
5/28/87	16.8	5.58	1.11	1.87	6.0	0.3
6/30/87	6.1	2.06	0.86	1.85	1.8	0.3
7/30/87	18	5.19	1.12	2.09	5.8	0.3
8/27/87	65	62.9	2.16	3.40	136.0	1.0
9/18/87	13	4.48	1.31	2.15	5.9	0.3
9/25/87	55	55.2	2.08	3.05	115.0	1.0

10/27/87	20	6.73	1.00	2.03	6.8	0.3
11/23/87	17.4	8.89	1.38	2.14	12.3	0.5
12/9/87	22	8.64	1.25	2.14	10.8	0.4
12/23/87	36	14.5	1.42	2.40	20.6	0.4
1/13/88	30.5	12.2	1.25	2.26	15.3	0.4
1/27/88	30	12.7	1.35	2.29	17.2	0.4
2/22/88	27.8	11.1	1.41	2.26	15.6	0.4
3/11/88	22.1	11.6	1.37	2.27	15.9	0.5
6/27/88	11	2.8	1.29	1.74	2.1	0.3
7/27/88	55	40.6	1.66	2.92	67.2	0.7
8/19/88	51	35.3	1.77	2.76	62.6	0.7
9/1/88	56	40.9	1.73	2.86	70.7	0.7
9/22/88	44	28.2	1.57	2.64	44.3	0.6
9/27/88	33.2	15.3	1.23	2.40	18.8	0.5
10/6/88	31	13.7	0.88	2.24	12.0	0.4
10/21/88	35	54.6	1.90	2.98	104.0	1.6
11/29/88	40	15.4	1.38	2.44	21.2	0.4
12/27/88	29	15	1.51	2.44	22.6	0.5
1/20/89	41	17.1	1.46	2.48	25.0	0.4
2/18/89	28.5	13.3	1.42	2.42	18.9	0.5
3/31/89	19.6	9.47	1.36	2.21	12.9	0.5
4/17/89	19.1	7.12	1.23	2.07	8.7	0.4
5/24/89	10	3.73	0.99	1.90	3.7	0.4
6/27/89	5.6	1.63	0.98	1.82	1.6	0.3
7/10/89	13.4	3.04	0.85	1.88	2.6	0.2
7/21/89	8.9	2.89	1.42	2.05	4.1	0.3
7/31/89	6	2.56	1.41	2.11	3.6	0.4
8/9/89	37.5	13.9	1.50	2.46	20.8	0.4
8/14/89	46.5	39.2	1.90	2.97	74.5	0.8
8/25/89	17.6	7.03	1.42	2.28	10.0	0.4
8/31/89	12.8	3.72	1.35	2.14	5.0	0.3
9/8/89	18.5	5.42	1.51	2.17	8.2	0.3
9/15/89	13.5	2.84	1.38	2.05	3.9	0.2
9/27/89	10.5	2.02	1.18	1.98	2.4	0.2
10/13/89	7	3.06	1.09	2.13	3.3	0.4
10/31/89	7.3	3.71	1.37	2.19	5.1	0.5
11/29/89	16.5	6.46	1.50	2.29	9.7	0.4
1/2/90	16	7.18	1.63	2.33	11.7	0.4
1/29/90	17.8	8.96	1.47	2.37	13.2	0.5
2/27/90	17.5	8.8	1.50	2.58	16.0	0.5
3/30/90	18	8.15	1.71	2.36	14.0	0.5
4/18/90	16.6	6.58	1.40	2.24	9.2	0.4
5/25/90	7.4	2.44	1.18	1.92	2.9	0.3
6/27/90	2.2	0.29	1.01	1.81	0.3	0.1
7/27/90	33	16.7	1.55	2.50	25.9	0.5
8/3/90	42	20.9	1.52	2.69	31.8	0.5
8/13/90	48	55.1	2.23	3.31	123.0	1.1
8/16/90	95	193	3.86	4.93	745.0	2.0
8/22/90	36	12.6	1.39	2.38	17.5	0.4

9/17/90	50.5	46.4	2.08	3.10	96.5	0.9
10/24/90	16.5	6.72	1.32	2.37	8.9	0.4
10/31/90	18.8	7.29	1.25	2.34	9.1	0.4
11/21/90	16.6	8.51	1.34	2.38	11.4	0.5
12/6/90	17.4	10.4	1.34	2.42	13.9	0.6
12/13/90	19	10.6	1.35	2.38	14.2	0.6
12/28/90	24.1	12.1	1.49	2.46	18.0	0.5
1/18/91	16.9	9.02	1.91	3.28	17.2	0.5
1/28/91	12.8	10.1	1.29	3.41	13.0	0.8
2/15/91	15.3	25.5	1.93	4.43	49.3	1.7
2/21/91	14.1	15.8	1.36	3.27	21.5	1.1
3/22/91	18.2	14	1.83	3.61	25.6	0.8
4/9/91	27.5	15.2	1.38	3.50	20.9	0.6
4/29/91	11.6	7.04	1.68	3.37	11.8	0.6
5/24/91	21.5	5.89	0.84	3.22	5.0	0.3
5/29/91	22.8	5.79	0.72	3.00	4.2	0.3
6/6/91	15.2	4.05	0.89	3.03	3.6	0.3
6/20/91	10	2.5	1.16	2.90	2.9	0.3
7/2/91	6.3	1.64	1.08	2.80	1.8	0.3
7/29/91	14.8	2.77	0.74	2.82	2.1	0.2
8/22/91	8.3	3.42	1.35	2.67	4.6	0.4
8/23/91	23	24.2	2.58	3.42	62.4	1.1
8/23/91	33	48	3.17	4.00	152.0	1.5
8/23/91	34	49	3.38	4.20	165.0	1.4
8/23/91	34	51.4	2.31	4.22	170.0	1.5
8/27/91	61	120	4.38	5.57	526.0	2.0
8/27/91	59	106	3.83	5.26	406.0	1.8
9/10/91	14.7	6.81	0.93	2.62	6.4	0.5
9/23/91	14.6	6.88	0.98	2.42	6.8	0.5
9/25/91	14.2	6.4	0.87	2.34	5.6	0.5
10/11/91	7.9	3.1	1.19	2.34	3.7	0.4
10/29/91	13.7	5.37	0.92	2.34	5.0	0.4
11/6/91	11.4	4.71	1.24	2.43	5.9	0.4
11/26/91	13.7			2.56	9.4	0.0
11/26/91	16.6	8.01	1.12	2.58	9.0	0.5
12/5/91	18.4	8.56	1.07	2.56	9.2	0.5
12/12/91	14.8	7.18	1.56	2.60	11.2	0.5
12/17/91	18.8	9.5	1.16	2.59	11.1	0.5
12/19/91	20.8	12.3	1.24	2.68	15.2	0.6
1/10/92	20.8	11.4	1.18	2.65	13.4	0.5
1/29/92	20.6	11.6	1.22	2.67	14.1	0.6
2/7/92	21.6	12.4	1.27	2.68	15.7	0.6
2/19/92	22.4	9.34	1.82	2.72	17.0	0.4
3/30/92	22.7	8.88	1.79	2.69	15.9	0.4
4/30/92	17.7	7.16	0.91	2.39	6.5	0.4
5/28/92	20.1	6.71	0.95	2.39	6.4	0.3
6/30/92	12.5	7.63	0.16	2.23	1.2	0.6
7/14/92	10.2	6.74	0.63	2.27	3.0	0.7
7/24/92	51	124	4.46	5.60	553.0	2.4

7/24/92	207	209	4.31	6.06	900.0	1.0
7/29/92	17	8.4	1.57	2.54	12.8	0.5
8/13/92	12	8.01	1.59	2.63	12.7	0.7
8/24/92	48	64.3	2.57	4.08	165.0	1.3
8/24/92	195	264	4.28	6.42	1130.0	1.4
8/28/92	23	25.3	1.08	2.91	27.4	1.1
9/25/92	14.8	4.43	1.02	2.41	4.5	0.3
9/29/92	16.5	6.09	0.63	2.43	3.0	0.4
10/30/92	16.4	6.92	0.75	2.58	5.2	0.4

SAN PEDRO AT CHARLESTON

1982 - 1992

2) Sorted w.r.t. Q

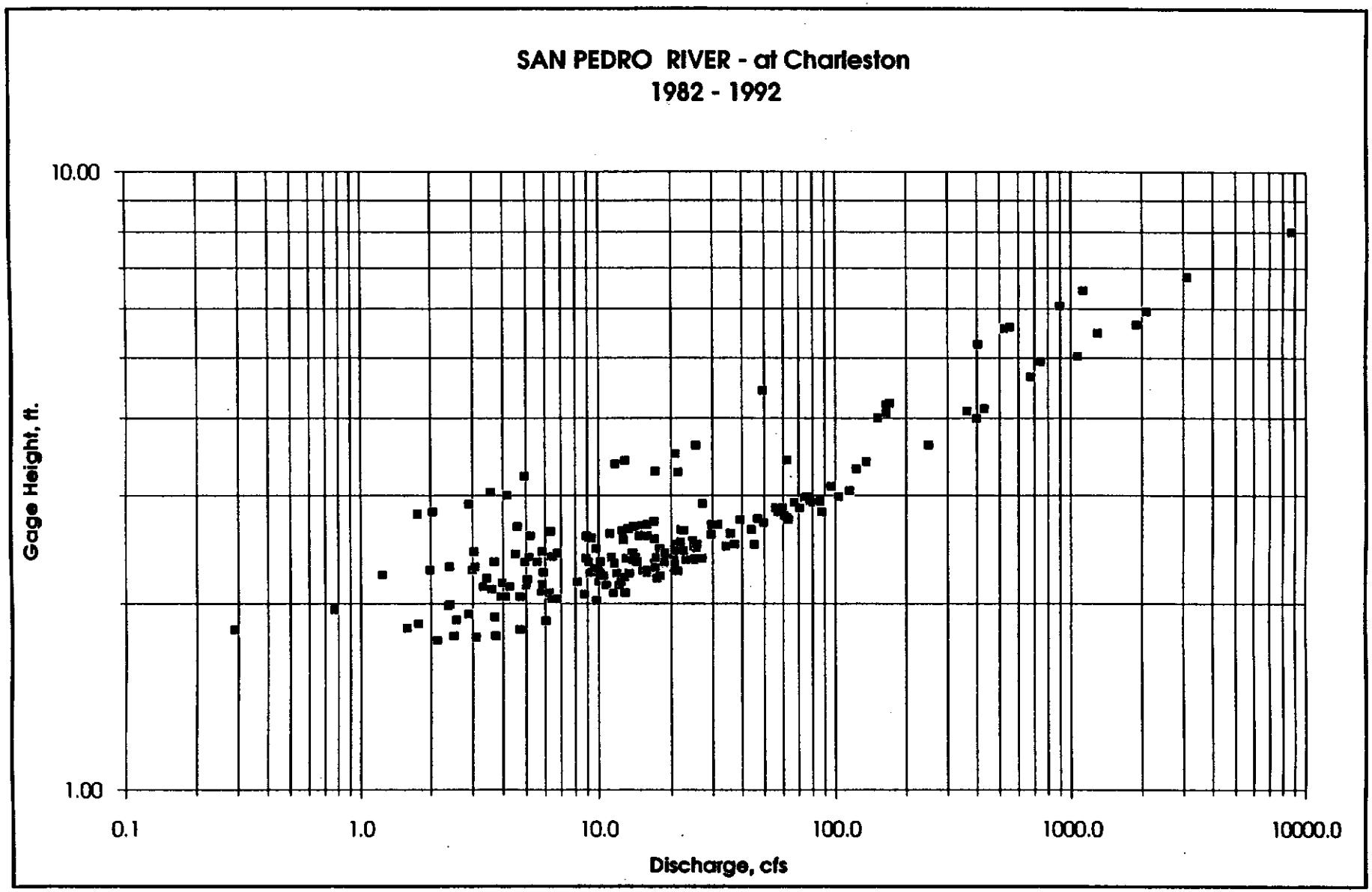
date	discharge	width	area	velocity	gage h	depth
6/27/90	0.3	2.2	0.29	1.01	1.81	0.13
6/24/82	0.8	2	0.65	1.18	1.95	0.33
6/30/92	1.2	12.5	7.63	0.16	2.23	0.61
6/27/89	1.6	5.6	1.63	0.98	1.82	0.29
7/2/91	1.8	6.3	1.64	1.08	2.80	0.26
6/30/87	1.8	6.1	2.06	0.86	1.85	0.34
6/27/83	2.0	6.9	1.88	1.06	2.27	0.27
7/29/91	2.1	14.8	2.77	0.74	2.82	0.19
6/27/88	2.1	11	2.8	1.29	1.74	0.25
9/27/89	2.4	10.5	2.02	1.18	1.98	0.19
7/21/83	2.4	6.1	2.18	1.10	2.30	0.36
5/24/82	2.4	6	1.97	1.23	1.99	0.33
6/26/86	2.5	8	3.42	0.73	1.77	0.43
7/10/89	2.6	13.4	3.04	0.85	1.88	0.23
5/25/90	2.9	7.4	2.44	1.18	1.92	0.33
6/20/91	2.9	10	2.5	1.16	2.90	0.25
7/14/92	3.0	10.2	6.74	0.63	2.27	0.66
9/29/92	3.0	16.5	6.09	0.63	2.43	0.37
6/25/84	3.1	3	2.96	1.20	2.30	0.99
6/14/85	3.1	6.2	2.09	1.48	1.76	0.34
10/13/89	3.3	7	3.06	1.09	2.13	0.44
5/27/84	3.4	5	3.06	1.13	2.20	0.61
6/6/91	3.6	15.2	4.05	0.89	3.03	0.27
7/31/89	3.6	6	2.56	1.41	2.11	0.43
10/11/91	3.7	7.9	3.1	1.19	2.34	0.39
5/24/89	3.7	10	3.73	0.99	1.90	0.37
6/23/85	3.7	10	3.02	1.24	1.77	0.30
9/15/89	3.9	13.5	2.84	1.38	2.05	0.21
10/25/82	4.0	12.8	4.67	0.85	2.16	0.36
7/21/89	4.1	8.9	2.89	1.42	2.05	0.32
5/29/91	4.2	22.8	5.79	0.72	3.00	0.25
8/25/83	4.3	8.2	3.51	1.22	2.13	0.43
9/25/92	4.5	14.8	4.43	1.02	2.41	0.30
8/22/91	4.6	8.3	3.42	1.35	2.67	0.41
8/27/82	4.7	9.5	3.88	1.22	2.05	0.41
5/22/86	4.7	9.9	4.98	0.95	1.81	0.50
5/24/91	5.0	21.5	5.89	0.84	3.22	0.27
10/29/91	5.0	13.7	5.37	0.92	2.34	0.39
8/31/89	5.0	12.8	3.72	1.35	2.14	0.29
4/26/82	5.0	15.2	49	1.05	2.16	3.22
10/31/89	5.1	7.3	3.71	1.37	2.19	0.51
5/24/83	5.2	14.3	4.5	1.17	2.38	0.31

	10/30/92	5.2	16.4	6.92	0.75	2.58	0.42
	9/25/91	5.6	14.2	6.4	0.87	2.34	0.45
	7/30/87	5.8	18	5.19	1.12	2.09	0.29
	9/18/87	5.9	13	4.48	1.31	2.15	0.34
	11/6/91	5.9	11.4	4.71	1.24	2.43	0.41
	11/22/82	5.9	17	6.07	0.98	2.25	0.36
	5/28/87	6.0	16.8	5.58	1.11	1.87	0.33
	9/27/82	6.3	13	8.53	0.74	2.08	0.66
	9/10/91	6.4	14.7	6.81	0.93	2.62	0.46
	9/25/85	6.4	14.5	4.77	1.34	2.03	0.33
	5/28/92	6.4	20.1	6.71	0.95	2.39	0.33
	4/30/92	6.5	17.7	7.16	0.91	2.39	0.40
	10/27/87	6.8	20	6.73	1.00	2.03	0.34
	9/23/91	6.8	14.6	6.88	0.98	2.42	0.47
	9/8/89	8.2	18.5	5.42	1.51	2.17	0.29
	4/17/89	8.7	19.1	7.12	1.23	2.07	0.37
	10/24/90	8.9	16.5	6.72	1.32	2.37	0.41
	11/26/91	9.0	16.6	8.01	1.12	2.58	0.48
	10/31/90	9.1	18.8	7.29	1.25	2.34	0.39
	12/5/91	9.2	18.4	8.56	1.07	2.56	0.47
	4/18/90	9.2	16.6	6.58	1.40	2.24	0.40
	11/26/91	9.4	13.7			2.56	0.00
	3/25/82	9.4	23	8.38	1.12	2.25	0.36
	11/29/89	9.7	16.5	6.46	1.50	2.29	0.39
	4/24/84	9.8	11.6	8.58	1.14	2.46	0.74
	5/23/85	9.8	17.2	8.42	1.17	2.02	0.49
	8/25/89	10.0	17.6	7.03	1.42	2.28	0.40
	1/25/82	10.1	23	8.62	1.05	2.17	0.37
	7/30/86	10.2	23.4	9.02	1.18	2.24	0.39
	9/29/86	10.2	15.3	7.83	1.30	2.34	0.51
	2/22/82	10.5	24	9.58	1.10	2.22	0.40
	10/28/86	10.7	16.1	864	1.24	2.14	53.66
	12/9/87	10.8	22	8.64	1.25	2.14	0.39
	12/17/91	11.1	18.8	9.5	1.16	2.59	0.51
	12/12/91	11.2	14.8	7.18	1.56	2.60	0.49
	11/21/90	11.4	16.6	8.51	1.34	2.38	0.51
	4/23/86	11.6	27	13.3	0.87	2.08	0.49
	1/2/90	11.7	16	7.18	1.63	2.33	0.45
	4/29/91	11.8	11.6	7.04	1.68	3.37	0.61
	10/6/88	12.0	31	13.7	0.88	2.24	0.44
	11/23/87	12.3	17.4	8.89	1.38	2.14	0.51
	8/22/85	12.5	25	9.88	1.26	2.17	0.40
	8/13/92	12.7	12	8.01	1.59	2.63	0.67
	7/29/92	12.8	17	8.4	1.57	2.54	0.49
	3/31/89	12.9	19.6	9.47	1.36	2.21	0.48
	5/5/87	13.0	23.3	9.72	1.33	2.08	0.42
	1/28/91	13.0	12.8	10.1	1.29	3.41	0.79
	1/29/90	13.2	17.8	8.96	1.47	2.37	0.50
	1/10/92	13.4	20.8	11.4	1.18	2.65	0.55

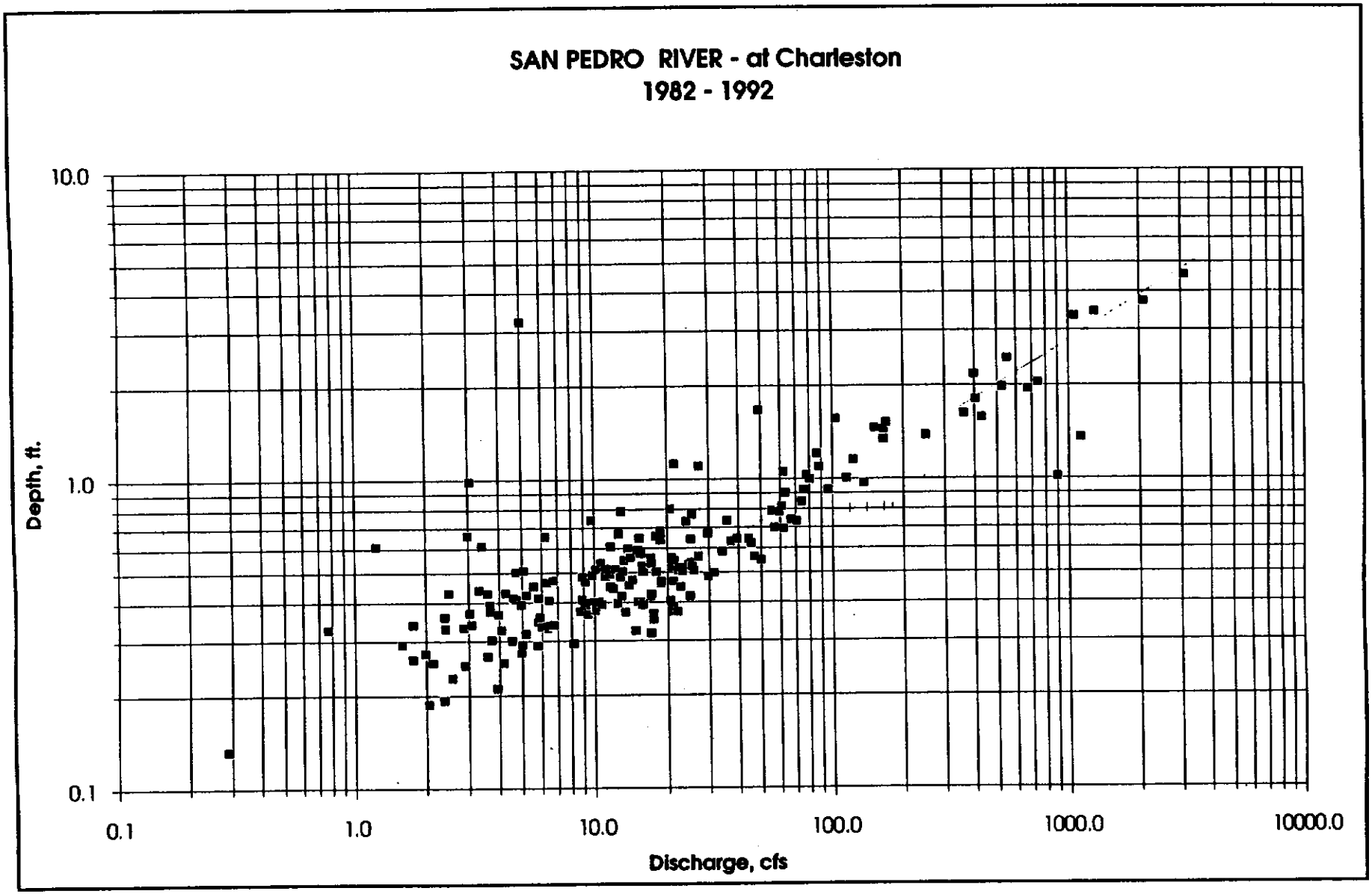
	9/27/83	13.5	33.5	12.4	1.09	2.24	0.37
	12/6/90	13.9	17.4	10.4	1.34	2.42	0.60
	3/30/90	14.0	18	8.15	1.71	2.36	0.45
	1/29/92	14.1	20.6	11.6	1.22	2.67	0.56
	12/13/90	14.2	19	10.6	1.35	2.38	0.56
	1/24/83	14.5	29	13.7	1.06	2.34	0.47
	9/24/84	14.9	37	11.9	1.25	2.58	0.32
	12/19/91	15.2	20.8	12.3	1.24	2.68	0.59
	1/13/88	15.3	30.5	12.2	1.25	2.26	0.40
	3/27/84	15.5	20.9	13.5	1.15	2.60	0.65
	2/22/88	15.6	27.8	11.1	1.41	2.26	0.40
	2/7/92	15.7	21.6	12.4	1.27	2.68	0.57
	11/25/86	15.8	26	10.2	1.54	2.25	0.39
	3/11/88	15.9	22.1	11.6	1.37	2.27	0.52
	3/30/92	15.9	22.7	8.88	1.79	2.69	0.39
	2/27/90	16.0	17.5	8.8	1.50	2.58	0.50
	2/19/92	17.0	22.4	9.34	1.82	2.72	0.42
	12/28/82	17.1	31.5	17.6	0.97	2.33	0.56
	4/26/83	17.1	49	15.5	1.10	2.55	0.32
	1/27/88	17.2	30	12.7	1.35	2.29	0.42
	1/18/91	17.2	16.9	9.02	1.91	3.28	0.53
	8/7/85	17.5	39.1	14.3	1.22	2.20	0.37
	8/22/90	17.5	36	12.6	1.39	2.38	0.35
	3/27/87	18.0	19.5	12.8	1.41	2.22	0.66
	12/28/90	18.0	24.1	12.1	1.49	2.46	0.50
	3/27/86	18.8	35.4	22.5	0.84	2.33	0.64
	1/29/87	18.8	19	12.7	1.48	2.34	0.67
	9/27/88	18.8	33.2	15.3	1.23	2.40	0.46
	2/18/89	18.9	28.5	13.3	1.42	2.42	0.47
	7/26/82	20.6	24	19.2	1.07	2.29	0.80
	12/23/87	20.6	36	14.5	1.42	2.40	0.40
	4/27/85	20.8	29	16.2	1.28	2.32	0.56
	8/9/89	20.8	37.5	13.9	1.50	2.46	0.37
	1/26/86	20.9	36.5	19	1.11	2.26	0.52
	4/9/91	20.9	27.5	15.2	1.38	3.50	0.55
	10/25/84	21.2	37	17.3	1.23	2.50	0.47
	11/29/88	21.2	40	15.4	1.38	2.44	0.39
	11/25/85	21.4	36	19.7	1.09	2.26	0.55
	2/21/91	21.5	14.1	15.8	1.36	3.27	1.12
	12/29/86	22.0	41	15.2	1.48	2.52	0.37
	12/29/83	22.2	36.2	18.4	1.21	2.64	0.51
	12/27/88	22.6	29	15	1.51	2.44	0.52
	2/26/84	22.8	36	16.1	1.42	2.63	0.45
	12/16/86	23.2	33.7	17	1.36	2.36	0.50
	2/26/87	24.2	20	14.6	1.66	2.36	0.73
	11/26/84	24.8	36.5	19.3	1.28	2.53	0.53
	1/20/89	25.0	41	17.1	1.46	2.48	0.42
	4/29/87	25.2	28.5	18.3	1.38	2.36	0.64
	12/27/85	25.3	38	20.4	1.24	2.37	0.54

	10/25/83	25.6	36.6	19.1	1.34	2.47	0.52
	3/22/91	25.6	18.2	14	1.83	3.61	0.77
	7/27/90	25.9	33	16.7	1.55	2.50	0.51
	2/23/86	27.2	37.9	21.3	1.28	2.37	0.56
	8/28/92	27.4	23	25.3	1.08	2.91	1.10
	9/9/86	29.8	42	20.3	1.47	2.59	0.48
	11/28/83	29.9	36	24	1.25	2.69	0.67
	8/3/90	31.8	42	20.9	1.52	2.69	0.50
	10/27/85	34.4	40.8	23.8	1.45	2.48	0.58
	2/20/83	35.9	32	23.5	1.53	2.60	0.73
	3/25/85	37.3	42	26.4	1.41	2.50	0.63
	1/25/84	39.6	36	23.1	1.71	2.74	0.64
	9/22/88	44.3	44	28.2	1.57	2.64	0.64
	8/21/86	45.4	47	29.2	1.55	2.50	0.62
	3/17/83	47.0	56.5	31.8	1.48	2.75	0.56
	2/15/91	49.3	15.3	25.5	1.93	4.43	1.67
	2/15/83	49.8	69.7	38.2	1.30	2.71	0.55
	12/27/84	55.9	37.5	29.6	1.89	2.86	0.79
	3/27/83	57.2	56	39	1.47	2.82	0.70
	8/12/83	59.8	58	45.4	1.32	2.86	0.78
	10/12/83	61.2	54	44	1.39	2.78	0.81
	8/23/91	62.4	23	24.2	2.58	3.42	1.05
	8/19/88	62.6	51	35.3	1.77	2.76	0.69
	7/24/85	63.7	45	40.4	1.58	2.74	0.90
	7/27/88	67.2	55	40.6	1.66	2.92	0.74
	9/1/88	70.7	56	40.9	1.73	2.86	0.73
	8/14/89	74.5	46.5	39.2	1.90	2.97	0.84
	8/26/84	75.9	47	43.2	1.76	2.98	0.92
	1/10/85	78.1	45.5	46.7	1.67	2.94	1.03
	2/24/85	80.6	46.5	46.4	1.74	2.92	1.00
	7/22/84	86.6	44	52.9	1.64	2.93	1.20
	9/14/82	88.2	55	60	1.47	2.82	1.09
	9/17/90	96.5	50.5	46.4	2.08	3.10	0.92
	10/21/88	104.0	35	54.6	1.90	2.98	1.56
	9/25/87	115.0	55	55.2	2.08	3.05	1.00
	8/13/90	123.0	48	55.1	2.23	3.31	1.15
	8/27/87	136.0	65	62.9	2.16	3.40	0.97
	8/23/91	152.0	33	48	3.17	4.00	1.45
	8/23/91	165.0	34	49	3.38	4.20	1.44
	8/24/92	165.0	48	64.3	2.57	4.08	1.34
	8/23/91	170.0	34	51.4	2.31	4.22	1.51
	4/28/87	250.0	64	88		3.62	1.38
	7/18/86	364.0	78	126	2.89	4.10	1.62
	1/28/85	401.0	67	145	2.77	3.99	2.16
	8/27/91	406.0	59	106	3.83	5.26	1.80
	9/10/82	432.0	100	157	2.75	4.14	1.57
	8/27/91	526.0	61	120	4.38	5.57	1.97
	7/24/92	553.0	51	124	4.46	5.60	2.43
	9/10/82	678.0	116	225	3.01	4.66	1.94

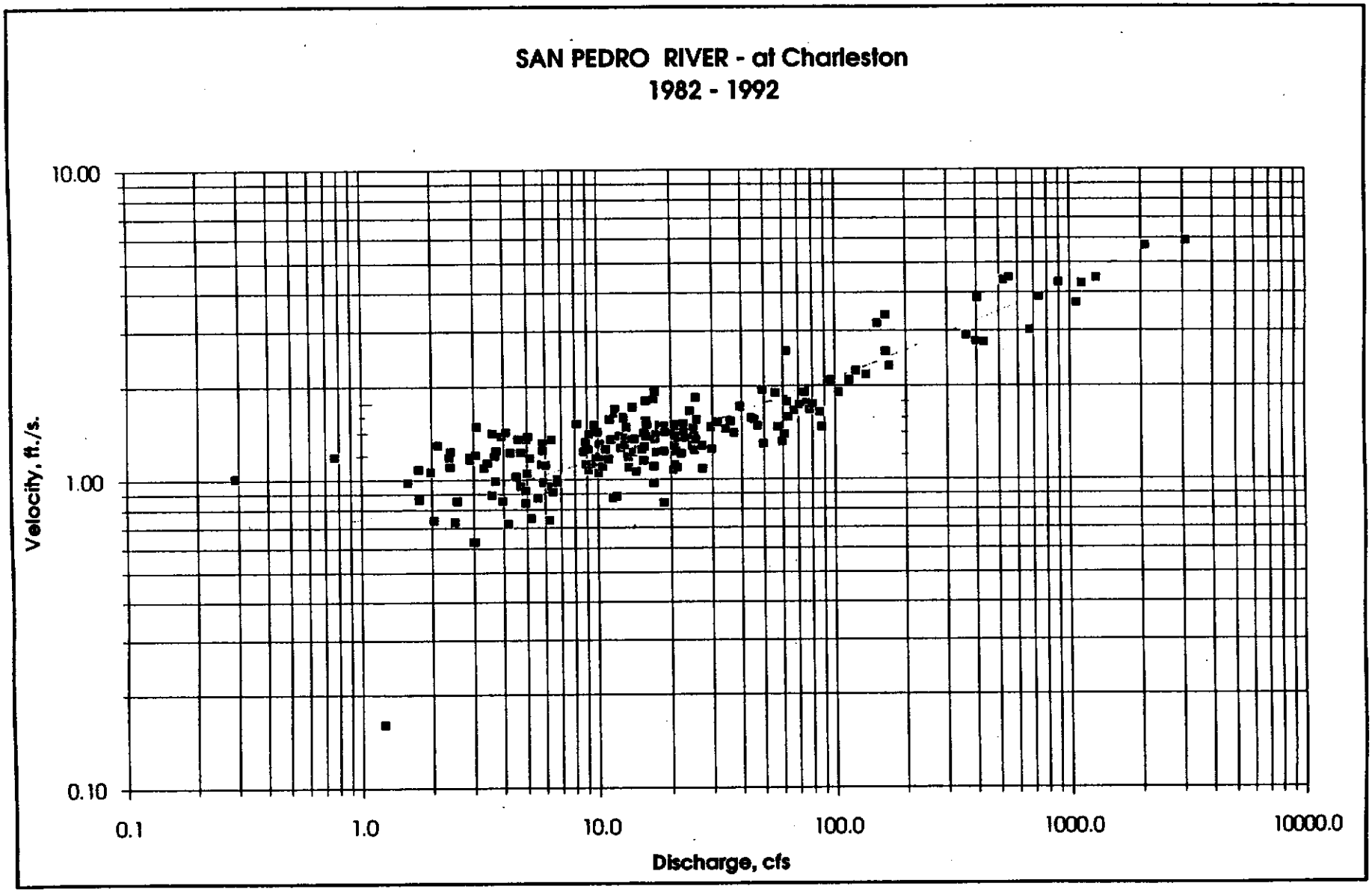
	8/16/90	745.0	95	193	3.86	4.93	2.03
	7/24/92	900.0	207	209	4.31	6.06	1.01
	10/4/83	1070.0	87	289	3.70	5.03	3.32
	8/24/92	1130.0	195	264	4.28	6.42	1.35
	8/6/84	1300.0	85	292	4.45	5.48	3.44
	2/4/83	1900.0				5.65	
	8/18/86	2090.0	98	364	5.66	5.94	3.71
	8/18/86	3110.0	117	530	5.87	6.75	4.53
	9/10/82	8700.0				8.00	


SAN PEDRO RIVER - at Charleston
1982 - 1992
10.00
1.00
Gage Height, ft.
0.1
1.0
10.0
100.0
1000.0
10000.0
Discharge, cfs

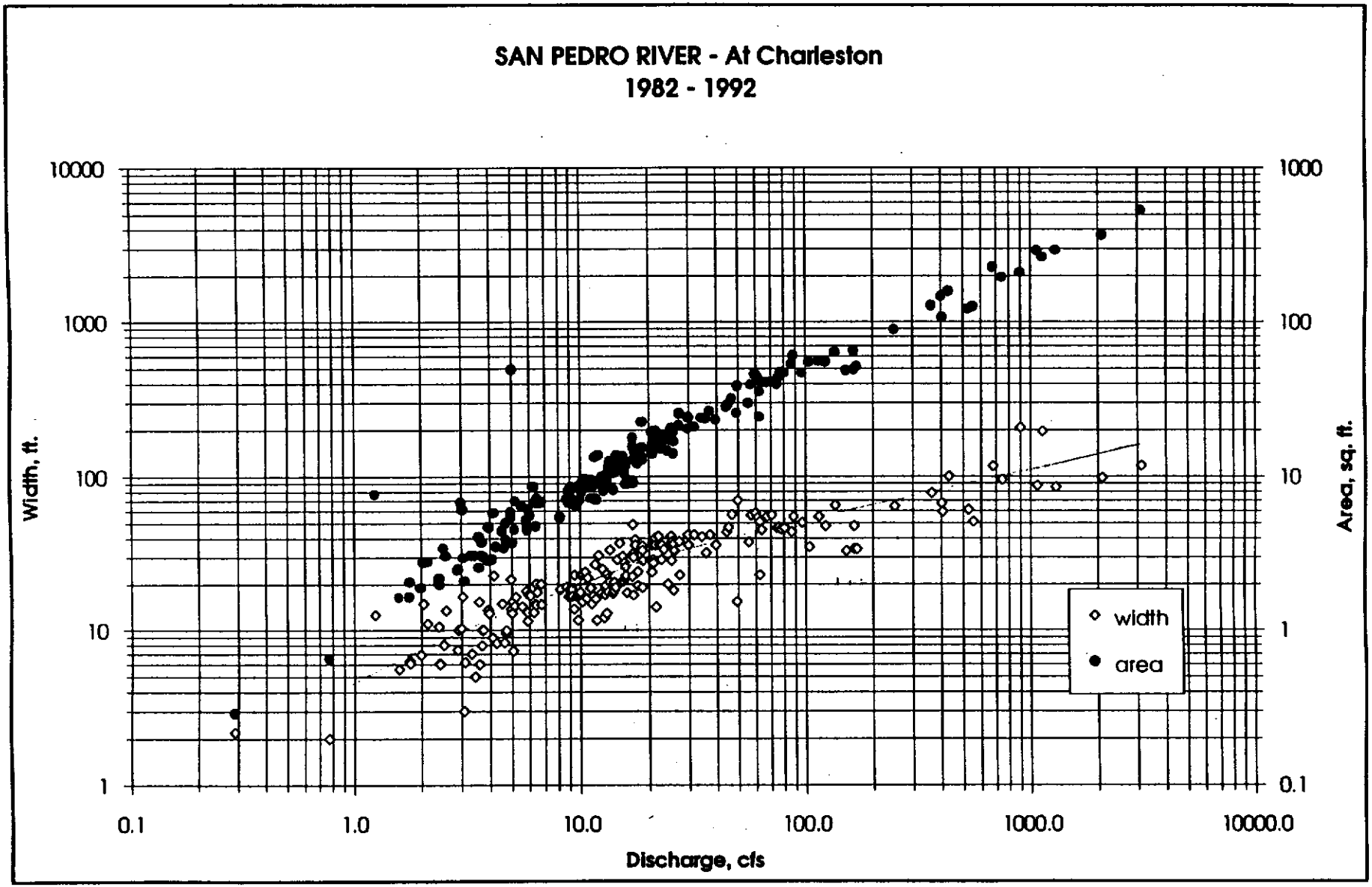
SPC-Q-GH.XLC


SAN PEDRO RIVER - at Charleston
1982 - 1992
10.0
1.0
0.1
Depth, ft.
0.1
1.0
10.0
100.0
1000.0
10000.0
Discharge, cfs

SPC-Q-D.XLC


SAN PEDRO RIVER - at Charleston
1982 - 1992
10.00
1.00
0.10
Velocity, ft./s.
0.1
1.0
10.0
100.0
1000.0
10000.0
Discharge, cfs

SPC-Q-V.XLC

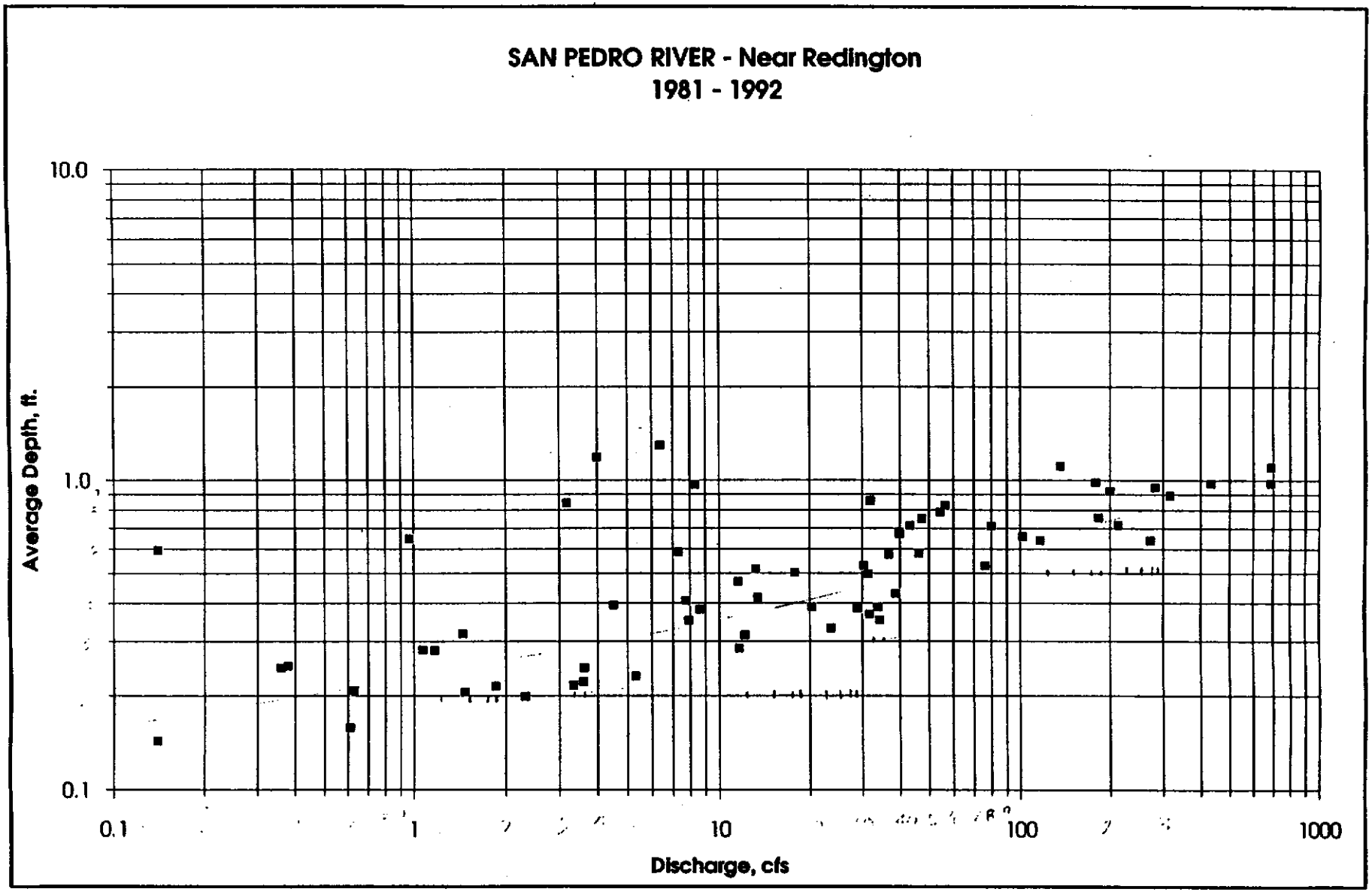

SAN PEDRO RIVER - At Charleston
1982 - 1992
Width, ft.
Area, sq. ft.
Discharge, cfs
10000
1000
100
10
1
0.1
1.0
10.0
100.0
1000.0
10000.0
0.1
width
area

SPC-Q-WA.XLC

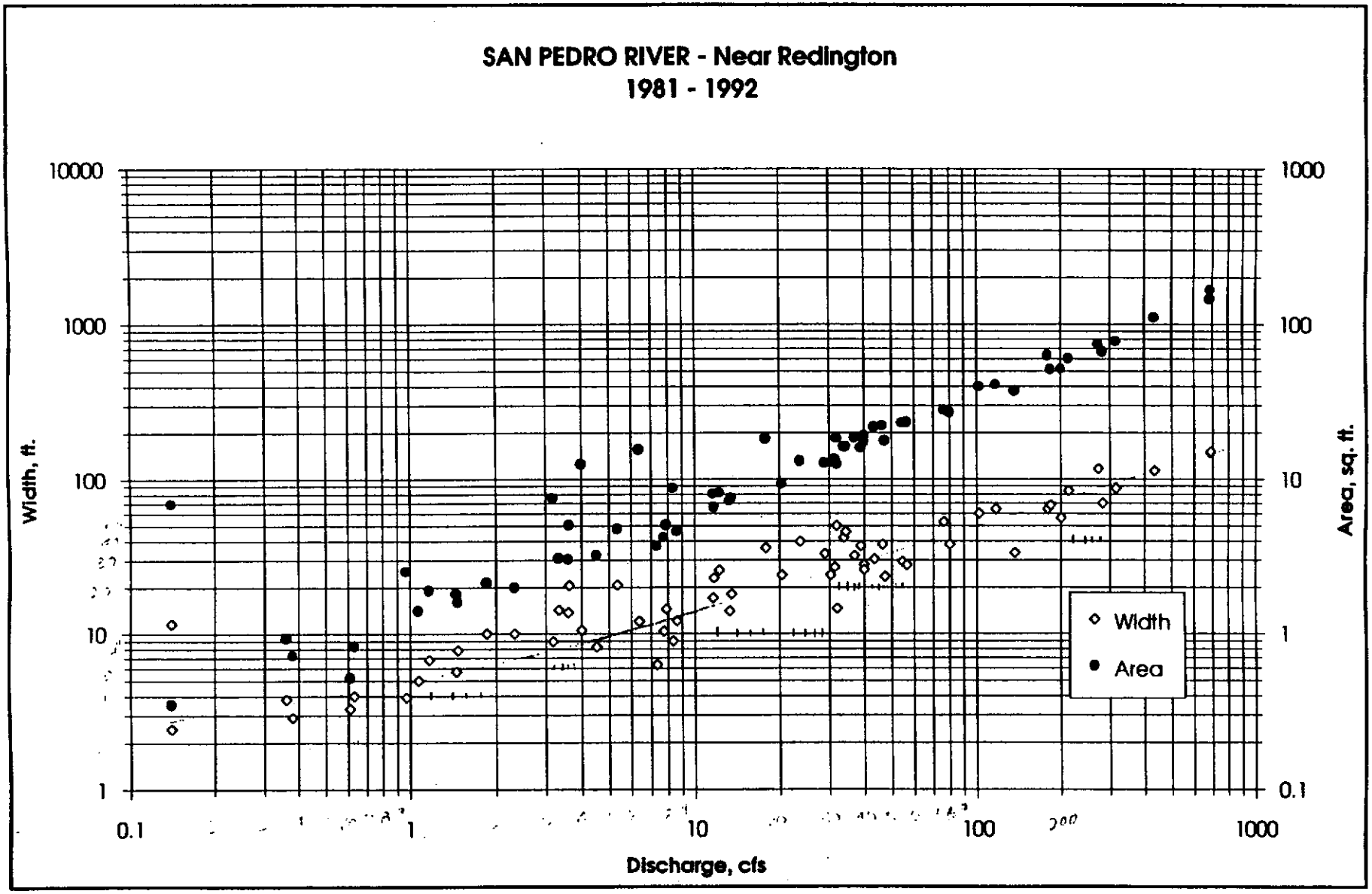
SAN PEDRO RIVER NEAR REDINGTON

1) Original Data

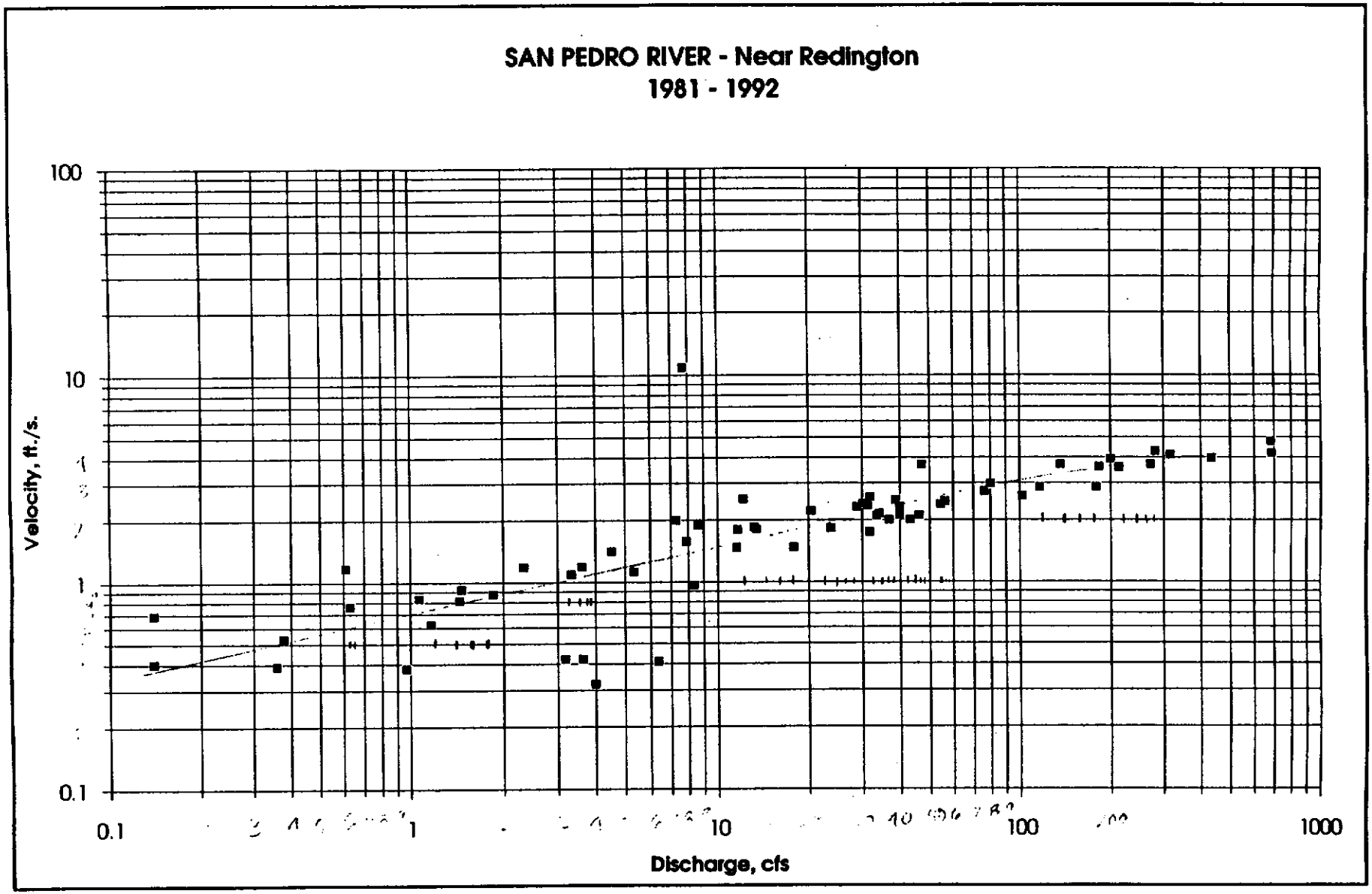
Meas #	Width	Area	Velocity	Gage H.	Discharge	Depth
501	5.7	1.8	0.81	7.15	1.45	0.3
502	10	1.98	1.18	7.48	2.33	0.2
502C	3.9	2.52	0.38		0.97	0.6
503				8.7	360	
504	50	18.3	1.74	7.76	31.8	0.4
505				9.6	900	
506	70	66.3	4.27	8.61	283	0.9
507	56	51.4	3.91	8.32	201	0.9
508				10.5	2700	
509	64	62.8	2.87	8.25	180	1.0
510	10	2.14	0.87	7.48	1.86	0.2
511				14.75	8700	
512	113	110	3.95	8.88	434	1.0
513	42	16.2	2.09	7.82	33.8	0.4
514	33	12.6	2.3	7.76	29	0.4
515				10.5	2000	
516	27	13.4	2.34	7.84	31.4	0.5
517	53	28	2.73	8.35	76.5	0.5
518	46	16.1	2.13	8.13	34.3	0.4
519	12.1	4.6	1.88	8.14	8.64	0.4
520				21.4	25400	
521	87	77.4	4.1	10.47	317	0.9
522	64	40.9	2.86	9.84	117	0.6
523	28	19	2.11	8.8	40	0.7
524	26	17.4	2.3	9.15	40	0.7
525				10.65	500	
526	33.5	37.1	3.69	9.23	137	1.1
527	23.5	17.6	3.69	8.8	47.4	0.7
528	24	12.7	2.39	8.5	30.4	0.5
529	17	7.96	1.46	8.12	11.6	0.5
530	150	165	4.18	10.5	689	1.1
531					3800	
532	37	15.8	2.48	9.34	38.8	0.4
533	148	144	4.77	10.85	687	1.0
534	38	27	2.97	9.32	80.2	0.7
535	116	74	3.69	9.67	273	0.6
536	23	6.53	1.79	8.79	11.7	0.3
537	24	9.27	2.2	8.83	20.4	0.4
538				14.5	7000	
539	84	60	3.57	9.81	214	0.7
540	38	22.1	2.1	9.1	46.3	0.6
541	30.5	21.7	2	9.2	43.4	0.7
542	14.2	3.06	1.09	8.78	3.34	0.2
543				11.9	1550	


SAN PEDRO RIVER - Near Redington
1981 - 1992
Average Depth, ft.
10.0
1.0
0.1
0.1
1
10
100
1000
Discharge, cfs

SPR-Q-D.XLC

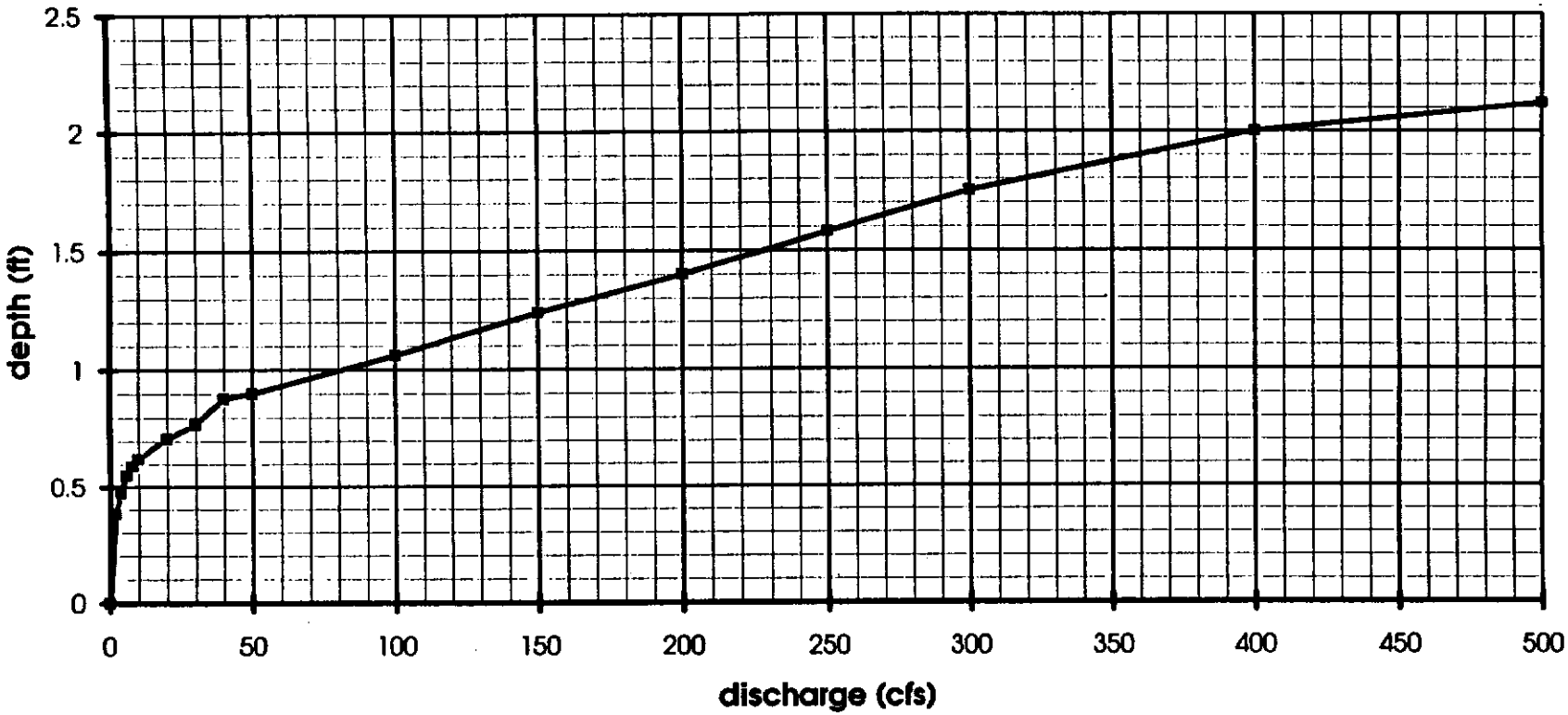

SAN PEDRO RIVER - Near Redington
1981 - 1992
Width, ft.
Area, sq. ft.
Discharge, cfs
10000
1000
100
10
1
0.1
1000
100
10
1
0.1
0.1
1
10
100
1000
Width
Area

SPR-Q-WA.XLC

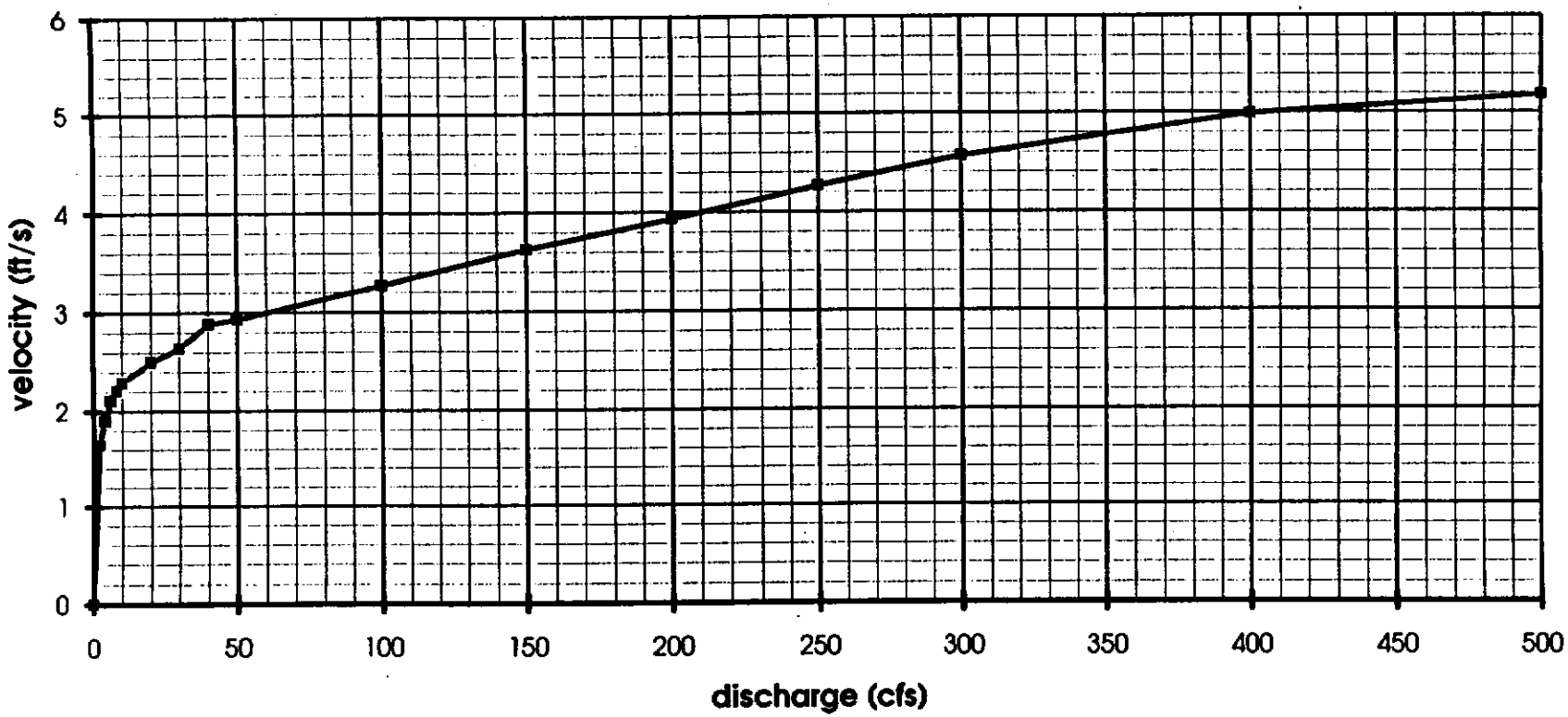

SAN PEDRO RIVER - Near Redington
1981 - 1992
Velocity, ft./s.
100
10
1
0.1
0.1
1
10
100
1000
Discharge, cfs

SPR-Q-V.XLC

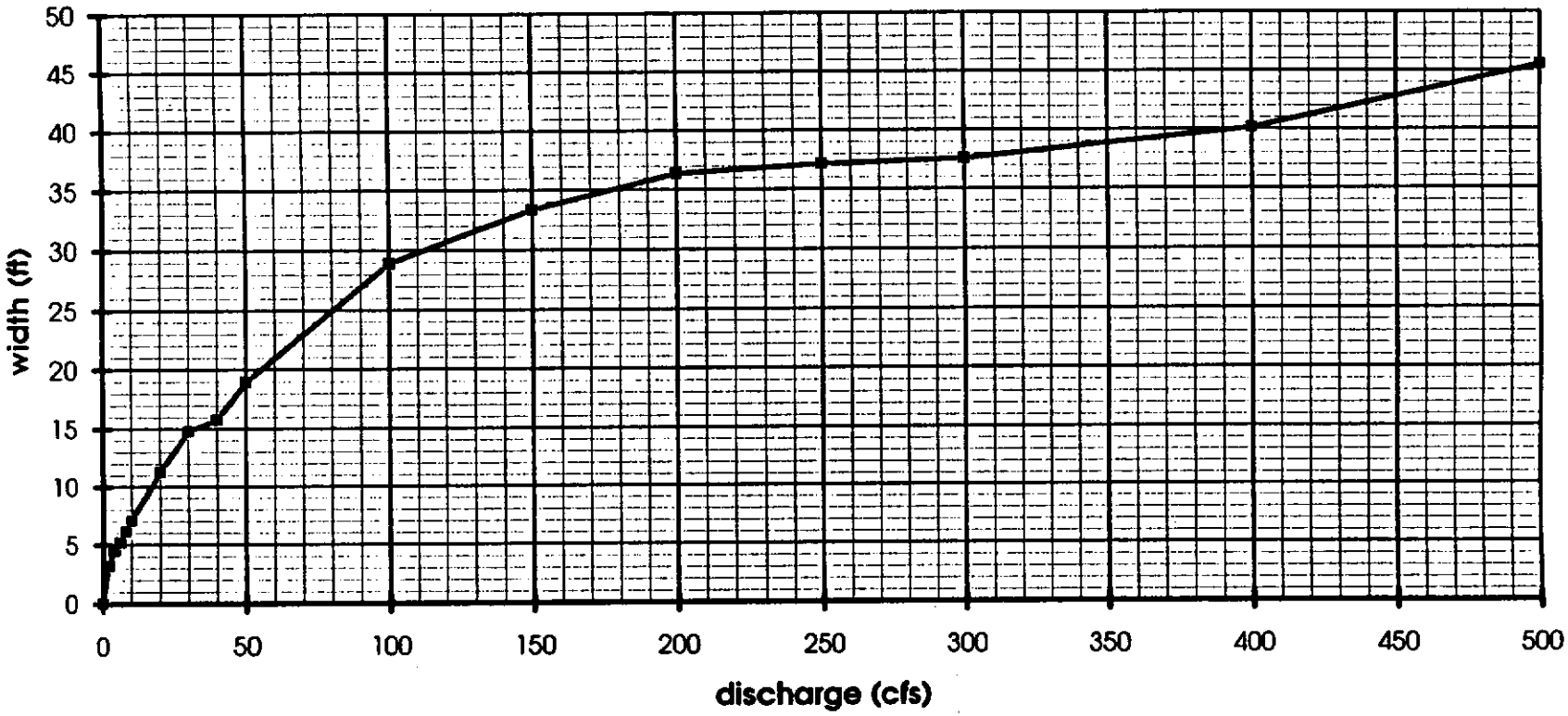
San Pedro River near Fairbank (1915 to 1924)



San Pedro River near Fairbank (1915 to 1924)

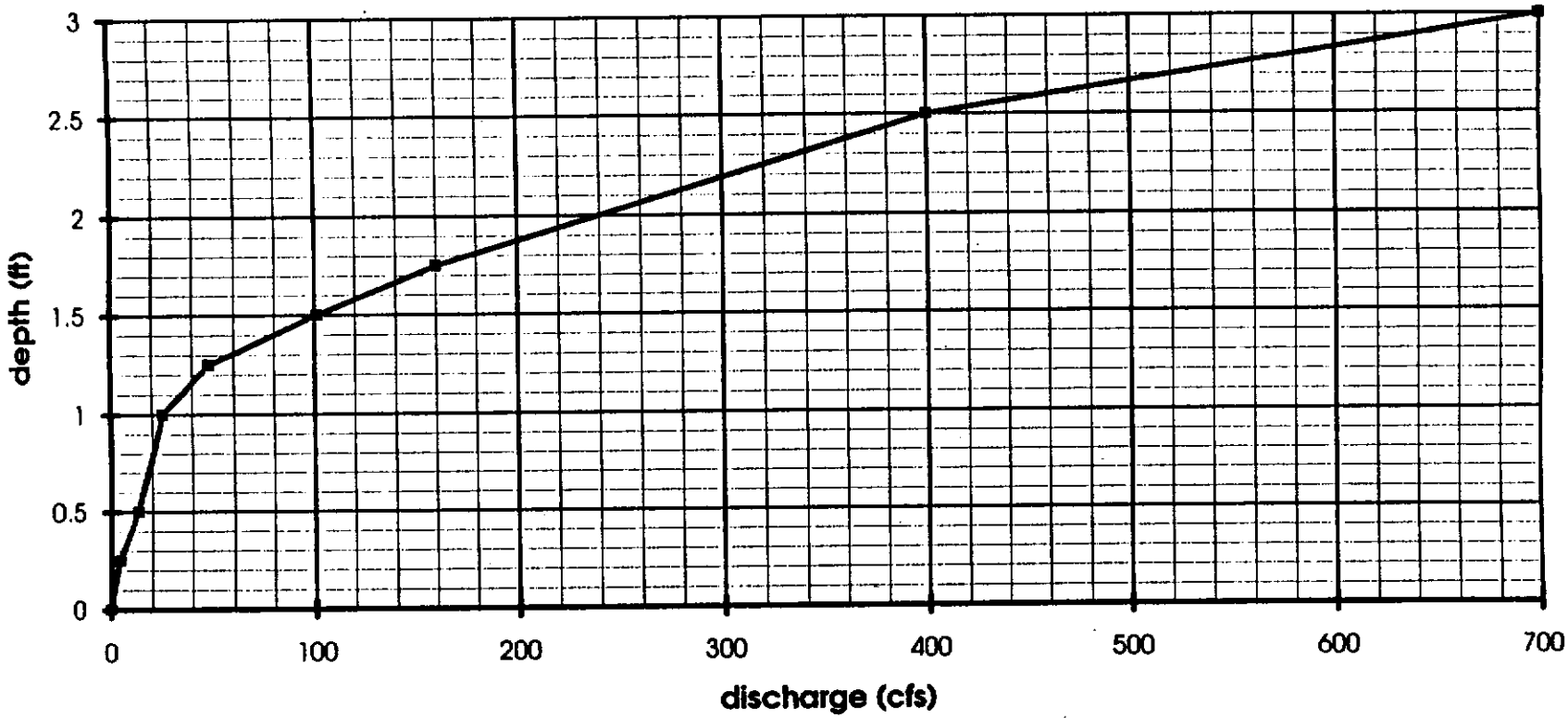


San Pedro River near Fairbank (1915 to 1924)

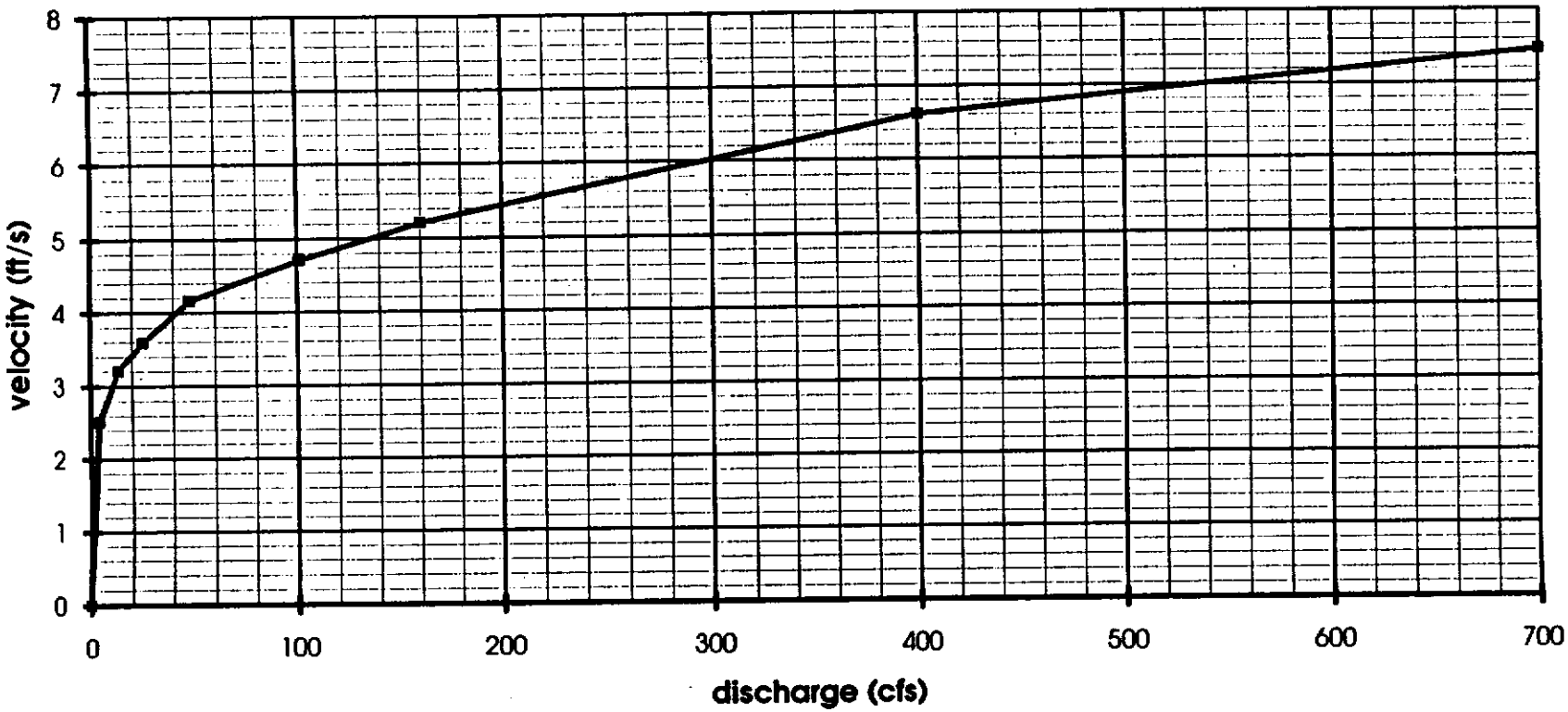


note: because of the shifting nature of a sandy gravelly channel, low flow estimations of widths may not be accurate

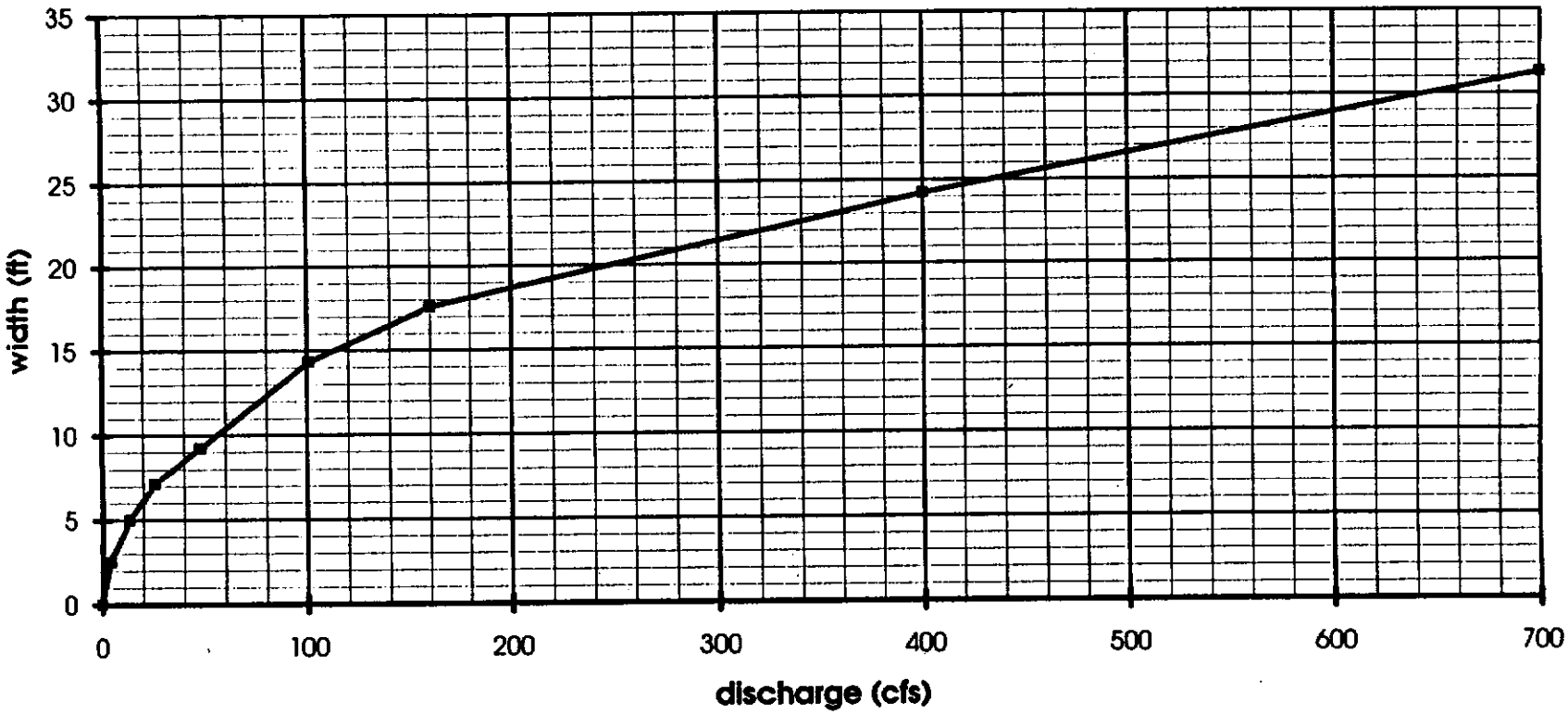
San Pedro River at Charleston (1904 to 1906)



San Pedro River at Charleston (1904 to 1906)



San Pedro River at Charleston (1904 to 1906)



within each cross section are described in the Ground Water chapter. Flood levels at each cross section are discussed in the surface water hydrology chapter.

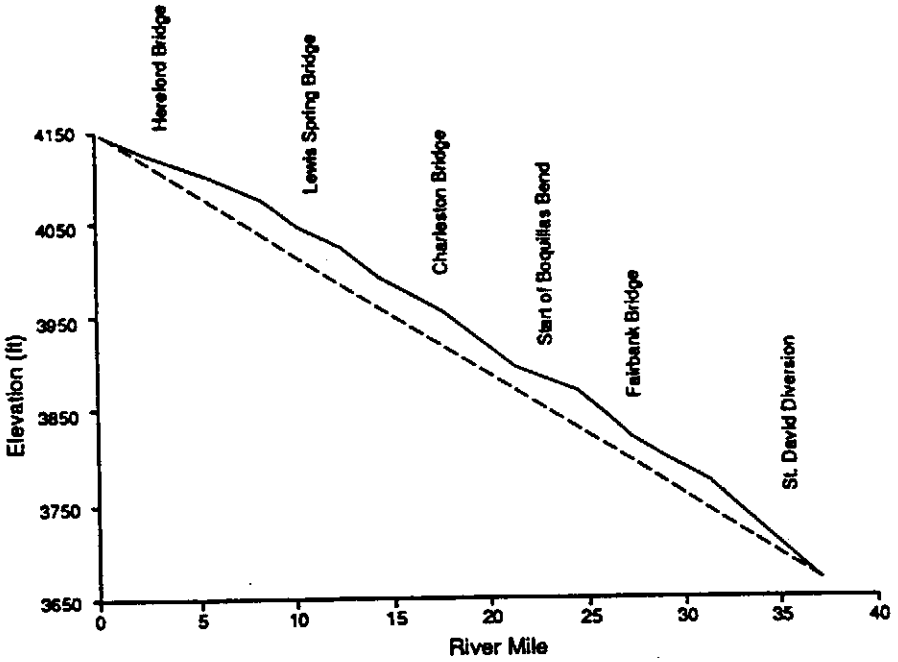


Figure 13. San Pedro River longitudinal profile.

Figure 14. (a-g) San Pedro River channel cross sections indicating the inundation extent of flood flows with 2-year, 10-year, 50-year, and 100-year return periods.

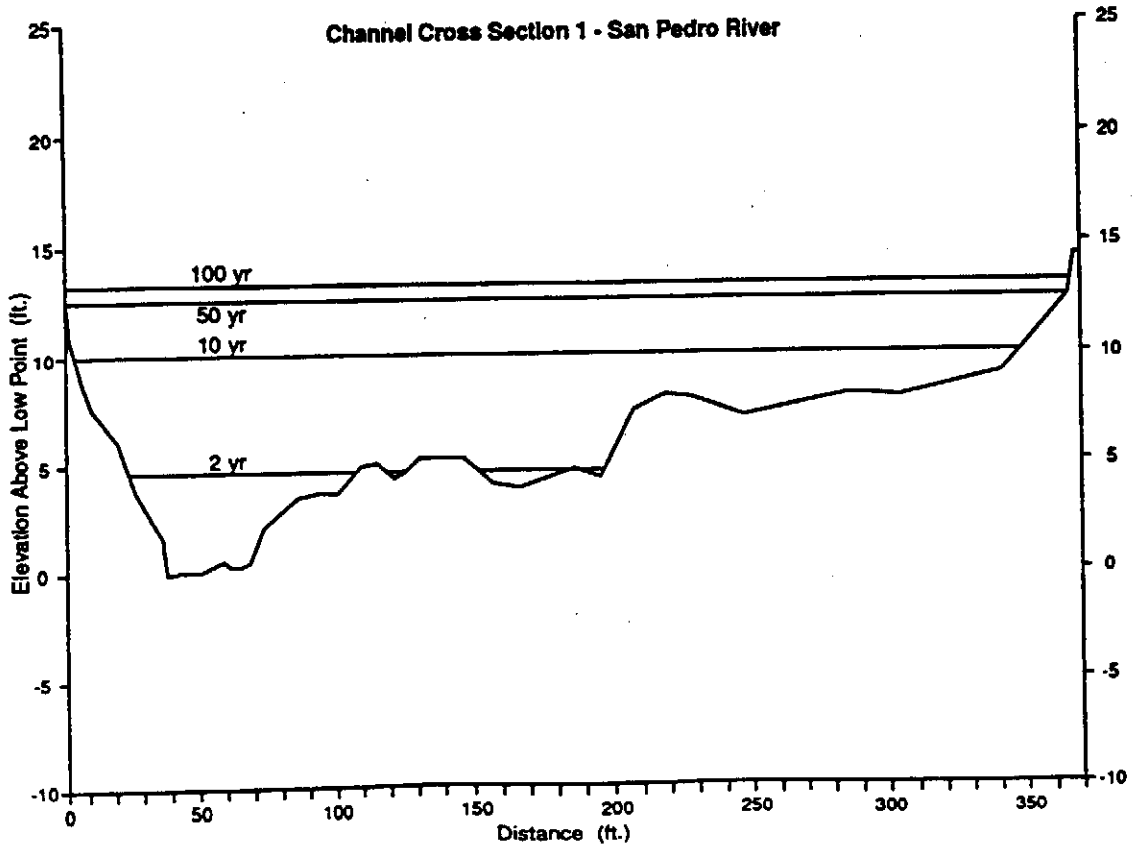


Figure 14a.

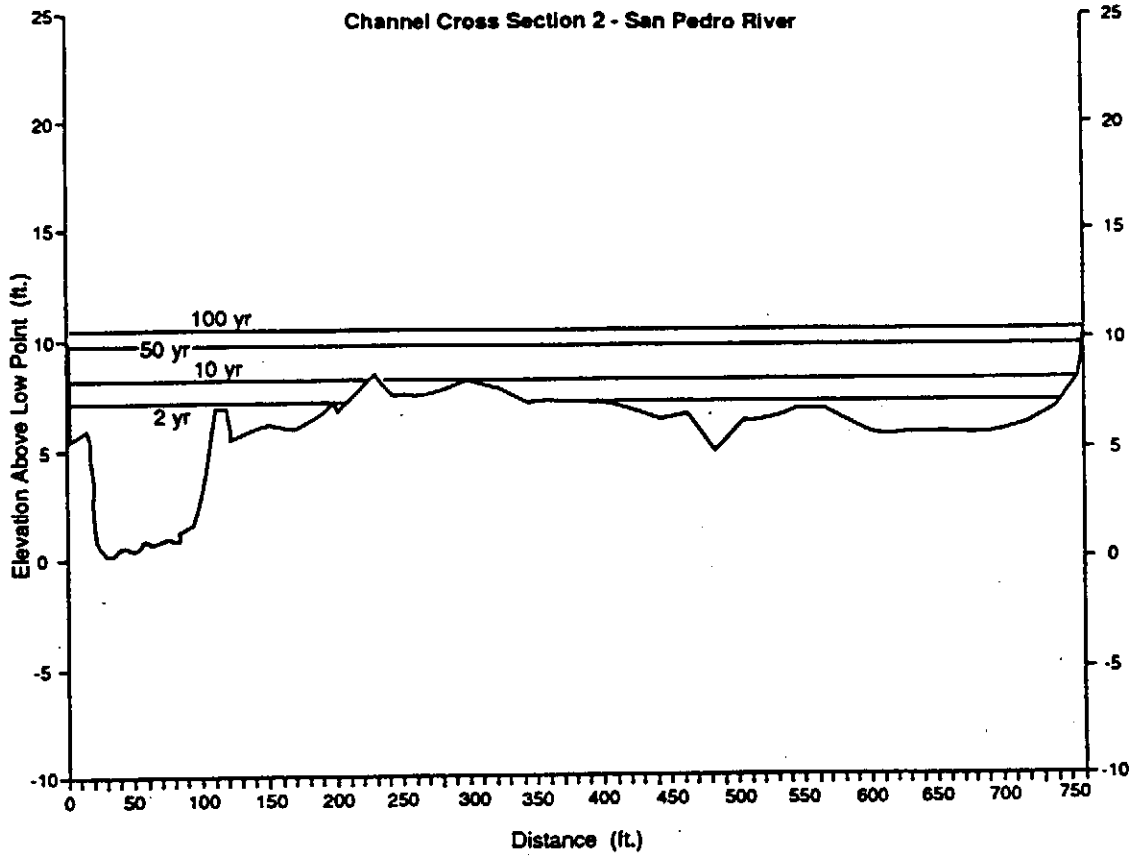


Figure 14b.

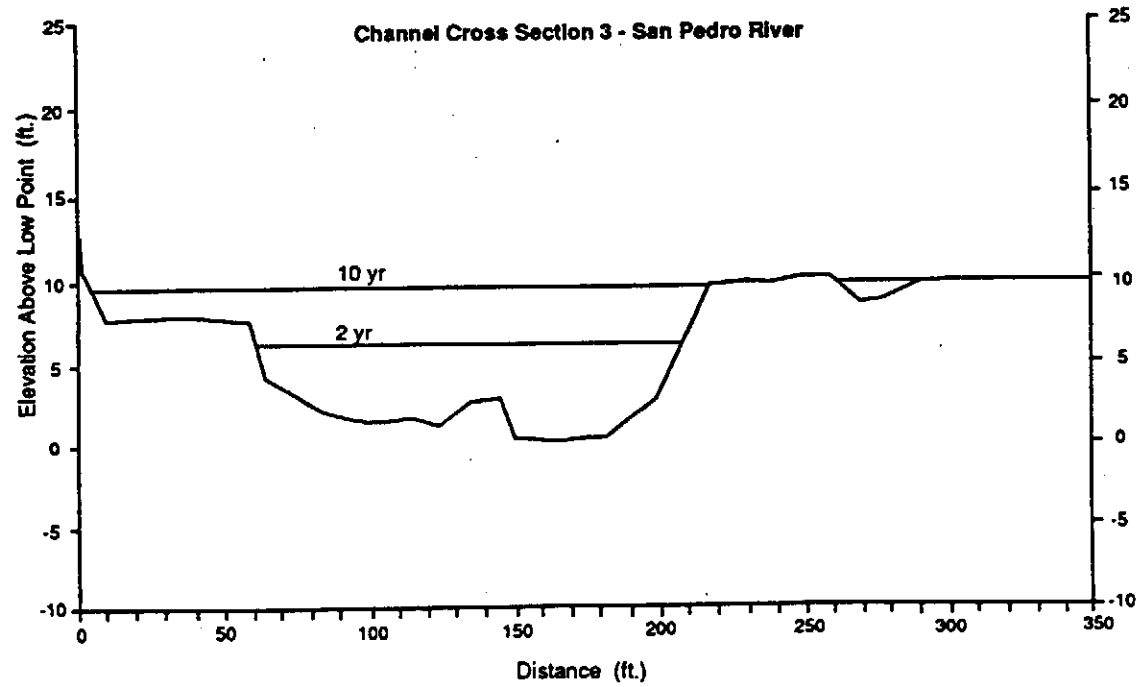


Figure 14c.

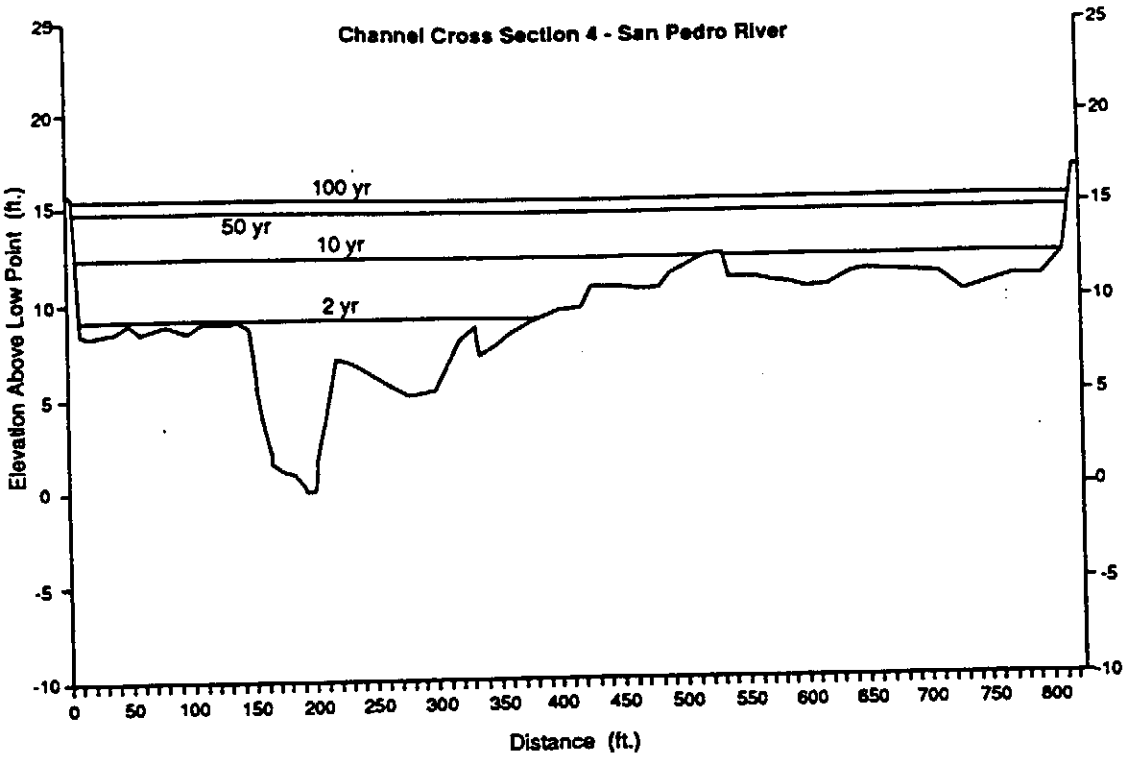


Figure 14d.

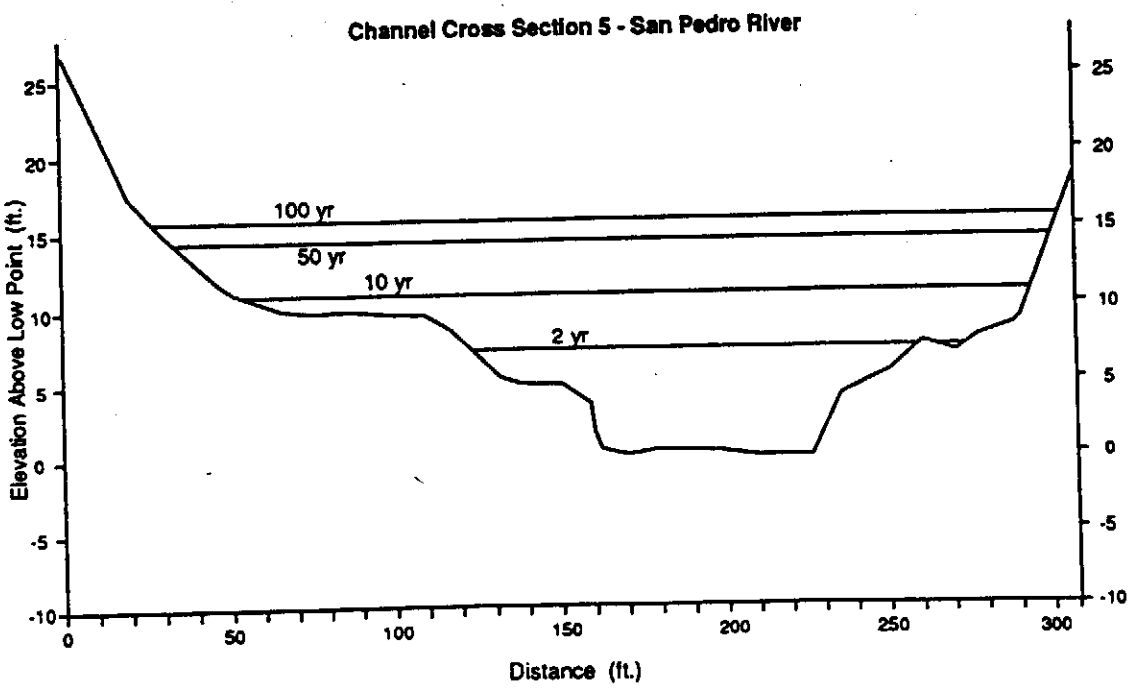


Figure 14e.

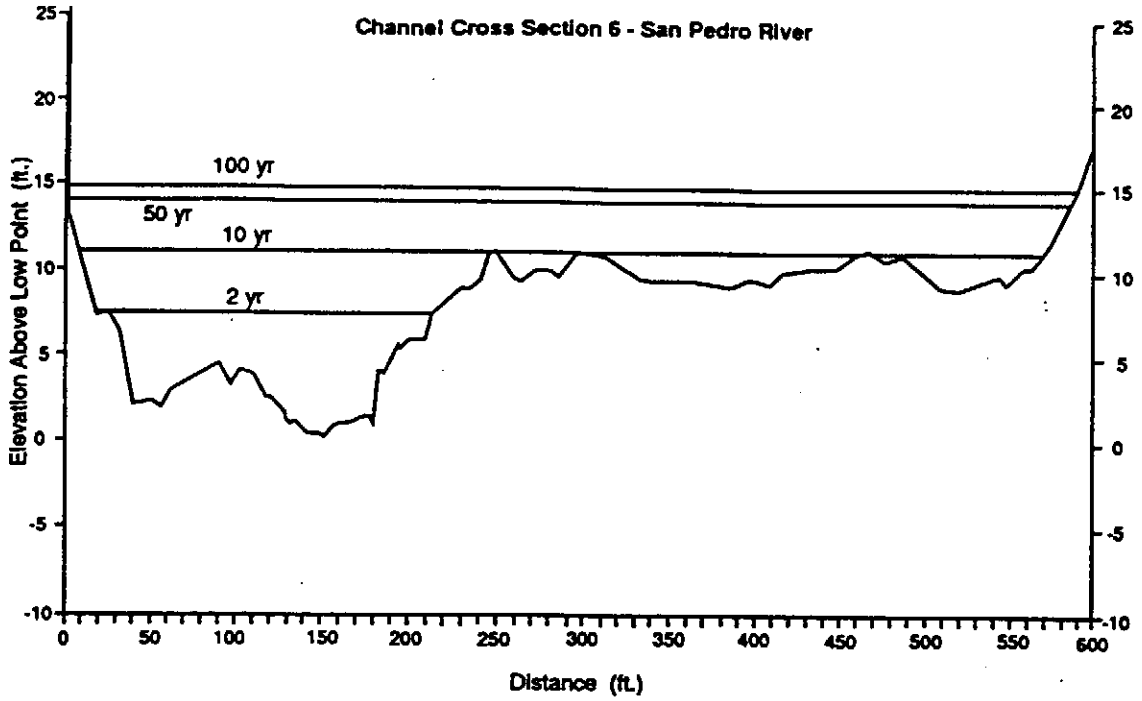


Figure 14f.

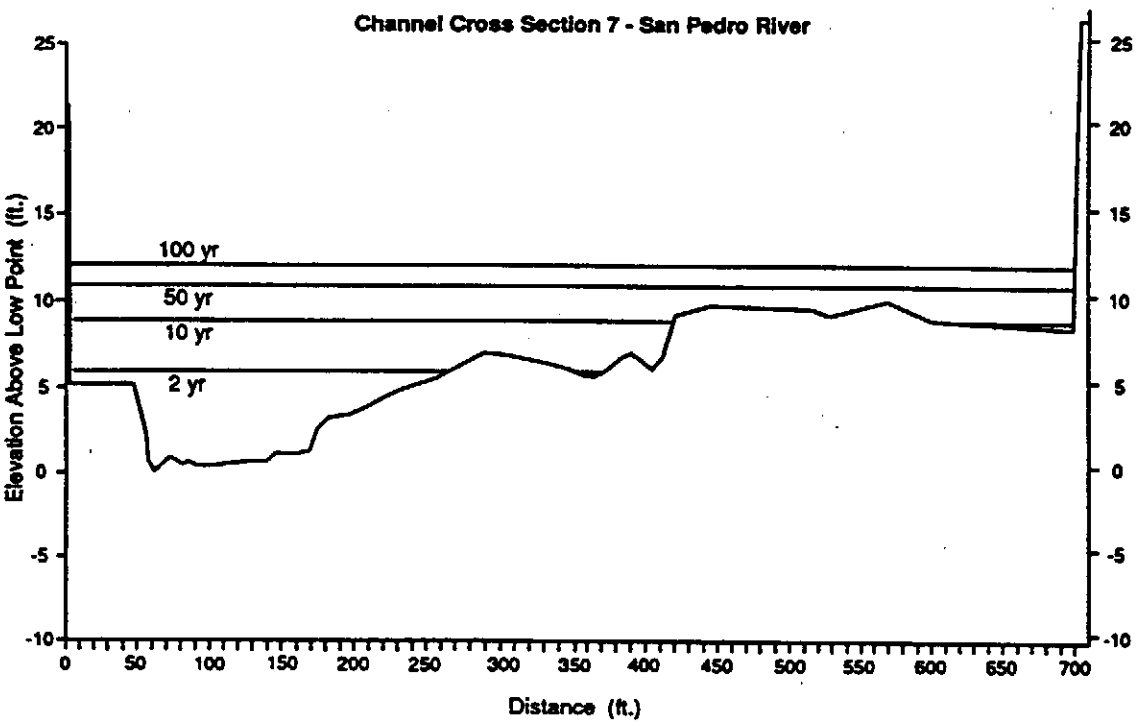


Figure 14g.

Figure 29. (a-g) Indirect discharge rating curves for San Pedro River cross sections.

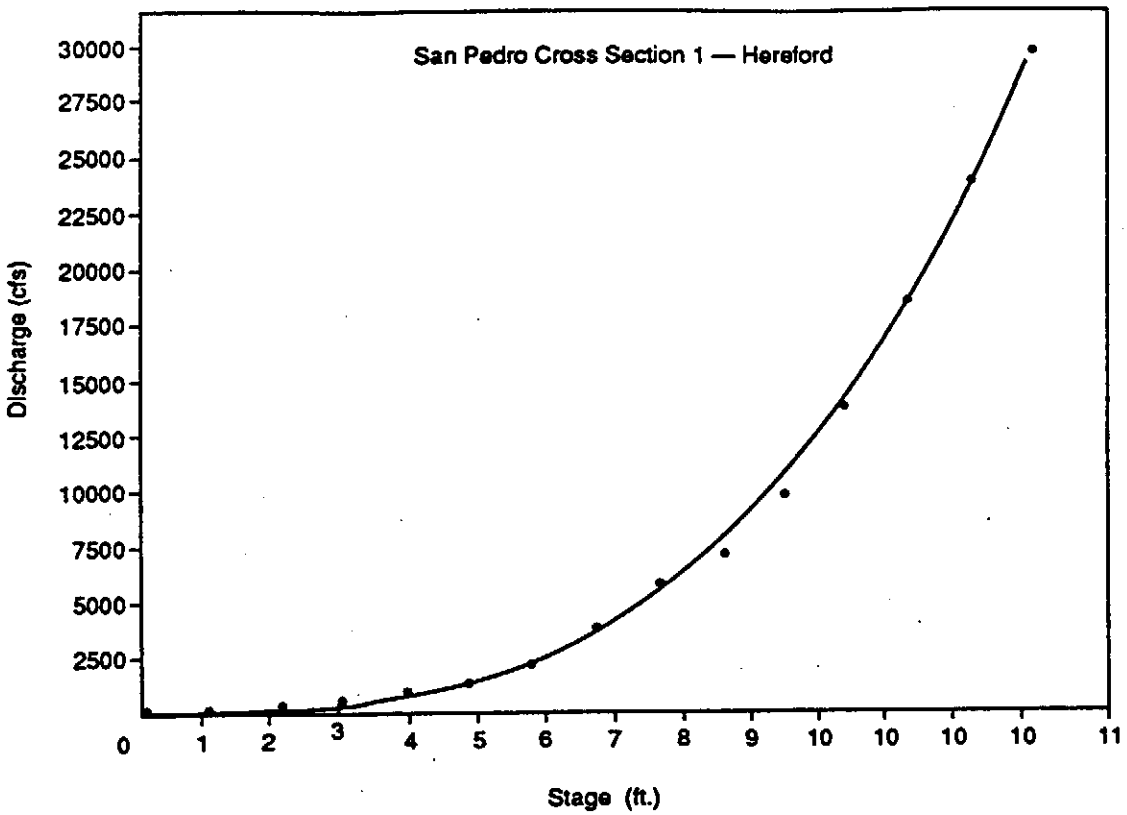


Figure 29a.

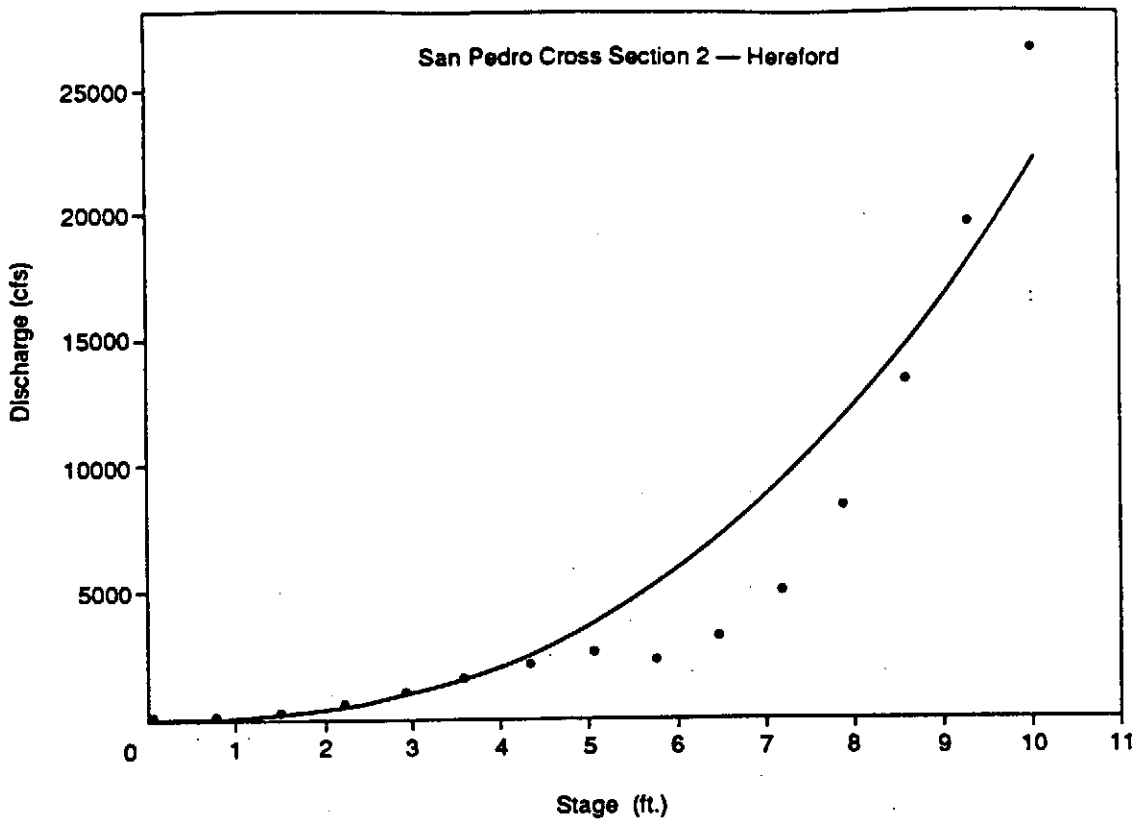


Figure 29b.

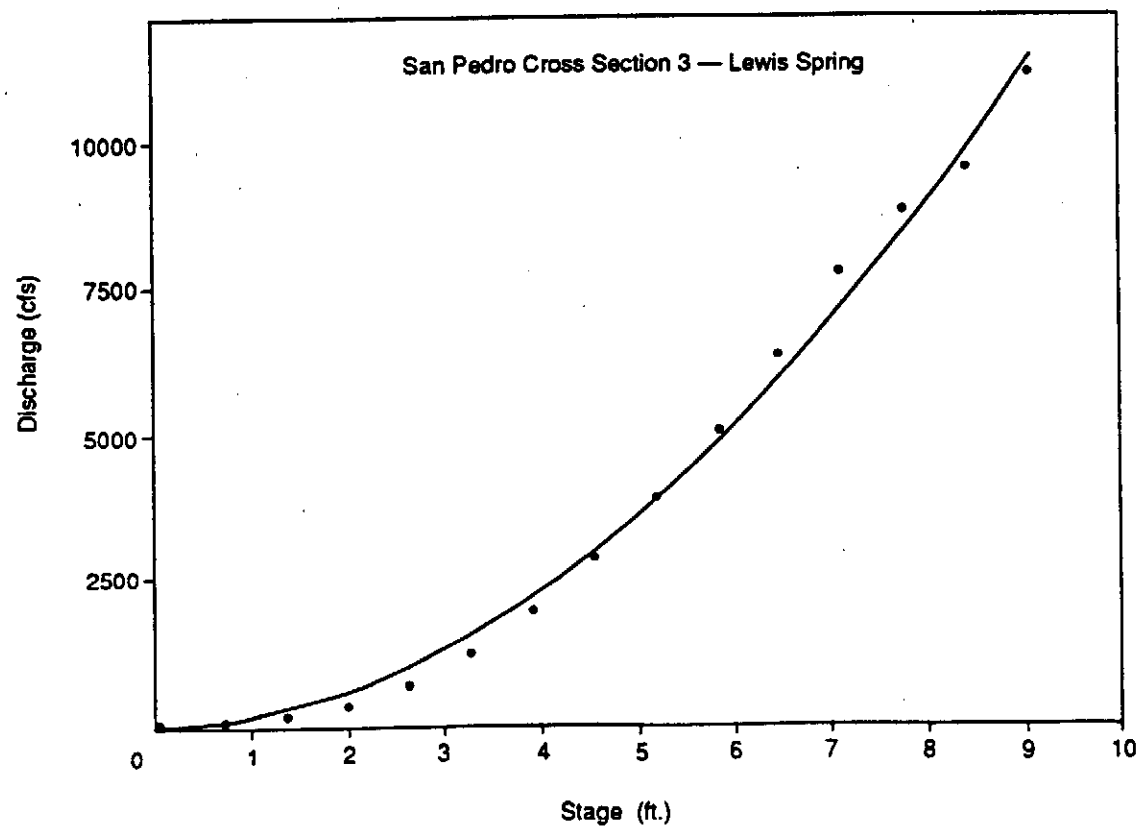


Figure 29c.

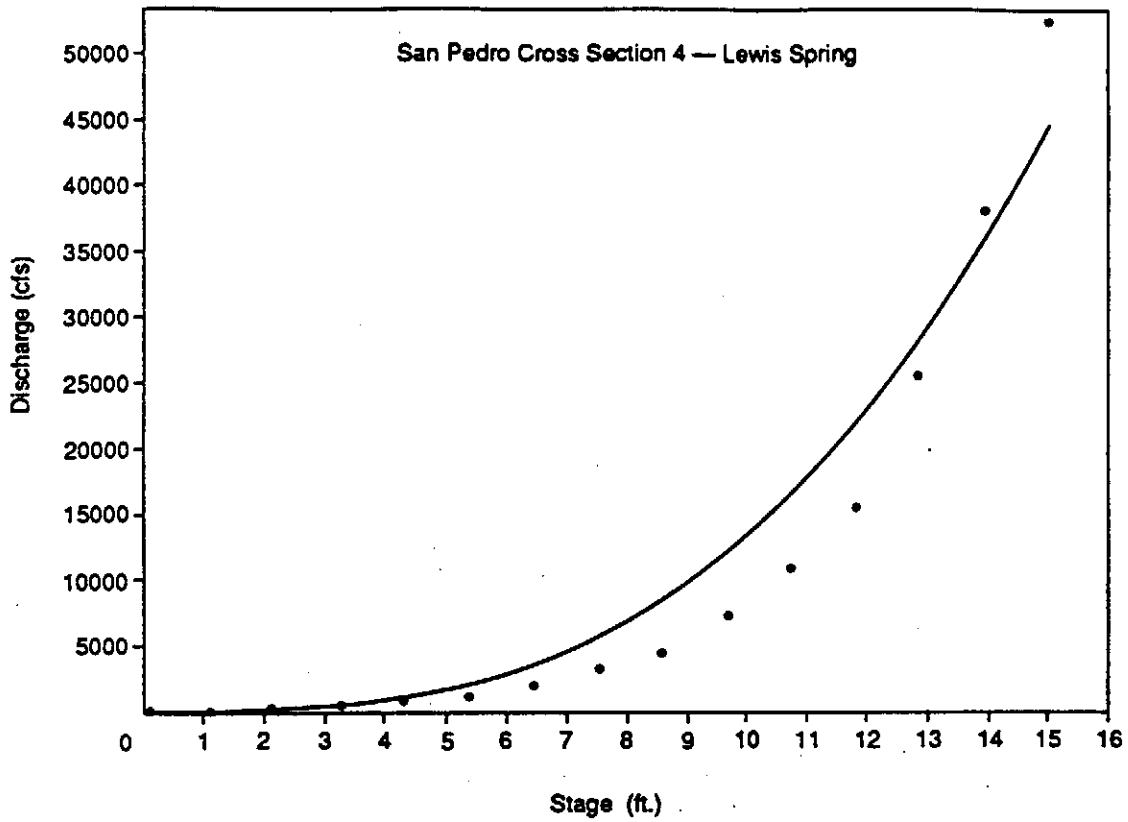


Figure 29d.

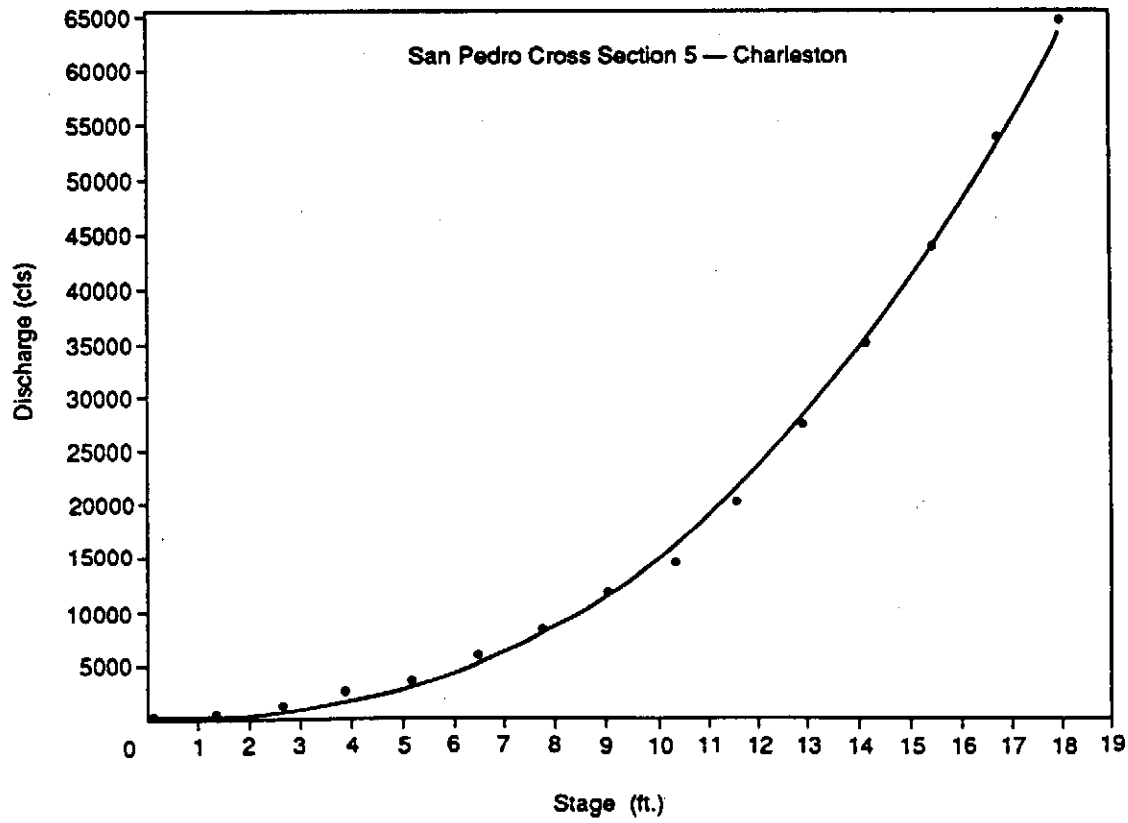


Figure 29e.

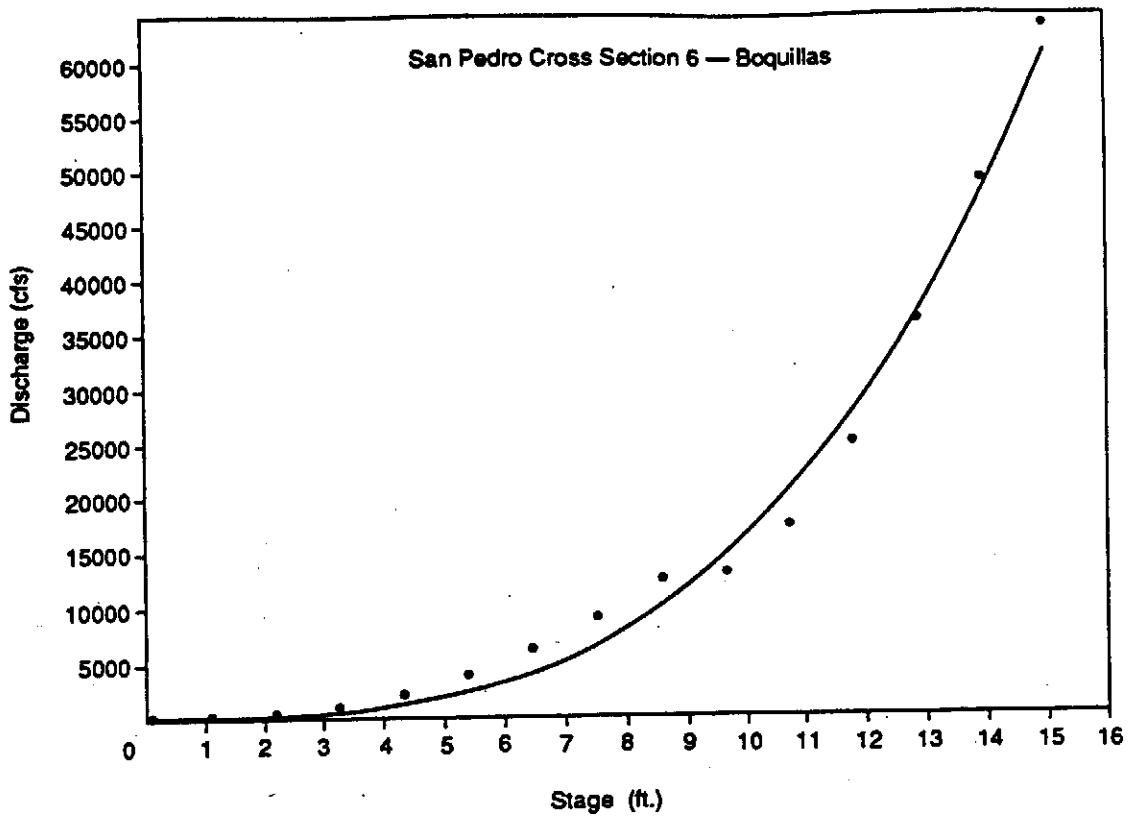


Figure 29f.

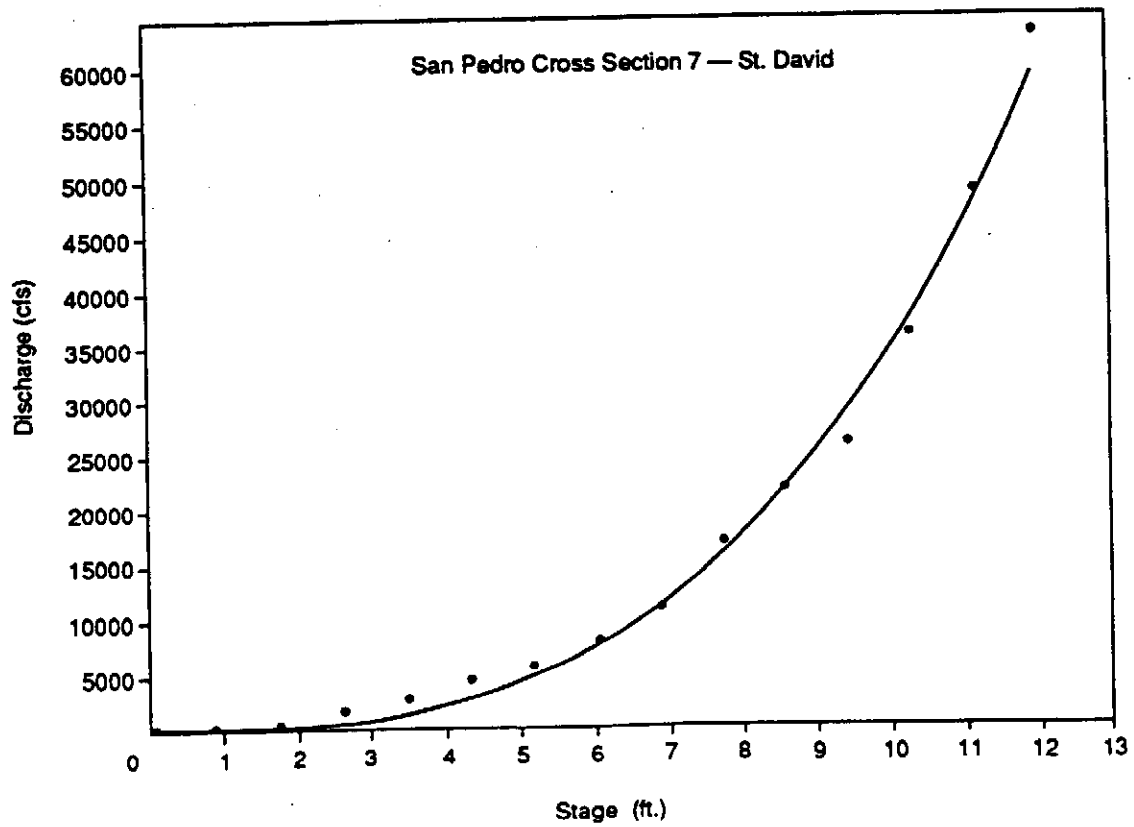


Figure 29g.

Appendix F
Arizona Climatic Variation

Arizona Climatic Variation

Introduction

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

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

Methodology

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

Stream Gage Records

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

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

Arizona Climate Change

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

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

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

of the tree-ring record indicates the following:

- The period from 1905-1920 (Arizona statehood in 1912) was the wettest period since 1580 in both the Salt and Verde River watersheds.

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

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

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

- Irrigation diversions impact Verde River streamflows.

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

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

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

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

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

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

Hastings and Turner (1965) reach similar conclusions as Cooke and Reeves, and also note a slight

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

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

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

Conclusions

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

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

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

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

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

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

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

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

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

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

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

Summary

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

Appendix G
Boating on Arizona Rivers

Boating on the Arizona Rivers

Introduction

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

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

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

Federal Criteria for Navigability

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

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

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

Source: US Fish and Wildlife, 1978

Table G-2
Minimum and Maximum Conditions for Recreational Water Boating

Type of Boat	Minimum Condition			Maximum Condition		
	Width	Depth	Velocity	Width	Depth	Velocity
Canoe, Kayak	25 ft.	3-6 in.	5 fps	-	-	15 fps
Raft, Drift Boat	50 ft.	1 ft.	5 fps	-	-	15 fps
Low Power Boating	25 ft.	1 ft.	-	-	-	10 fps
Tube	25 ft.	1 ft.	1 fps	-	-	10 fps

Source: Cortell and Associates, 1977

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

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

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

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

Historical Accounts of Boating

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

- Travel
- Ferries
- Recreation

- Mail Delivery
- Flood Rescues
- Transport of Goods

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

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

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

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

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

The type of boats typically used were flat-bottomed boats, skiffs, or canvas and wooden canoes. Information presented in Table G-3 summarizes probable stream characteristic required to support use of the type of boats available at statehood. The criteria for canoes are not substantially different from criteria for canoes available today.

Table G-3
Flow Requirements for Pre-1940 Canoeing

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

Source: Slingluff, J., 1987

Historical Accounts of Fish

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

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

Modern Accounts of Boating

Some Arizona rivers are still boated in modern times. While modern boat use of a river may not provide definitive proof of susceptibility of a stream to navigation at statehood, it is evidence that is readily available for consideration. Boat-making technology has improved[1] since the times

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

of statehood, with use of inflatable rafts, inflatable and hard-shell kayaks becoming one of the preferred modes of travel. However, while canoe technology has changed to make these boats more durable, the depth of water required for canoeing has not substantially changed. In addition, flow rates on Arizona rivers have generally declined since 1912. Therefore, modern use of a river reach by canoes probably indicates that canoes could have been used as of the time of statehood.

The Central Arizona Paddlers Club (CAPD), an organization of boaters, recently conducted a survey of their members to determine what rivers had been boated. With 20 percent of members responding the survey indicated that all of the Salt River study reach, all of the Verde River downstream of Perkinsville, and the San Pedro from Palominas to Hereford Road have been boated in recent years (Central Arizona Paddlers Club, 1992). CH2M HILL informally polled CAPD members willing to be interviewed to determine flow conditions at the time various rivers were boated. Data collected in this poll reveal that all of the San Pedro River except the reach from Mammoth to Aravaipa Creek, and Curtis to I-10 have been boated at least once. Although several boaters claimed to have heard of boating portions of the Hassayampa River, no documentation of this was uncovered. A brief summary of the CAPD poll showing reaches and flow data is presented in Table G-4.

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

Although the Salt and San Pedro Rivers have been boated, Arizona State Parks Department classified the San Pedro as a hiking or general recreation reaches (1989). Some boaters who have travelled on the San Pedro River described driving to the reach and waiting for summer monsoons to occur before being able to float the stream. Others have attempted to float some reaches merely on base flow. All but one of the boating excursions on the San Pedro River occurred in the month of August, during the monsoon season. The Salt River below Granite Reef Dam is not mentioned in the Parks publication. The Hassayampa is mentioned only for hiking, even in reaches of perennial flow. A boating guide to the southwest does not list any of the four rivers[2] (Anderson, 1982).

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

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

River	Reach	Date mo-yr	Flow (cfs)	Depth (ft)	Width (ft)	Craft	Portage (%)
Salt	Granite Reef to McKellips Dr.	1-92	1,000	1-4	30-100	Kayak	0
	Gilbert Rd. to Priest Dr.	4-93	20,000	> 6	< 300	Kayak	0
	Gilbert Rd. to 51st Ave.	5-82	1,000	1-2	< 100	Kayak	0
	Mill Ave. to 115th Ave.	2-92	4,000	3-4	< 1,200	Canoe	0
Verde	Morgan Ranch to Perkinsville	10-89	30	0.5-1	< 15	Canoe	1
	Morgan Ranch to Salt River	10-88	< 50	> 0.5	> 10	Canoe	1
	Horseshoe to Needlerock	3-92	20,000	> 10	300	Kayak	0
San Pedro	Mexican Border to Palominas	8-92	n.a.	< 1	< 15	Kayak	50
	Palominas to Hereford Rd.	8-92	12	< 1	< 10	Kayak	50
	Hereford to Highway 90	1-93	n.a.	< 5	< 40	Rubber Raft	0
	San Pedro Preserve	87-92	n.a.	n.a.	n.a.	Canoe	n.a.
	I-10 to Mammoth	8-73	200	> 0.5	< 20	Small Raft	5
	Aravaipa Ck. to Hayden	3-79	1,000	1.5	< 120	Canoe	0
Hassayampa	None	-	-	-	-	-	-

Navigability Decisions

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

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

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

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

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

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

Summary

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

Appendix H
San Pedro River GIS

San Pedro River GIS Plots

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

Appendix H.1: Data Formats

INFO (PAT) FILE FORMAT

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

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

OWN_CODE = COUNTY+BOOK+MAP+PARCEL

RELATE FILE FORMAT (Privately owned and some agency lands)

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

SALTP PAT FORMAT (UNREVISED GIS)

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

RVG AND TNK PAT FORMAT

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

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

STR PAT FORMAT

TYPE	13 C
QUAD	4 C

SPVEG PAT FORMAT

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

*Identical to items in ALRIS NATVEG layer.

Land Use Categories and Codes

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

2310 Mineral/mining
2320 Salvage yards / equipment storage
3000 Municipal / County
3100 Administrative
3200 Field facilities / shops
3300 Parks / recreation / drainage
3400 Water / wastewater treatment plants

Appendix H.2: Data Inventory

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

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

Relate Files:

Verde: VE_OWN
San Pedro: SP_OWN
Hassayampa: HA_OWN

Riparian Data

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

SALTP PAT FORMAT (UNREVISED GIS)

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

Appendix I
Photographs of the Modern San Pedro River

Appendix J
Public Comment

PUBLIC INFORMATION MEETING

ARIZONA STREAMBED NAVIGABILITY STUDIES
SAN PEDRO RIVER STUDY PUBLIC INFORMATION GATHERING

September 29, 1993

Dear Interested Party:

The Arizona State Land Department and CH_2M Hill Consulting Engineers invites you to attend a public information meeting regarding the San Pedro River navigability study at:

Thursday, October 21, 1993 7:00 p.m.
Sierra Vista Library - Art Gallary
2950 East Tacoma Street
Sierra Vista, AZ

In July, 1992, the Arizona State Land Department was charged by the Arizona Legislature under House Bill 2594 with gathering information and performing studies to assist the Arizona Navigable Stream Adjudication Commission (ANSAC) in its duties related to determining the navigability of Arizona's watercourses at the time of Statehood (1912) and thereby resolving clouded titles. The information which is gathered from the public and agencies will include the history, archaeology, hydrology, hydraulics, geomorphology, ownership and use of the underlying lands within and along the study rivers.

In order to complete the San Pedro River study currently in progress the Department needs your assistance to obtain additional existing available information from the public which will be included in the final report.

We appreciate any assistance you can provide us in these studies. If you have any questions or require additional information, you may contact:

Arizona Streambed Program
Drainage & Engineering Section
Arizona State Land Department
1616 West Adams
Phoenix, AZ 85007
(602) 542-3507
(fax) 542-4668

MEETING ATTENDANCE

Date: Oct. / 21 / 93 Subject: San Pedro River Streambed Meeting

Name	Representing/Address	Phone #
Don Henderson	ARID POBx3015 SV, AZ 85636	378364
Jim V[illegible]	Cochise Cty Bisbee	432-[illegible]
A L Rand	Az. Water Co. P.O. Box AW Bisbee Az. 8560	432-5321
Sherry Rutherford	Az Game & Fish 555 N. Greasewood, Tucson 85745	628-5[illegible]
[illegible]	City of SV 2400 [illegible]	[illegible]
Greg Yuncevich	BLM RR#1 Box 9853 Huachuca City Az	457-226[illegible]
Jeff Inwood	ASL 2701 N. 16th St. Phoenix, AZ 85006	263-9522
Michael Lacey	ASL 2701 N 16th ST #106 Phx AZ 85006	263-952[illegible]

MEETING ATTENDANCE

Date: Oct. / 21 / 93 Subject: San Pedro River Streambed

Name	Representing/Address	Phone #
FREDERIC L. SALINGER	C.H.A. Democrats Lions	458-4945

ARIZONA STREAMBED NAVIGABILITY STUDY - GILA RIVER

- PUBLIC INQUIRIES -

Today's Date: 10/21/93 **Location:** Sierra Vista

Name: Greg Yurkevich

Address: RR#1 Box 9853
Huachuca City, AZ 85616

Telephone: 457-2265 **Fax No.:** Same

Comment/Question:

Have Historical on San Pedro — Work for BLM Sierra Vista Office. → Recommend to contact Ben Londeli - BLM Phoenix Office.

Response: Yes ☐ No ☐ IP #69

Follow-Up:

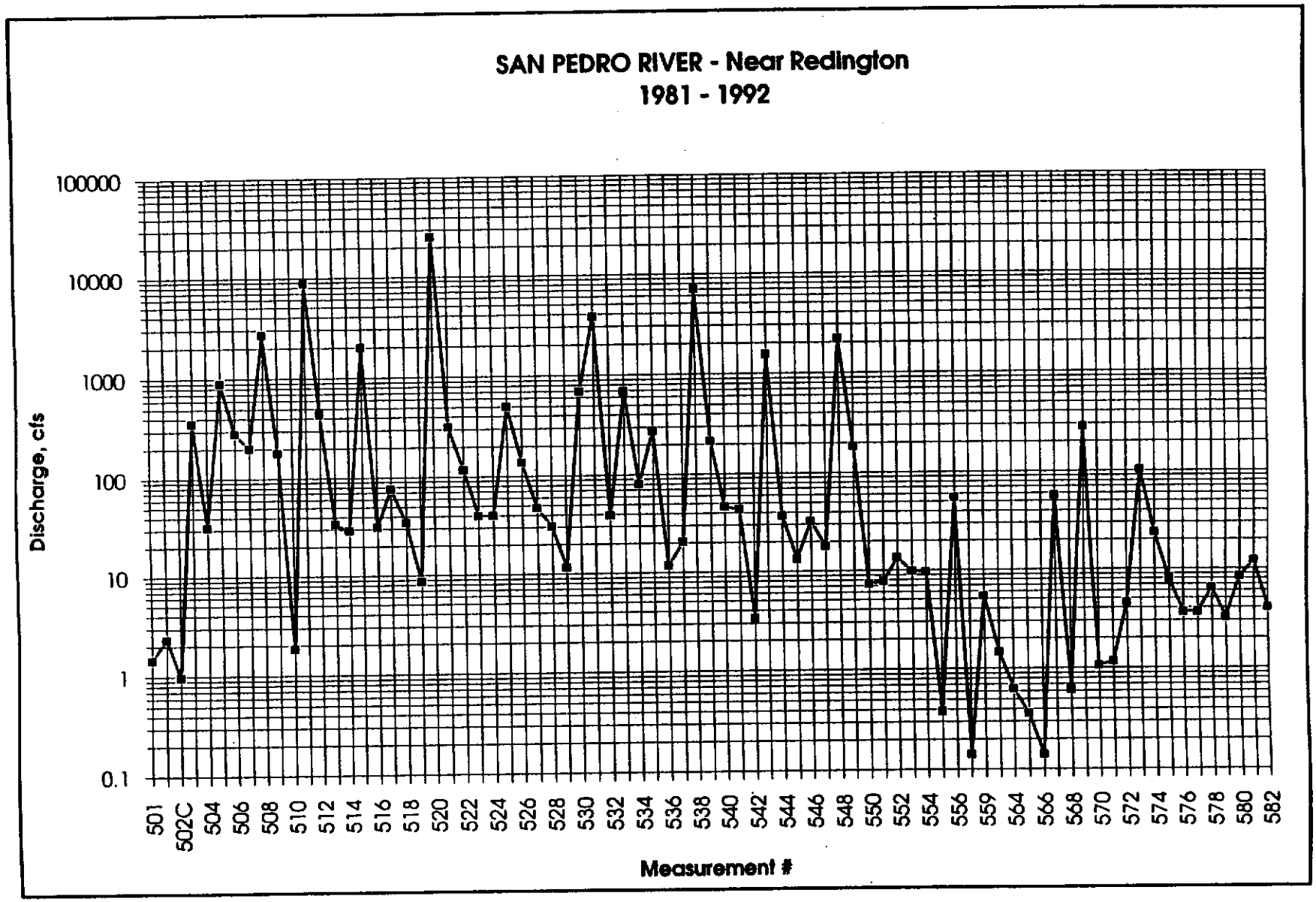
Appendix K

Lower San Pedro River: Supplemental Geomorphic Analysis

544	32	18.4	2	8.94	36.9	0.6	
545	14	7.21	1.84	8.67	13.3	0.5	
546	14.5	12.4	2.57	9.04	32	0.9	
547	36	18.1	1.47	8.82	17.9	0.5	
548				12.4	2180		
549	68	51.3	3.59	10.04	184	0.8	
550	6.3	3.69	1.99	8.76	7.33	0.6	
551	10.4	4.21	10.85	8.7	7.75	0.4	
552	18	7.48	1.8	8.8	13.5	0.4	
553				8.77	9.83		
554				8.93	9.61		
555	2.9	0.72	0.53	8.54	0.38	0.2	
556	29.4	23.1	2.36	9.27	54.6	0.8	
557	11.6	6.89	0.69	8.46	0.14	0.6	
559	20.7	4.77	1.12	9	5.35	0.2	No Q for 55
560	7.8	1.6	0.92	8.14	1.47	0.2	
564	4	0.83	0.76		0.63	0.2	
565	3.8	0.93	0.39		0.36	0.2	
566	2.45	0.35	0.4	7.59	0.14	0.1	
567	28	23.2	2.44	8.42	56.6	0.8	
568	3.3	0.52	1.17	7.82	0.61	0.2	
569				9.15	281		
570	5	1.4	0.83	7.84	1.07	0.3	
571	6.8	1.9	0.62	7.86	1.17	0.3	
572	8.2	3.22	1.41	8.08	4.53	0.4	
573	60	39.5	2.59	8.6	102	0.7	
574	39.5	13	1.82	8.3	23.7	0.3	
575	14.4	5.03	1.57	8.92	7.92	0.3	
576	13.7	3.03	1.19	9	3.6	0.2	
577	20.5	5.03	0.42	9.11	3.63	0.2	
578	12	15.5	0.41		6.38	1.3	
579	8.9	7.5	0.42		3.18	0.8	
580	9	8.67	0.96		8.36	1.0	
581	25.8	8.07	2.51		12.2	0.3	
582	10.5	12.4	0.32		4	1.2	

SAN PEDRO RIVER NEAR REDINGTON					
2) Sorted w.r.t. Q					
Meas #	Discharge	Width	Area	Velocity	Gage H.	Depth
557	0.14	11.6	6.89	0.69	8.46	0.6
566	0.14	2.45	0.35	0.4	7.59	0.1
565	0.36	3.8	0.93	0.39		0.2
555	0.38	2.9	0.72	0.53	8.54	0.2
568	0.61	3.3	0.52	1.17	7.82	0.2
564	0.63	4	0.83	0.76		0.2
502C	0.97	3.9	2.52	0.38		0.6
570	1.07	5	1.4	0.83	7.84	0.3
571	1.17	6.8	1.9	0.62	7.86	0.3
501	1.45	5.7	1.8	0.81	7.15	0.3
560	1.47	7.8	1.6	0.92	8.14	0.2
510	1.86	10	2.14	0.87	7.48	0.2
502	2.33	10	1.98	1.18	7.48	0.2
579	3.18	8.9	7.5	0.42		0.8
542	3.34	14.2	3.06	1.09	8.78	0.2
576	3.6	13.7	3.03	1.19	9	0.2
577	3.63	20.5	5.03	0.42	9.11	0.2
582	4	10.5	12.4	0.32		1.2
572	4.53	8.2	3.22	1.41	8.08	0.4
559	5.35	20.7	4.77	1.12	9	0.2
578	6.38	12	15.5	0.41		1.3
550	7.33	6.3	3.69	1.99	8.76	0.6
551	7.75	10.4	4.21	10.85	8.7	0.4
575	7.92	14.4	5.03	1.57	8.92	0.3
580	8.36	9	8.67	0.96		1.0
519	8.64	12.1	4.6	1.88	8.14	0.4
554	9.61				8.93	
553	9.83				8.77	
529	11.6	17	7.96	1.46	8.12	0.5
536	11.7	23	6.53	1.79	8.79	0.3
581	12.2	25.8	8.07	2.51		0.3
545	13.3	14	7.21	1.84	8.67	0.5
552	13.5	18	7.48	1.8	8.8	0.4
547	17.9	36	18.1	1.47	8.82	0.5
537	20.4	24	9.27	2.2	8.83	0.4
574	23.7	39.5	13	1.82	8.3	0.3
514	29	33	12.6	2.3	7.76	0.4
528	30.4	24	12.7	2.39	8.5	0.5
516	31.4	27	13.4	2.34	7.84	0.5
504	31.8	50	18.3	1.74	7.76	0.4
546	32	14.5	12.4	2.57	9.04	0.9
513	33.8	42	16.2	2.09	7.82	0.4
518	34.3	46	16.1	2.13	8.13	0.4
544	36.9	32	18.4	2	8.94	0.6

532	38.8	37	15.8	2.48	9.34	0.4
523	40	28	19	2.11	8.8	0.7
524	40	26	17.4	2.3	9.15	0.7
541	43.4	30.5	21.7	2	9.2	0.7
540	46.3	38	22.1	2.1	9.1	0.6
527	47.4	23.5	17.6	3.69	8.8	0.7
556	54.6	29.4	23.1	2.36	9.27	0.8
567	56.6	28	23.2	2.44	8.42	0.8
517	76.5	53	28	2.73	8.35	0.5
534	80.2	38	27	2.97	9.32	0.7
573	102	60	39.5	2.59	8.6	0.7
522	117	64	40.9	2.86	9.84	0.6
526	137	33.5	37.1	3.69	9.23	1.1
509	180	64	62.8	2.87	8.25	1.0
549	184	68	51.3	3.59	10.04	0.8
507	201	56	51.4	3.91	8.32	0.9
539	214	84	60	3.57	9.81	0.7
535	273	116	74	3.69	9.67	0.6
569	281				9.15	
506	283	70	66.3	4.27	8.61	0.9
521	317	87	77.4	4.1	10.47	0.9
503	360				8.7	
512	434	113	110	3.95	8.88	1.0
525	500				10.65	
533	687	148	144	4.77	10.85	1.0
530	689	150	165	4.18	10.5	1.1
505	900				9.6	
543	1550				11.9	
515	2000				10.5	
548	2180				12.4	
508	2700				10.5	
531	3800					
538	7000				14.5	
511	8700				14.75	
520	25400				21.4	


SAN PEDRO RIVER - Near Redington
1981 - 1992
Discharge, cfs
100000
10000
1000
100
10
1
0.1
501
502C
504
506
508
510
512
514
516
518
520
522
524
526
528
530
532
534
536
538
540
542
544
546
548
550
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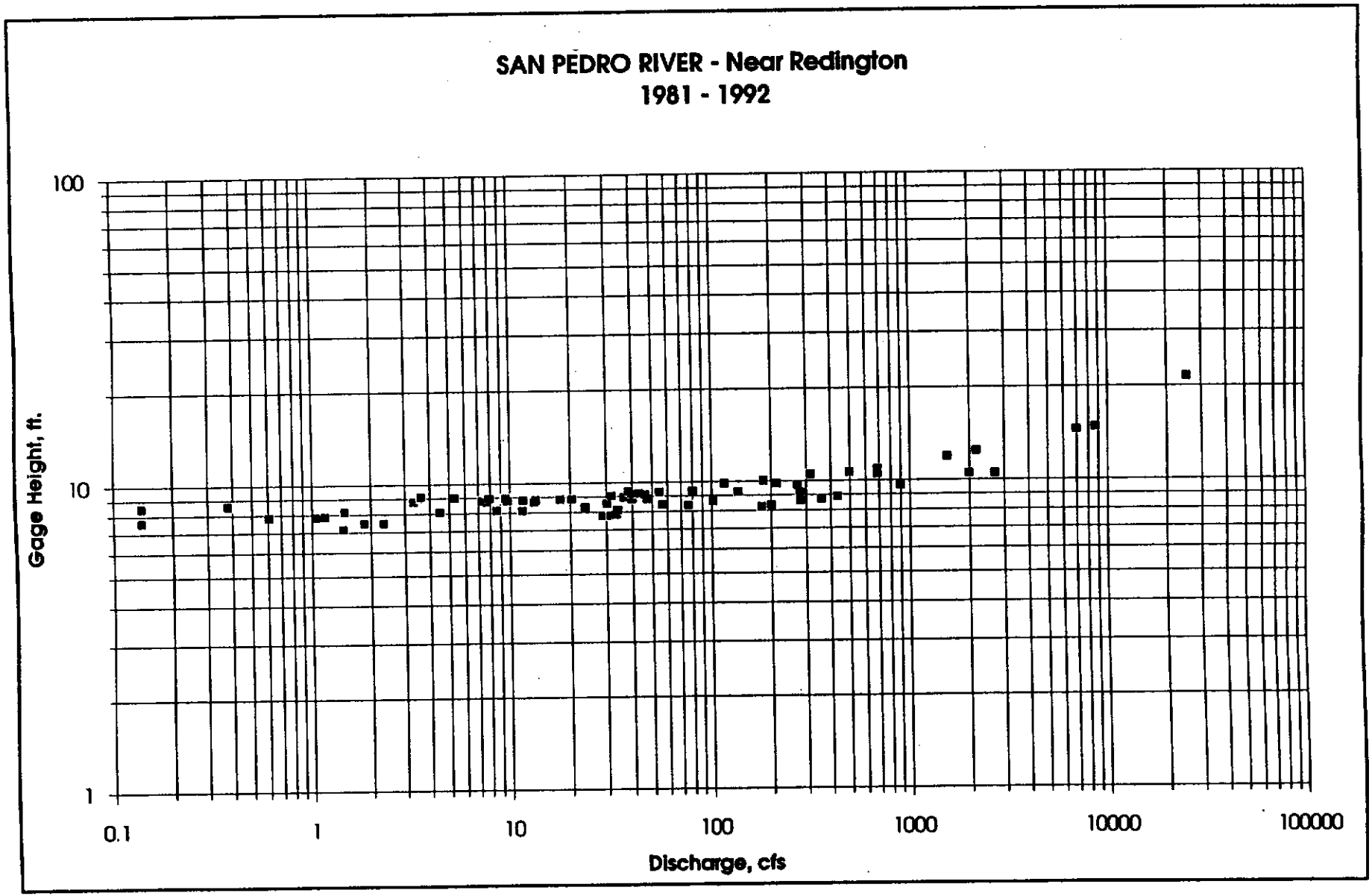
580
582
Measurement #

SPR-M-Q.XLC


SAN PEDRO RIVER - Near Redington
1981 - 1992
100
10
1
Gage Height, ft.
0.1
1
10
100
1000
10000
100000
Discharge, cfs

SPR-Q-GH.XLC

HISTORICAL CHANNEL CHANGES ALONG THE LOWER SAN PEDRO RIVER

An Investigation Conducted for the
Arizona State Land Department

by Michelle Lee Wood
Arizona Geological Survey
August 1997

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INTRODUCTION

The San Pedro River is divided into upper and lower reaches based on environmental and geomorphic contrasts (Tuan, 1962; Heindl, 1952a,b). The upper reach extends from the headwaters to "The Narrows," a bedrock constriction near Benson. The lower reach extends from The Narrows to the San Pedro River's confluence with the Gila River (Figure 1). A previous study of the historical geomorphology of the San Pedro River conducted by the Arizona Geological Survey for the Arizona State Land Department (Huckleberry, 1996) summarized the available published information regarding the nature and timing of channel changes along the upper and lower San Pedro River. Whereas there is an abundance of published information regarding the character and timing of channel changes along the upper San Pedro River, there is very little published information available regarding channel changes along the lower San Pedro River.

Major channel changes and arroyo formation occurred on the upper San Pedro River during the late 1800's and early 1900's. Much of the published literature inferred that the upper San Pedro became entrenched as a result of the flood events that occurred during the 1890's. In addition, many inferred that the timing and general character of channel changes were similar on the upper and lower San Pedro River. The Arizona Geological Survey recently received feedback from residents of the lower San Pedro River whose family records and historical photographs suggested that the lower San Pedro River had a history of channel change significantly different from that of the upper San Pedro River. In particular, they believed that greater channel changes resulted from the 1926 flood event than from the 1890's flood events.

This report summarizes a new investigation of historical channel changes along the lower San Pedro River that supplements Huckleberry's 1996 report and explores the possible differences between the channel-change histories of the lower and upper reaches. It contributes to the baseline information that may be used by the Arizona Stream Navigability Commission in its determination of the potential navigability of the San Pedro River at the time of Statehood (1912). The primary objective of the research presented in this report is to establish a *chronology* of changes in channel characteristics along the lower San Pedro River, rather than to determine the *causes* of channel changes. For a review of the causes of channel change and arroyo formation on the San Pedro River and

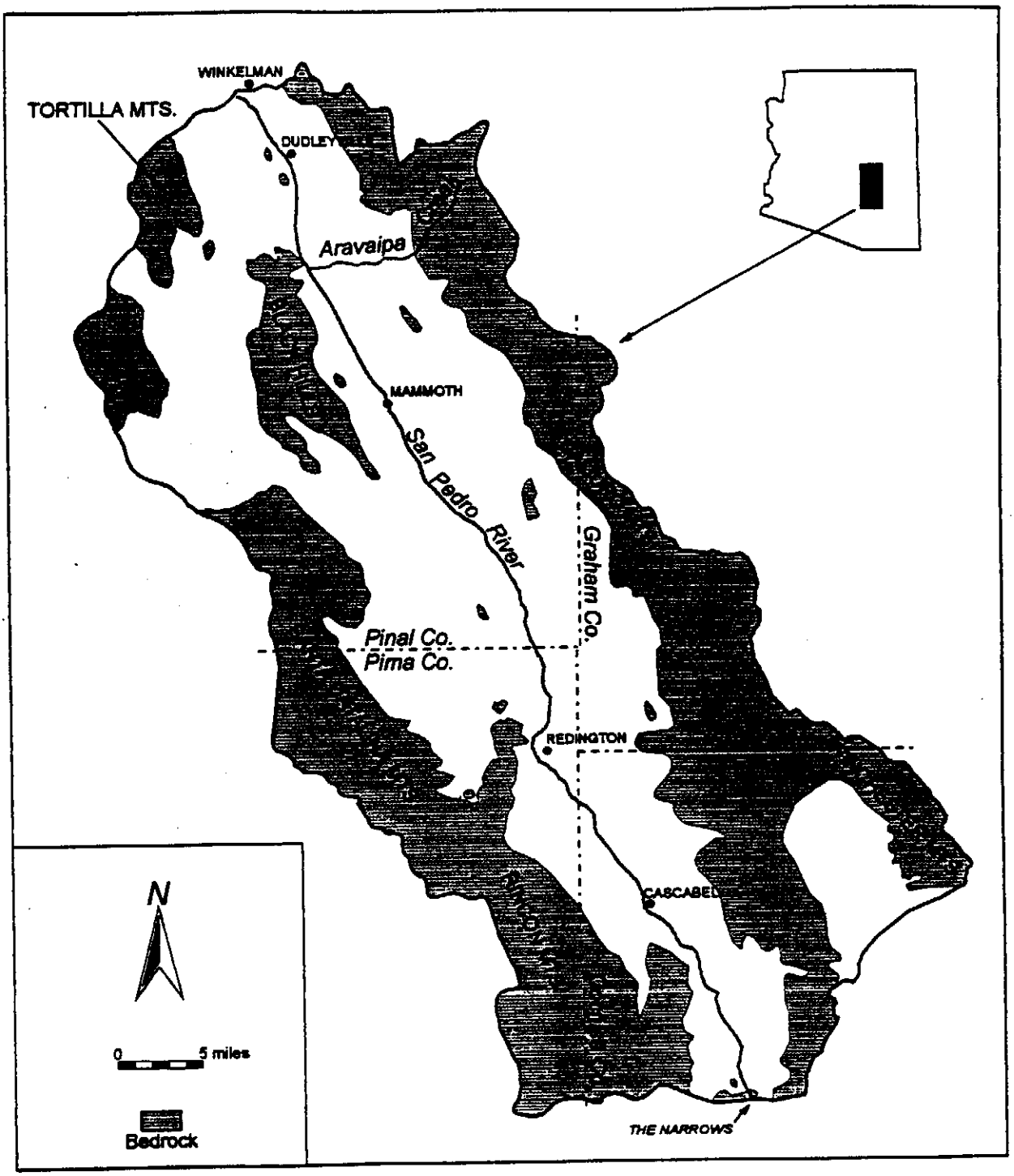

Figure 1. Lower San Pedro River Basin (adapted from Huckleberry, 1996, and Heindl, 1952.)

other rivers in southeastern Arizona, refer to such publications as Antevs (1952), Hastings and Turner (1965), Cooke and Reeves (1976), Betancourt and Turner (1990), and Hereford and Betancourt (in press).

The next section provides a description of the sources of information available for this report. The third and fourth sections provide discussions of the changes in channel width and location, and of the timing of entrenchment of the reaches of the lower San Pedro River near Redington and Mammoth/Dudleyville, the reaches for which there was historical information available. The fifth section of this report compiles all available archival and physical evidence that describes streamflow and channel characteristics into chronological listings for the Redington and Mammoth/Dudleyville reaches. The final section summarizes the most notable channel changes to occur along the lower San Pedro River.

SOURCES OF INFORMATION

This research focused on the collection of information relating to channel changes along the entire length of the lower San Pedro River between 1890 and 1926, a period that encompasses not only the date of Statehood, but also the time of most dramatic change along the San Pedro River. Several sources of information were investigated: published and unpublished references; historical maps; aerial and ground photographs; and, oral histories collected from people who have lived along the lower San Pedro River.

The search for historical information had four phases. The first phase was a thorough review and update of the published references compiled by Huckleberry (1996). Digital reference databases maintained by several different universities were searched using The University of Arizona's computerized card-catalog system known as "SABIO." In addition, the card catalogs compiled by The University of Arizona's Special Collections and the Arizona Historical Society's Tucson library were searched manually.

The second phase consisted of sending letters to approximately one hundred individuals and families that owned land along the lower San Pedro River. The letters inquired about knowledge of family records such as photographs, historical maps, manuscripts, diaries, or any other information or memories that related to channel characteristics between 1890 and 1926. The names and addresses for the mass mailing were retrieved from the Land Ownership Geographical Information System, which was

compiled as part of the 1993 Arizona Stream Navigability Study[1] and was archived by the Arizona State Land Department.

The third phase involved contacting over forty public and private agencies. The goals of this phase were to locate unpublished reports and project work, and to identify long-time residents of the lower San Pedro River Valley who might have memories or family records that described the channel at the turn of the century. The final phase of the search for historical information was contacting, by telephone or in person, current and former residents of the lower San Pedro Valley. A list of agencies and individuals that provided information, and summaries of the oral interviews and response letters, is provided in Appendix C. Information provided by these contacts that is relevant to the thesis of this report is interwoven throughout the following sections.

The vast majority of the data gathered related to two specific reaches of the San Pedro River: a ten-mile reach near Redington, and a twenty-five-mile reach between Mammoth and the Gila-San Pedro confluence. Information that relates to the history of arroyo formation in these two reaches is presented in the next section. Information about changes in channel width and location is presented in the fourth section of this report. The fifth section of this report provides detailed chronological listings of historical channel and streamflow descriptions for the Redington and Mammoth reaches of the lower San Pedro River.

Many of the oral histories described *flow* characteristics rather than *channel* characteristics. Much of the information in general related to changes that occurred after both Statehood and the 1926 flood event. Although such information did not fall within the scope of this investigation, it was included in the chronological listings if the authors thought it could be useful in the Arizona Navigable Stream Adjudication Commission's determination of the potential navigability of the San Pedro River.

Places mentioned in the following text are shown in Figure 1 or Plates 1, 2, and 3. Because the locations of many places are described using the Bureau of Land Management's system of land division, an explanation of this system is provided in Appendix A. Appendix B contains one historical photograph and nine recent ground

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[1] Arizona Stream Navigability Study for the San Pedro River: Gila River Confluence to the Mexican Border, November 1993, Draft Final Report. Prepared by CH2M Hill, SWCA Environmental Consultants, and Arizona Geological Survey for the Arizona State Land Department and the Arizona Navigable Stream Adjudication Commission.

photographs that illustrate conditions along the Redington and Mammoth reaches of the river, and Appendix C contains the list of contacts and oral history summaries.

LATERAL CHANNEL CHANGES ALONG THE LOWER SAN PEDRO RIVER

The dominant channel-change mechanism in each reach of a river depends on channel morphology, channel sediment, bank resistance, and flood magnitude. Where the channel is entrenched into an arroyo, a combination of fluvial processes and bank retreat mechanisms leads to arroyo change (Parker, 1995). The different types of lateral and vertical changes a river channel may experience are described in Table 1.

Major channel changes along the San Pedro River have occurred primarily as a result of large flood events (Hastings, 1959; Hastings and Turner, 1965; Cooke and Reeves, 1976; Hereford and Betancourt, in press). Newspaper accounts indicated that large floods occurred on the San Pedro River in 1881, 1886*[2], 1887*, 1890*, 1891*, 1893, 1894, 1896, 1900, 1901*, 1904*, 1905*, and 1926* (Hereford and Betancourt, in press). Figure 2 provides the annual peak discharge measurements recorded by the U.S. Geological Survey gages at Charleston (located at the northernmost part of the upper San Pedro River) and near Redington, that began in 1916 and 1926, respectively. The gage record at Redington indicated that large floods occurred in 1926, 1940, 1947, 1951, 1977 (Water Year[3] 1978), 1983 (Water Year 1984), and 1993. The Charleston and Redington discharge records and the newspaper accounts indicated that the largest flood of record occurred in September of 1926.

This section of the report focuses on historical changes in the channel width and location of the San Pedro River, near Redington and Mammoth/Dudleyville, that resulted from the large floods of the late 1800's and early 1900's. To ascertain such lateral channel changes, the channel location and boundaries discerned from historical survey maps, and from historical and recent aerial photographs, were compiled onto 1:24,000-scale base maps. Table 2 describes the maps and photographs that were available for this study.

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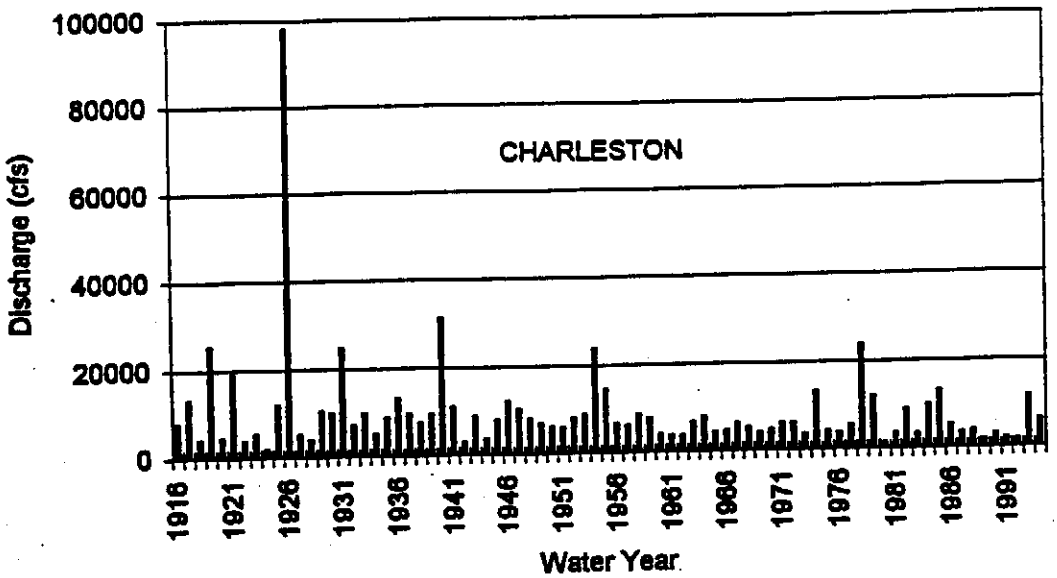
[2] Asterix (*) indicates a year in which newspaper accounts noted flood(s) specifically on the lower San Pedro River.

[3] A water year is defined as October 1st of the previous calendar year to September 30th of the current calendar year.

Table 1. Channel change mechanisms.
(Source: Wood *et al*, 1996. Adapted from Parker, 1995.)

MECHANISM	DESCRIPTION
Meander migration:	Lateral shifts of centerline position associated with the inception of meanders and their subsequent downstream translation, lateral extension, or rotation of meander axis.
Avulsion:	An abrupt shift in channel position that occurs when overbank flow incises new channels as other channels aggrade and are abandoned.
Meander cutoff:	An abrupt shift in channel position that occurs at meanders and may or may not involve concurrent aggradation of the abandoned channel segment. Meander cutoff and avulsion tend to occur where channels are shallowly incised, the floodplain is active, and aggradation rates generally are high.
Channel widening:	Results primarily from high flows that erode weakly cohesive banks. It is different from arroyo widening because arroyo boundaries may delineate not only a channel but also a floodplain at the bottom of the arroyo. It is a product of corrasion by fluvial erosion during rising flow, or mass wasting of banks following the flow peak.
Vertical change:	Results from changes in stream power, sediment comcentration, or resistance that occur as a result of variation in flood magnitude, sediment availability, channel morphology, or local channel gradient. "Degradation and aggradation occur over years to decades and may reflect climatic changes, adjustments to channel widening or narrowing, sediment storage and episodic transport, and natural or artificial changes in channel-hydraulic properties... Degradation and aggradation can alternate in time and space." [Parker, 1995, p. 24]

Figure 2. Annual peak discharges recorded at the Charleston and Redington gages.



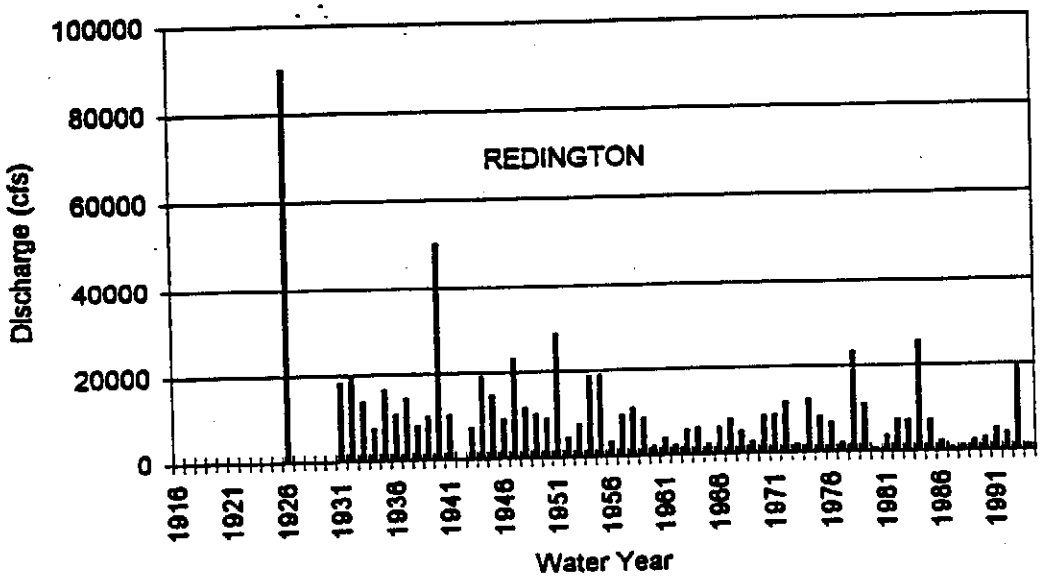


Table 2. Historical maps and aerial photographs available for this study.

DATE	TITLE	SURVEYOR	COMMENTS
1877	Survey of Gila & Salt River Meridian (Mammoth/Dudleyville reach)	John L. Harris, Government Land Office	See Plate 2 and Plate 3. Maps were available for all Townships except T.8S. R.16E.
1879	Survey of Gila & Salt River Meridian (Redington reach)	John L. Harris, Government Land Office	See Plate 1.
1899	[Map showing location of canals diverting water from the San Pedro River.]	U.S. Geological Survey	Small-scaled map published in the U.S. Geological Survey's Twenty-First Annual Report of the United States Geological Survey to the Secretary of the Interior, 1899-1900 Part IV - Hydrography.
1902	Map of the Desert Land Entry No. 3248, Embracing W1/2 SE1/4 Sec 10, and W1/2 NE1/4 Sec 15, T11S R18E, Gila and Salt River Meridian, Arizona	N/A [Filed Charles Bayless]	Scale: 1 inch = 1000 feet
1907	Property of the Bayless and Berkalew Company Situated Along the San Pedro River, Arizona.	William B. Alexander, C.E., U.S. Land Surveyor, Tucson, AZ	See Plate 1. Scale: 1 inch = 2000 feet
1913	30' Winkelman Topographical Quadrangle	U.S. Geological Survey	Surveyed in 1910-11. Scale: 1:125,000
1921	Gila River Determination, Pima and Cochise Counties, Arizona: Map of surveys showing irrigated lands under ditches taking water from Gila River or tributaries, District No. 3	State Water Commissioner	This boundaries of the river channel on this map did not compare well with maps of earlier or later surveys. For example, when the river boundaries and ditch locations from the 1921 map were overlaid onto the 1981 base map, the river and Bayless Ditch were located high on the side of a present-day hill. Scale: 1 inch = 1000 feet
1926 Feb.	Untitled.	N/A	Area of Bayless and Berkalaw Company holdings. Scale: 1 inch = 1000 feet
Pre-1926 Flood	Untitled. [RR-East]	N/A	This is a survey of the channel area conducted by a railroad company (Smallhouse, 1997, oral commun.). It is a detailed map of all drainage features along only the eastern bank of the river. The location of the channel boundaries in this map closely matches the location of the river on the maps surveyed in 1902 and 1907. Scale: ~3 inches = 1 mile

Table 2. Historical maps and aerial photographs available for this study, continued.

DATE	TITLE	SURVEYOR	COMMENTS
Post-1926 Flood	Untitled. [RR-West]	N/A	This is identical in design to the above map, except that it is a survey of the drainage features west of the San Pedro's channel, and the location of the channel boundaries in this map resemble the boundaries depicted in the 1934 aerial photographs, indicating that it was probably surveyed after the flood of 1926. Scale: ~3 inches = 1 mile
1934	Aerial photographs of the San Pedro Valley.	Soil Conservation Service	See Plate 1, Plate 2, and Plate 3. This is the first systematic aerial photography performed for the lower San Pedro River. Scale: 1:62,500.
1945	15' Redington Topographical Quadrangle	U.S. Geological Survey	The survey was conducted in 1942-43. Scale: 1:62,500
1948	7.5' Mammoth Topographical Quadrangle	U.S. Geological Survey	Scale: 1:24,000
1949	7.5' Winkelman and Saddle Mountain (now Dudleyville) Topographical Quadrangles	U.S. Geological Survey	Scale: 1:24, 000
1950	7.5' Lookout Mountain Topographical Quadrangle	U.S. Geological Survey	Scale: 1:24,000
1972	7.5' Dudleyville, Lookout Mountain, and Mammoth Topographical quadrangles	U.S. Geological Survey	See Plate 2 and Plate 3. Scale: 1:24,000
1981	7.5' Redington Topographical Quadrangle	U.S. Geological Survey	See Plate 1. Scale: 1:24,000
1994	Aerial photographs of Pinal County.	Pinal County Department of Planning	See Plate 2 and Plate 3. Scale: 1 inch = 600 feet
1995	Aerial photographs of Pima County.	Pima County Maps and Records	See Plate 1. Scale: 1 inch = 600 feet
1997	Aerial photographs of the Nature Conservancy's holdings along the San Pedro River in Pinal County.	Nature Conservancy – Dudleyville	Scale: 1 inch = 400 feet

The next two parts of this section describe the changes in channel width and location that have occurred in the past century.

The timing of arroyo formation is not discussed until the fourth section of this report. However, because it is widely accepted that the channel of the lower San Pedro River has been entrenched at least since the 1926 flood event, and because periods of channel widening were often associated with periods of vertical change, it is impossible to completely segregate the discussion of channel widening and channel entrenchment. Therefore, the term "arroyo" and other key phrases used throughout this report are defined below.

Channel: A long, narrow, troughlike depression occupied and shaped by a stream.

Active channel: The San Pedro River, like many streams in the Southwest, is intermittent; that is, it has reaches that flow only during wet weather or during part of the year, and reaches that flow year-round. In addition, the streamflow experiences great variability from one season to the next, and from one year to the next. Hence, this report uses the phrase "active channel" to describe the area of the sandy channel bottom that was cleared of vegetation by recent flows ("recent" relative to the time a map was surveyed or aerial photograph taken), rather than the area of the sandy channel bottom covered by streamflow, or the area delineated by defined channel banks or *arroyo* walls.

Floodplain: A belt of low, flat ground present on one or both sides of a stream channel, subject to inundation by floods and underlain by stream-laid sediment deposits.

Arroyo: In the convention established by Bryan (1922) and refined by Antevs (1952), the term "arroyo" is used when there is a single channel incised in unconsolidated material consisting of clay, silt, sand and some gravel, with banks more than two feet high. The boundaries of an arroyo are defined by its steep banks. Once an arroyo widens to the point that it becomes relatively stable, the former floodplain becomes a terrace, and the arroyo floor becomes a floodplain (Meyer, 1989). Hence, the steep banks of an arroyo may delineate an *active channel* and a *floodplain* at the bottom of the arroyo.

Note: Several of the historical maps and written accounts did not define their use of the word "channel." That is, their use of the word "channel" may refer to the area of the channel bottom covered by water, the area delineated by defined channel banks or arroyo banks, or the area defined by the sandy channel bottom cleared of vegetation. In such cases, this report uses "channel" in the same context as it was used in the historical reference.

Lateral Channel Changes in the Redington Area

A compilation map of channel changes created for the San Pedro River near Redington is shown in Plate 1. Channel locations from the 1879 General Land Office

(GLO) survey, the 1907 Bayless and Berkalew Company (BBC) survey, and the 1934 and 1995 aerial photographs, were transferred to the U.S. Geological Survey's 1981 Redington topographic quadrangle using a zoom-transfer projector. The 1879 GLO survey maps showed the channel location rather than the channel boundaries. In addition, the position of the channel was surveyed only where it crossed cadastral lines; channel locations between the cadastral lines were interpolated (Huckleberry, 1996).

The 1907 BBC survey mapped distinct channel boundaries; however, it is not known whether this survey defined the channel boundaries by the extent of a sandy channel bottom, by the edges of streamflow, or by the presence of defined channel banks. However, the channel boundaries drawn on the July 1902 Desert Land Entry map, the February 1926 Bayless and Berkalew map, the 1921 State Water Commission map, and the Rail Road-East Bank map, all recorded comparable channel widths. Such similarity in channel widths indicates that the channel was defined by the presence of distinct banks or by the area of the channel bottom that was cleared of vegetation.

The channel boundaries discerned from the 1934 and 1995 aerial photographs were defined by the extent of the active channel, rather than by the location of defined channel banks. The precise location of the channel banks was not visible in several of the aerial photographs, either because the photographs were shot at an angle that did not show the relief of the channel banks, or because the channel banks were obscured by vegetation. However, field observations in 1997 indicated that the extent of the sandy channel bottom typically coincided with the location of the steep channel banks that defined the width of the arroyo that had formed by this time along the Redington reach of the San Pedro River.

Although only the channel location was depicted by the 1879 maps of the lower San Pedro River, measurements of channel width were surveyed normal to cadastral lines and recorded in the notes of the surveyor, John L. Harris. Following the procedure of Burkham (1972), Huckleberry (1996) compiled and averaged the channel width measurements surveyed by Harris for each Township. The channel had a mean width of 35 feet in T.11S. R.18E., and 26 feet in T.12S. R.18E.

Between 1879 and 1907, three relatively short segments of the river experienced greater-than-1000-foot shifts in the their locations: a half-mile segment downstream of The Narrows (T.12S. R.18E. Sec.13; refer to Plate 1). Otherwise, the location of the San Pedro River channel changed very little between 1879 and 1907. However, the channel widened

considerably during that period. The San Pedro River channel had a width of approximately 400 feet in T.11S. R.18E., and approximately 200 feet in T.12S. R.18E. The channel was as narrow as 150 feet at the R.18E./R.19E. Range line in T.12S., and as wide as 900 feet at the T.11S./T.12.S Township line in R.18E.

Between 1907 and 1934, a 1.5-mile segment of the river in T.12S. R.18E. had shifted to approximately 1300 feet west of its 1907 location, probably as a result of the 1926 flood event.[4] Except for the movement of channel meanders (i.e. in T.11S. R.18E. Section 15), no other changes in channel location occurred during the period from 1907 to 1934. Although the channel widened very little during this period upstream of Redington, it widened dramatically downstream of Redington. Huckleberry (1996) determined that the 1934 channel had a mean width of 236 feet in T.12S. R.18E. (upstream of Redington), and 837 feet in T.11S. R.18E. (downstream of Redington).

The 1995 aerial photographs showed that the channel location upstream of Redington (T.12S. R.18E.) had not changed since 1934, and that channel width had changed very little since 1934. However, the channel located downstream of Redington (T.11S. R.18E.) had widened dramatically since 1934. Several of the reaches had widths in excess of 1200 feet (i.e. in Sections 10, 11, 15, 26, and 34).

Lateral Channel Changes Between Mammoth and the Gila Confluence

The compilation maps of the reach between Mammoth and the San Pedro- Gila River confluence are illustrated by Plate 2 (the Mammoth area) and Plate 3 (the Dudleyville area). Channel locations from the 1877 General Land Office (GLO) survey, the U.S. Geological Survey's 1911 Winkelman topographical quadrangle, and the 1934 and 1994 aerial photographs, were transferred to the U.S. Geological Survey's 1972 topographic quadrangles of that reach using a zoom-transfer projector. The 1877 GLO survey maps showed the channel location rather than the channel boundaries, and the position of the channel was surveyed only where it crossed cadastral lines (Huckleberry, 1996). The 1911 Winkelman quadrangle appeared to depict the channel boundaries as the extent of the sandy channel bottom.

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[4] Refer to the chronology of channel descriptions for the Redington reach in the fifth section of this report for more details about this segment of the river.

The channel boundaries discerned from the 1934 and 1994 aerial photographs were defined by the extent of active channel, rather than by the location of defined channel banks. The precise location of the channel banks was not visible in several of the aerial photographs, either because the photographs were shot at an angle that did not show the relief of the channel banks, or because the channel banks were obscured by vegetation. In contrast to the Redington reach, field observations in 1997 of the Mammoth-Dudleyville reach indicated that the boundaries of the active channel typically did *not* coincide with the location of the steep banks of the arroyo that had formed by this time. In many segments of this reach, the arroyo walls delineated both an *active channel* and a *floodplain* at the bottom of the arroyo.

Although only the channel location was depicted by the 1877 maps of the lower San Pedro River, measurements of channel width were surveyed normal to cadastral lines and recorded in the notes of the surveyor, John L. Harris. The channel had a mean width of 35 feet in T.5S. R.15E., 36 feet in T.6S. R.16E., 38 feet in T.7S. R.16E., 35 feet in T.8S. R.16E., and 40 feet in T.8S. R.17E.

The U.S. Geological Survey's 1911 survey indicated that several segments of the river experienced notable shifts in location since the 1877 survey. For example, a one-mile segment of the channel located east of and upstream from the historic location of Dudleyville (T.5S. R.15E. Sec.25, Plate 3) had shifted approximately 1000 feet east of the location of the 1877 channel. A shift of similar magnitude occurred upstream of Malpais Hill (T.6SS. R.16E. Sections 17 and 20, Plate 3) and downstream from Mammoth (T.8S. R.17E. Sec.18, and T.7S. R.16E. Sec.22 and 35, Plate 2). The 1911 survey also indicated that the San Pedro River channel had widened considerably along the Mammoth/Dudleyville reach since 1877. The 1911 channel had a width of approximately 1700 feet at its confluence with the Gila River, 700 feet in T.5S. R.15E., 850 feet in T.6S. R.16E. (with a dramatically wide reach of 2300 feet in Section 26), 800 feet in T.7S. R.16E., and 600 feet in T.8S. R.16E. and T.8S. R.17E. The channel continued to widen between 1911 and 1934. In 1934, the active channel had a mean width of 1600 feet in T.5S. R.15E., 1280 feet in T.6S. R.16E., 930 feet in T.7S. R.16E., 1120 feet in T.8S. R.16E., and 925 feet in T.8S. R.17E (Huckleberry, 1996). The active channel mapped from the 1934 photographs may indicate the location of the channel banks because of the relatively recent large flows that occurred in 1931 and 1932, may have kept vegetation from becoming re-established in the channel after the 1926 flood of record.

The comparison of the 1934 and 1995 active-channel boundaries of the Mammoth/Dudleyville reach indicated that the 1995 active channel was more narrow and sinuous than the 1934 channel. As noted above, field observations in 1997 indicated that, in many segments of this reach, the arroyo that had formed by this time had stablized to the degree that the arroyo walls delineated both an *active channel* and a densely-vegetated *floodplain* at the bottom of the arroyo. However, Plate 2 and Plate 3 also show several segments of that reach where the 1995 active channel meandered beyond the boundaries of the 1934 active channel.

ARROYO FORMATION AND CHANGE ALONG THE LOWER SAN PEDRO RIVER

Many earth scientists have observed and sought to explain the almost synchronous arroyo formation experienced by the San Pedro River and other major watercourses of southern Arizona around the turn-of-the-century (Bryan, 1925; Antevs, 1952 and 1955; Hastings and Turner, 1965; Melton, 1965; Cooke and Reeves, 1976; Betancourt and Turner, 1990; and, Hereford and Betancourt, in press). However, Hereford and Betancourt (in press) noted that neither the archival nor physical evidence of arroyo formation along the San Pedro River has received more than cursory attention. In addition, Huckleberry (1996) determined that, while there is an abundance of published information regarding the character and timing of channel changes along the upper San Pedro River, there is very little published information available regarding channel changes along the lower San Pedro River.

This section of the report describes the compilation and evaluation of archival and physical evidence, both published and unpublished, that better define the timing and character of arroyo initiation along the lower San Pedro River. The next part of this section provides a brief summary of a commonly-quoted view of historical channel entrenchhment along the San Pedro River. Then final two parts present published and unpublished information that specifically relates to the channel entrenchment histories of the Redington and Mammoth/Dudleyville reaches of the river.

General Background Information

Three often-cited statements made by Bryan (1925), Charles H. Bayless (1901), and Hastings and Turner (1965), for many years have shaped the commonly-held views on the timing and character of channel entrenchment along the San Pedro River:

> "The trench on the San Pedro River was cut progressively headward between 1883, when an arroyo formed at the mouth of the river, and 1892, when the headwater fall cut through the boundaries of the Boquillas Grant 200 km upstream." (Bryan, 1925, p. 342)

> "Where the San Pedro River of southeastern Arizona formerly wound its sluggish course northward through a marshy, largely unchanneled valley, in August, 1890, it began carving a steep-walled trench through which it thereafter emptied rapidly and torrentially into the Gila. Where it formerly ran more or less consistently throughout the year, after 1890 its flow became intermittent, leaving the new channel dry over much of its length for most of the time..." (Hastings and Turner, 1965, p.3)

> "About twelve years [1888] ago the San Pedro Valley consisted of a narrow strip of subirrigated and very fertile lands. Beaver dams checked the flow of water and prevented the cutting of a channel. Trappers exterminated the beavers, and less grass on the hillsides permitted greater erosion, so that within four or five years a channel varying in depth from 3 to 20 feet was cut almost the whole length of the river. Every year freshets are carrying away new portions of the bottom lands. At present this valley is a sandy waste from bluff to bluff, while the few fields remaining are protected from the river at large and continuous expense. Thus, in addition to curtailing the area of good land, the deep channel has drained the bottoms, leaving the native grass no chance to recover from the effects of close pasturing. It also makes it more difficult to get irrigating water onto the surface of the land." (C.H. Bayless, as cited in Griffith, 1901, p. 111[5])

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[5] In December of 1900, Charles H. Bayless received a circular from D.A. Griffiths, who was the chief botanist in charge of grass and forage plant investigations for the Arizona Experiment Station in Tucson (Griffiths, 1901; Santiago, 1994; Bahre, 1991). Griffiths had sent a circular to a select group of ranchers in southern Arizona in order to obtain accurate knowledge of range conditions before the livestock boom of the 1880's. The above quote is Charles H. Bayless' response to the questions, "Can you describe any specific instances of the destructive action of water gullying out the river valleys? Can you state how and at what time such gullying started in any particular instance, and the extent to which the washing progressed in a given time?" To better understand the intensity and thoroughness of Bayless' response, it may help to know a bit of his history. Charles H. Bayless, born on November 23, 1863, in Highland, Kansas, was a well-respected resident of southern Arizona. He first came to Arizona in 1879 when he took off a year from his studies in Kansas to travel with his father and uncle out West and to spend several months clerking at a store in Tombstone (Santiago, 1994). He returned to Kansas in 1880 and resumed his studies at Highland Unviersity, where he received a B.A. in 1884. Bayless then became a partner of the Bayless and Berkalew Company (the properties of which were located in the San Pedro River Valley near Redington) with his father, William Bayless, and Jehiel W. Berkalew, in 1884. He spent a few months over the winter of 1884-85 helping his father acquire more cattle for

Although Bryan's 1925 claim has continued to be a popular citation, more recent research has cast doubt on his assertions (Hastings, 1959; Cooke and Reeves, 1976; and, Hereford and Betancourt, in press). Cooke and Reeves (1976) claim that the assertions about the timing of arroyo cutting made in Bryan's often-quoted 1925 paper are almost wholly incorrect:

> "The dates are not substantiated, and the notion of headward erosion seems to be derived more from the contemporary geomorphological 'conventional wisdom' related to drainage rejuvenation than from historical data. All available sources point towards a more complex history....." (Cooke and Reeves, 1976, p. 42)

Hereford and Betancourt (in press) explained that Bryan's sources did not support his statement that arroyo development progressed from the mouth into the upper San Pedro in less than ten years. Hereford and Betancourt also noted that, over the short term, bedrock outcrops located at The Narrows and at Charleston[6] should have restricted propagation of headcuts or coalescence of discontinuous arroyos from one subbasin to another.

While not incorrect, the statements made by Hastings and Turner (1965) and Bayless (1901) are, perhaps, overly simplistic. Hereford and Betancourt (in press) and, in subsequent chapters of their book, Hastings and Turner (1965), provided evidence that painted a more complicated picture of the character of the San Pedro River than implied by the introductory paragraph of Hastings and Turner's 1965 publication, and Bayless' 1901 statement. Hastings and Turner's review of historical references dating to the mid-1800's found that the upper San Pedro River and parts of the lower San Pedro were characterized by a perenial stream flowing through a grass-choked valley with *cienegas*[7] and pools. However, they also found evidence that the river was intermittent in some reaches, especially in the lower San Pedro River Valley, and that some reaches were entrenched, both in the upper and lower San Pedro River Valley.

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their company, and then returned to Kansas. He received a M.A. from Highland University in 1887, taught at Highland University for several years, and then began studies for a Ph.D. at John Hopkins University in Baltimore in the fall of 1891. However, when his father fell seriously ill, Bayless left his studies in February of 1892 and returned to southern Arizona to help manage his father's properties near Redington and Oracle. By 1900, Bayless had developed the very firm opinion that the extinction of the beavers caused excessive flooding in the San Pedro Valley, and that overstocking, not drought, had turned the range into desert (Santiago, 1994).

[6] Charleston is located about 35 miles upstream of The Narrows in the upper San Pedro River Valley.

[7] "Cienega" is a term applied by Spanish explorers to the distinctive, treeless, riparian marshes of the Southwest.

Regarding the timing of channel entrenchment along the San Pedro River, Hastings and Turner (1965) cited two 1890 newspaper accounts that described channel-bank erosion near Dudleyville[8] and Mammoth[9] that resulted from the 1890 flood event, and one account of the flood-caused destruction that occurred between Tres Alamos (located just south of The Narrows) and the confluence with the Gila River.[10] They made no mention of channel-bank erosion due to the 1890 flood event along any other reach of the river.

Hereford and Betancourt (in press) more thoroughly compiled and evaluated archival records for all reaches of the San Pedro River, and field mapped the floodplain surfaces and cutbank stratigraphy of a reach in the upper San Pedro. Their goals were to better define general floodplain conditions before arroyo-cutting and to establish timelines for major floods and cutting episodes. They ascertained that alternating marshes, mesquite thickets, and short entrenched channels appeared to have persisted in the middle and lower San Pedro until the 1880's, and probably as late as the early 1900's in the upper reaches of the San Pedro River Valley. In addition, they noted that, although 1881, 1882, and 1883 had unusually wet summers, and large floods occurred in 1886, 1887, 1890, and 1891, arroyo initiation probably did not occur along the southern reach of the upper San Pedro River until 1896, and the northern reach of the upper San Pedro River did not become entrenched until the 1910's.

Although Hereford and Betancourt's manuscript provided the most thorough review of archival and physical evidence of any reference to date, it highlighted the sparcity of information available for the lower San Pedro River Valley. The rest of this section provides evidence that better defines the timing and character of channel entrenchment in the lower San Pedro River. There are two parts: one part that describes channel

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[8] "At Riverside, the road is fordable for the first time in two weeks, but raining again on the San Pedro. If the San Pedro continues to rise the next thing we'll see is Dudleyville floating down the Gila. Has caved within 15 ft of Cook's place. He piled brush to divert, but now it has washed out. Mr. Bates house in danger, several of his outhouses gone. The Riverside-Globe road impassable for two weeks; is being rebuilt on Kane Springs Canyon stretch." (*Arizona Daily Star*, September 6, 1890, as cited in Hereford and Betancourt, *in press*)

[9] "Recent floods at Mammoth washed the soil out in places 30 ft deep along the river bottom. Exposed area at bottom brought out in many places evidence of ancient civilizations...." (*Arizona Daily Star*, October 2, 1890, as cited in Hereford and Betancourt, *in press*)

[10] "Of the country down the San Pedro, from Tres Alamos to the Gila [Captain Van Alstine] . . .says, "all of it is gone, destroyed, torn up, 'vamosed' down with high water." He never saw such a destruction in all his life. . . The San Pedro never was as high as it was this time, and will not probably be for the next ten years. The losses sustained by the people will reach into the thousands." (*Arizona Daily Star*, August 14, 1890, as cited in Hastings and Turner, 1965, p.42)

entrenchment in the Redington reach; and, one part that describes the Mammoth/Dudleyville reach.

Channel Entrenchment in the Redington Reach of the San Pedro River

Four types of information were found that described the nature and timing of arroyo initiation along the Redington reach of the lower San Pedro River: historical maps with the location of *acequias* noted; oral histories; historical ground photographs; and, previously-published accounts of channel entrenchment. Each type of information is first described individually below, and then discussed together in the final part of this section.

Location of Acequias

The location of historical *acequias*, or gravity-flow ditches, can provide information about the local channel characteristics in two ways.[11] Gravity-flow ditches, as their name implies, rely on the slope of the land to transport water from the source (a river or spring) to the fields that need irrigation. Hence, if the intake of a given *acequia*, that has the river as its source, is located immediately upstream of the fields for which it supplies water, it can be inferred that the channel is not entrenched (Huckleberry, 1996). In addition, the upstream movement of *acequia* intakes (also called "ditch heads") over time implies that changes have occurred in the slope of the channel, probably due to arroyo initiation and deepenng.

The locations of ditch heads discerned from the historical maps and oral histories for the Redington area are listed in Table 3 and plotted on Plate 1.

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[11] Jack Smallhouse, grand-nephew of C.H. Bayless, brought it to the attention of the authors that comparing the location of *acequia* intakes over time could help to determine possible changes in the depth of the channel (Smallhouse, 1997, oral commun.). He contributed a number of historical maps to this project that were not found in any other private or public map collection. He also contributed several oral histories passed on to him by his neighbors and family members. Much of the information presented in this section would have been unknown, but for Smallhouse's generosity with his time and family records.

Table 3. Historical locations of ditch heads along the Redington reach.

NAME OF DITCH[12]	DITCH-HEAD LOCATION[13]	YEAR	SOURCE OF INFORMATION[14]
Bayless Ditch:[15]	T.12S. R.19E. Sec. 19 BBB T.12S. R.19E. Sec. 19 BAD T.12S. R.19E. Sec. 19 BAD	1879 1907 Before 1926	GLO Survey Bayless & Berk. Map RR-East Map
Los Angeles Ditch:	T.12S. R.19E. Sec. 30 ABA	1907	Bayless & Berk. Map
Markham Ditch:	T.11S. R.18E. Sec. 26 CBD T.11S. R.18E. Sec. 27 DDA	1902 1907	Desert Land Entry Map Bayless & Berk. Map
Bollen Ditch:	T.11S. R.18E. Sec. 23 BAB/BBA T.11S. R.18E. Sec. 14 CCA T.11S. R.18E. Sec. 23 BBA T.11S. R.18E. Sec. 23 CD	1879 1902 1907 After 1926[16]	GLO Survey Desert Land Entry Map Bayless & Berk. Map Smallhouse (1997, oral c.)
Unnamed Ditch - 1:	T.12S. R.18E. Sec. 11 ABA T.12S. R.18E. Sec. 2 DCC	1879 Before 1926	GLO Survey RR-East Map
Unnamed Ditch - 2:	T.12S. R.18E. Sec. 2 BBC[17]	1879	GLO Survey

[12] Several of the historical maps used different names for the same ditches. The names listed above were the most commonly used for each of the different ditches.

[13] Refer to Appendix A for a description of the system of land subdivision used to describe the location of the ditch heads.

[14] Several of the historical maps listed in Table 2 showed the location of ditches. However, only the ditch heads located on large-scale maps with reliable surveys were listed above and plotted on Plate 1.

[15] The modern intake for the Bayless Ditch is located about one mile upstream of the historic intakes, south of the reach shown on this map (Smallhouse, 1997, oral commun.).

[16] The Bollen ditch had its intake at approximately this location until it was abandoned during the 1940's, when an irrigation well was drilled.

[17] The intake for this ditch was was not located near the river. It may have had a spring as a source.

The 1879 survey map showed that the intake for the Bayless Ditch was located near the fields that it irrigated, implying that the channel was not entrenched in that segment of the Redington reach. The locations of the other *acequias* (Bollen Ditch, and two unnamed ditches) were either not as near the fields they irrigated, or were noted in areas that had no field delineated on the maps. However, Cooke and Reeves (1976) noted that it is unlikely that ditches would have been constructed where the main river was entrenched.

The records of ditch-head movement for the Bollen and Bayless ditches are the most useful for inferring channel changes because they bracket the entire period of interest: before and after the 1880-90's floods; and, before and after the 1926 flood. The intake location for the Bollen ditch remained almost unchanged between 1879 and 1907. However, it shifted almost a mile upstream after the 1926 flood event.

In contrast, the 1907 and Before-1926 intakes of the Bayless Ditch were located more than a half of a mile upstream of the 1879 intake. However, the contrast between the pre-1926 flood intake locations and post-1926 flood intake location is even more dramatic. The modern location of the Bayless Ditch intake is almost a mile upstream of the 1907 intake location.

The segments of the Bayless and Los Angeles ditches located at the Redington Narrows[18] provided another type of information about the rate of channel entrenchment in that reach. The canal for the Los Angeles Ditch, located on the western bank of the channel, was carved through the cemented conglomerate that forms the constriction known as the Redington Narrows *before* the flood of 1926, and was later reinforced with cement during the 1940's (Smallhouse, 1997, oral commun.). The U.S. Geological Survey's Twenty-First Annual Report (1901) indicated the presence of the Los Angeles Ditch as early as 1899, and the Bayless and Berkalew Company map showed the location of its intake in 1907 upstream of the Redington Narrows. Photograph #1 in Appendix B shows the canal as a horizontal line of white cement perpendicular to the gaging station. The photograph also shows a grass-covered surface to the right of the cemented conglomerate

[18] The geographical feature known as the Redington Narrows is not labelled on Plate 1. However, it can be easily identified by the constriction of the river channel approximately 1500 feet east of the Cochise-Pima County line; also, it coincides with the location of the Redington gage, labelled "Gaging Station" on the base map.

that is even with the canal, indicating that this surface existed prior to the pre-1926. The canal and pre-1926 surface are 17 feet above the surface of the modern-day channel floor.

Photograph #2 shows a tunnel that was dug in 1927 for the Bayless Ditch through the cemented conglomerate of the eastern bank of the Redington Narrows. To the left of the tunnel is the modern canal on the floor of the present-day channel, about two feet lower than the base of the 1927 tunnel. The difference in elevation between the pre-1926 Los Angeles Ditch and the 1927 Bayless Ditch indicate a vertical change in the channel bottom of about 15 feet, probably as a result of the 1926 flood event. The two-foot difference between the bases of the 1927 and 1997 canals indicate that very little net vertical change has occurred in this segment of the channel during the last seventy years.

Oral Histories

Cayetano Ronquillo told Jack Smallhouse that he and his family crossed the San Pedro River in several locations using simple foot bridges before the 1926 flood event, and that the 1926 event changed the course of the river and incised it (Smallhouse, 1997, oral commun.). He showed Jack Smallhouse where they used a cable foot bridge tied from a tree. Photograph #4 in Appendix B, taken in June of 1997, shows the remains of the cable still tied to a tree at the edge of an abandoned channel. Though the channel is barely noticeable in this photograph, it was discernable in the field as a very gentle dip in the ground to the west of the current location of the present-day channel (T.12S. R.18E. Sec.3, "Photo 4" on Plate 1). Ronquillo showed Smallhouse a second place where there had been a foot bridge across a narrow channel, in T.12S. R.18E. Sec. 27.

Barbara Clark, of the Cascabel[19] area, recounted histories of the area told to her by long-time residents such as Carey Smith and Emma Bennett. According to Smith and Bennett, the 1926 flood caused the entrenchment of the channel in the Cascabel area. Clark also was able to indicate in the field the location of an abandoned channel that she believed to be a former channel of the San Pedro River, although she did not know when it had been abandoned. The abandoned reach that she indicated closely resembled the abandoned channels present in the Redington area in width and depth.

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[19] Cascabel is located upstream (south) of the Redington reach, between The Narrows and the Redington Narrows.

Conrad Gamez, who was born in 1928 in the Cascabel area, noted that there have not been any large floods in the Cascabel/Redington area for a long time, and therefore the sand was building up in the channel bed (Gamez, oral commun., 1997).

Historical Photographs

The Arizona Historical Society's archives contained several photographs taken in 1903 along the San Pedro River during one of Bayless and Berkalew Company's cattle drives. The photograph entitled, "A round-up in old Arizona, taken on the Bayless and Berkalew Ranch, San Pedro River, fall of 1903" [AHS #21329], gave the best view of the river. Refer to Photograph #5 in Appendix B to see a copy of the original 1903 photograph, and Photograph #6 to see the same view in June of 1997.

The 1903 photograph showed a very narrow, shallow channel with flow. The floodplain immediately adjacent to it was very flat with little vegetation (perhaps because of the cattle, perhaps because of recent flood events). There were no signs of steep arroyo walls in this photograph. However, steep channel banks were not discernable in the 1997 photograph, either, not because there were no steep banks, but because the photographer was standing on one bank to take the picture, and the other bank was hidden from site by the vegetation in the distance and by the angle of the view.

Previously-Published Accounts

Charles H. Bayless' account (cited in Griffiths' 1901 publication) claimed that by 1900, the valley was a "sandy waste from bluff to bluff" and a channel varying in depth from 3 to 20 feet was cut almost the whole length of the river. He also noted that it was more difficult to get irrigating water onto the surface of the land. Because he managed ranches near Redington, it probably would be sensible to infer that he had particular experience with channel change along the Redington reach of the river.

The U.S Geological Survey's Twenty-First Annual Report was the first published account to note the presence of a sandy channel bed and intermittent reaches:

> "The period of greatest precipitation is in the months of July and August, when floods of considerable size come down San Pedro River. During the rest of the year the stream is small, winding back and forth in its sandy bed... In the lower portions of its course the river is in places dry, owing to the diversions made by a large number of small canals" (USGS, 1901, p.352)

However, no mention was made in this report of the presence of entrenched reaches or of which reaches were dry.

Cooke and Reeves (1976) cited Melton (1965) and Jones (1968) when they noted that marked downcutting north of The Narrows appeared to have occurred in two periods: prior to 1895, when a continuous sand-bed was formed; and, 1926-27, when major floods resulted in notable incision. Entrenchment was reported to have happened as late as 1926-27 between The Narrows and Hot Springs Canyon near Cascabel (Melton, 1965, oral communication with a rancher, Charles Gillespie, as cited in Cooke and Reeves, 1976).

Discussion

The historical photographs and maps, and the accounts by the U.S. Geoloical Survey, Bayless, and Cooke and Reeves, all indicated that a wide channel with a sandy bed had been established along the Redington reach, and, indeed, along most - if not all - of the San Pedro River in the late 1800's to early 1900's. However, the different types of evidence imply a more complicated history of channel entrenchment along the Redington and Cascabel reaches of the San Pedro River.

Bayless' account indicated that the entire San Pedro River became entrenched prior to 1900. An alternate scenario would be one in which only particular segments of the reach became notably incised. Oral histories and previously published accounts indicated that the channel in the Cascabel area did not become entrenched until 1926. The analysis of the movement of the Bollen Ditch intakes indicated that that segment of the Redington reach did not become incised until the 1926 flood event, or, if it became incised prior to 1926, the entrenchment was not deep enough to affect the location of the intakes. The analysis of the Bayless Ditch intakes at the Redington Narrows indicated that that segment of the Redington Reach probably did become incised somewhat prior to the 1926 flood event. However, comparison of (1) the elevations of the pre-1926 Los Angeles Ditch and the 1927 Bayless Ditch, and (2) the pre- and post-1926 locations of the Bayless Ditch intakes, indicates that even more dramatic incision resulted from the 1926 flood event.

The oral histories that described the use of foot bridges over a narrow San Pedro River prior to the 1926 flood event, the abandoned channels near Redington, and the photograph of the 1903 channel provided inconclusive, or even contradictory, information about channel entrenchment. They seemed to imply that the channel prior to the 1926 flood event was still very narrow. However, the historical maps and several other accounts

indicated that the channel was very wide and had a sandy base. Perhaps the accounts of the narrow channel were describing an active channel defined by the low-discharge perennial flow. Such an active channel may have been inset into a wide, sandy channel bottom that may or may not have had arroyo walls.

Channel Entrenchment in the Mammoth/Dudleyville Reach of the San Pedro River

There was much less information available for the Mammoth/Dudleyville reach of the lower San Pedro River than for the Redington reach. However, the evidence available describes a more straight-forward history of widening and entrenchment.

John L. Harris' 1877 cadastral survey of the Mammoth and Dudleyville areas indicated several *acequias* (gravity-flow ditches) along the channel, implying non-entrenchment. [Refer to Plate 2 and Plate 3 for the locations of the ditch heads.] Cooke and Reeves (1976) noted that it is unlikely that ditches would have been constructed where the main river was entrenched. Ditches located away from the main channel probably indicated other sources of water, such as springs. Unfortunately, there was no other historical information available that described the location of ditch intakes at the turn of the century.[20, 21]

Hereford and Betancourt (in press) noted that, although there were several large floods in 1886 and 1887, the first mention of extensive channel widening and channel entrenchment were described in newspaper accounts of the damage resulting from the flood events of August and September 1890:

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[20] Every attempt was made to locate State Water Commission maps for the Mammoth and Dudleyville areas, and to locate water rights information that may have described the location of ditches, but to no avail. Appendix C provides the the names of various agencies and mining companies that may have information archived, but the researcher who pursues such avenues must be willing to spend weeks or months tracking down the right contacts and exploring long-filed archives.

[21] Ralph Garcia and John Smith, long-time residents of the Dudleyville area, remembered that there had been several ditches along the river that had been in use until the 1940's, when irrigation wells with electric pumps replaced the ditches as sources of irrigation water. Huckle's 1991 publication that described the life of Jo Curtis confirmed Garcia and Smith's memories. Jo Curtis and Gussie Flieger bought the farm located at Cook's Lake in 1940. Not long after, Jo Flieger became annoyed by the amount of effort required by the ditch that brought irrigation water from the river, drilled a well, and used a pump to get water onto his fields (as told to Huckle, 1991). Unfortunately, field checks in June of 1997 indicated that most of the ditches had been eroded by bank collapse along the main channel; hence, intake locations were not discernable.

"At Riverside, the road is fordable for the first time in two weeks, but raining again on the San Pedro. If the San Pedro continues to rise the next thing we'll see is Dudleyville floating down the Gila. Has caved within 15 ft of Cook's place. He piled brush to divert, but now it has washed out. Mr. Bates house in danger, several of his outhouses gone. The Riverside-Globe road impassable for two weeks; is being rebuilt on Kane Springs Canyon stretch." (*Arizona Daily Star*, September 6, 1890, as cited in Hereford and Betancourt, *in press*)

"Recent floods at Mammoth washed the soil out in places 30 ft deep along the river bottom. Exposed area at bottom brought out in many places evidence of ancient civilizations...." (*Arizona Daily Star*, October 2, 1890, as cited in Hereford and Betancourt, *in press*).

The 1911 Winkelman Topographic Quadrangle indicated that the entire length of the Mammoth/Dudleyville reach had been widened significantly between 1877 and 1911. The widening of newly-formed arroyos and the extension of headcuts continued until 1926 in the Mammoth and Dudleyville areas as a result of subsequent flood events. (Refer to the chronological listing of newspaper accounts in the next section.) However, the 1926 flood event seemed to produce the most dramatic channel changes since the floods of 1890, as evidenced by this account:

"Every highway and railroad bridge on the San Pedro River from the International boundary line to where it flows into the Gila River below Mammoth were either destroyed or rendered useless last Monday evening and Tuesday morning when the San Pedro River, swollen by a three day rain, went on the most destructive rampage in its entire history... Mammoth highway bridge totally destroyed." (*Tombstone Weekly Epitaph*, September 30, 1926, as cited in Hereford and Betancourt, *in press*)

In addition, large parts of the Clark Ranch (~2 miles south of Mammoth) were removed by channel-bank erosion caused by the 1926 flood flow (Charles Clark Sr., 1997, oral commun. *via* Charles Clark Jr.). Landholders reported that some of their diversion canals were abandoned after the 1926 flood event because the river had incised well below the intake level (Jones, 1968).

Hereford and Betancourt (in press) and Charles Clark Jr. (1997, oral commun.) noted that the channel downtream of Mammoth has been aggrading in recent years. However, large flood events have continued to cause the widening of the steep-walled channel in many locations. For example, Ralph Garcia (1997, oral commun.) reported that the 1993 flood event resulted in dramatic undercutting of the arroyo walls in T.6S. R.16E. Sections 8 and 17, and, indeed, Plate 3 shows that the 1995 active channel extends well beyond the 1934 channel in these areas. This indicates that, although no modern flow

event had exceeded the magnitude of the 1926 flood event (refer to Figure 2), and the 1995 active channel was more narrow than the 1934 channel, widening of the arroyo had occurred since 1926.

LOWER SAN PEDRO RIVER CHRONOLOGIES

The data collected from the published and unpublished references, historical maps, and oral histories were synthesized into two chronologies. The first chronology describes the historical streamflow and channel characteristics of the Redington reach, and the second chronology describes the reach between Mammoth and the Gila-San Pedro confluence. The chronologies have three components: the date of the description; the description itself; and the source of the descriptive information.

When possible, the exact year, month, and day were provided in the "Date" column of the chronology. Often an exact year was not provided in the oral histories. In such cases, the approximate date provided by the interviewee is annotated with a tilde ("~") symbol. In addition, some of the historical maps were not dated at all. However, information from undated maps was included in the chronological listing if the date of the map could be constrained to a particular range of years.

For the sake of clarity and brevity, much of the information gathered from published sources is presented in the "Description" column as direct quotes. The source of the information is provided in parentheses following the description.

Redington Reach:

Date:	Description (Source):
1879	John L. Harris performed the first cadastral survey of the Redington area in 1879. Based on Harris' survey notes, the channel had a mean width of 35 feet in T.11S. R.18E., and 26 feet in T.12S. R.18E. (Huckleberry, 1996). His survey plat maps showed *acequias*, or gravity-fed irrigation ditches, in T.11S. R.18E. and T.12S. R.18E., implying nonentrenchment of the river channel in those areas. [Refer to Plate 1 for the location of the ditch heads.] Harris' observations of flow in the channel, and the presence of cottonwoods and irrigation ditches, indicate intermittent to perennial flow in this reach (Fonseca, unpublished manuscript).
~1884-88	"About twelve years ago the San Pedro Valley consisted of a narrow strip of subirrigated and very fertile lands. Beaver dams checked the flow of

water and prevented the cutting of a channel. Trappers exterminated the beavers, and less grass on the hillsides permitted greater erosion, so that within four or five years a channel varying in depth from 3 to 20 feet was cut almost the whole length of the river. Every year freshets are carrying away new portions of the bottom lands. At present this valley is a sandy waste from bluff to bluff, while the few fields remaining are protected from the river at large and continuous expense. Thus, in addition to curtailing the area of good land, the deep channel has drained the bottoms, leaving the native grass no chance to recover from the effects of close pasturing. It also makes it more difficult to get irrigating water onto the surface of the land." (C.H. Bayless, as cited in Griffith, 1901)

~1890 "My mother told me that the river was narrow when they first came to Redington. They used just a little board to cross the river. My father had his fields there; everything was cultivated - even the sides of the hills - all the way from Benson to Winkelman. But the river got wider and wider, and it swept away my father's fields and the house we lived in. Can you imagine - they told me that Winkelman is on the banks of the river now!" (Paulina Moreno Montoya, b. 1905[22], as cited in Martin, 1992)

1883-92 "The trench on the San Pedro River was cut progressively headward between the years 1883, when the arroyo first formed at the mouth of the river, and 1892, when the head water fall cut through the boundaries of the Boquillas Grant 125 miles upstream." (Bryan, K., 1925, p. 342)[23]

1899 "The period of greatest precipitation is in the months of July and August, when floods of considerable size come down San Pedro River. During the rest of the year the stream is small, winding back and forth in its sandy bed... In the lower portions of its course the river is in places dry, owing to the diversions made by a large number of small canals" (USGS, 1901, p.352). [No mention was made in this report of the presence of entrenchment or of which reaches were dry.]

1903 A ground photograph[24] taken along the river during a Bayless and Berkalew cattle drive shows a very narrow, shallow channel with flow. The floodplain immediately adjacent to it is very flat with little vegetation. There

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[22] The date of this entry is a very uncertain estimate. Paulina Moreno Montoya was born in Redington in 1905 and was the seventh of eight children. Her mother, Vicente Soto de Moreno, came to the Tanque Verde area near Tucson from Mexico when she was nine years old because of a war (probably the war against French occupation, according to Martin (1992)). Vicente Soto de Moreno's date of birth was not mentioned in Martin (1992).

[23] Cooke and Reeves (1976) claim that the assertions about the timing of arroyo cutting made in Bryan's often-quoted 1925 paper are almost wholly incorrect. Refer to the fourth section of this report for a more detailed discussion.

[24] "A round-up in old Arizona, taken on the Bayless and Berkalew Ranch, San Pedro River, fall of 1903." Arizona Historical Society Photograph #21329; refer to Photograph #5 in Appendix B to see a copy of the original 1903 photograph, and Photograph #6 to see the same view in June of 1997.

is no sign of any steep arroyo walls in this photograph.

1907 The 1907 map of the Bayless and Berkalew property indicated that the San Pedro River channel had a mean width of approximately 400 feet in T.11S. R.18E., and 200 feet in T.12S. R.18E. However, the channel was as narrow as 150 feet at the R.18E./R.19E. range line in T.12S., and as wide as 900 feet at the T.11S./T.12.S township line in R.18E. This maps also showed *acequias* in T.11S. R.18E. and T.12S. R.18E., implying nonentrenchment of the river channel [Refer to Plate 1 and the fourth section of this report for a more detailed review of this map and the significance of the *acequias*.]

~1925 Cayetano Ronquillo showed Jack Smallhouse many years ago where he and his family crossed the San Pedro River near Redington using a cable foot bridge tied from a tree, before the river changed its course and became entrenched. In June of 1997, Smallhouse showed one of the authors of this report the remains of the cable still tied to a tree at the edge of an abandoned channel. The channel was subtle, but discernable as a very gentle dip in the ground to the west of the current location of the present-day channel (T.12S. R.18E. Sec.3, "Photo 4" on Plate 1). Refer to Photograph #4 in Appendix B. Ronquillo showed Smallhouse a second place where there had been a foot bridge across a narrow channel, located in T.12S. R.18E. Sec. 27.

1926 The September 28, 1926, flood event resulted in deep entenchment of the San Pedro River channel in the Redington and Cascabel areas (based on oral histories gathered by J. Smallhouse and B. Clark from local residents such as Cayetano Ronquillo, Carey Smith, and Emma Bennet). [Refer to the fifth section of this report for a more detailed description of the entrenchment history of the lower San Pedro River.]

~1926-27 "Entrenchment is reported to have been initiated north of Benson - between The Narrows and Hot Springs Canyon <near Cascabel, south of Redington> - as late as 1926-7 [Melton, 1965, quoting an oral communication with a rancher, Charles Gillespie]." (Cooke and Reeves, 1976, p.45)

1934 The Soil Conservation Service performed the first systematic aerial photography of the lower San Pedro River Valley in 1934. "The photography reveals a shallow, braided channel within an incised floodplain. The channel is dramatically wider than in the 19th century..., especially downstream from Redington... Because of the wider, entrenched reach below Redington, changes in channel position through time are greater along this segment than any other part of the river." (Huckleberry, 1996, p.15.) Huckleberry (1996) determined that the channel had a mean width of 837 feet in T.11S. R.18E., and 236 feet in T.12S. R.18E.

1926-1940's — Plate 1 shows how a one-and-a-half-mile reach of the river in T.12S. R.18E. had shifted to about 1300 feet west of its 1907 location. The abandoned 1907 channel was distinctly visible in the 1934 photographs but not in the 1995 photographs. According to J. Smallhouse (1997, oral commun.), this abandoned segment of the 1907 channel was in the same location as the main channel prior to the 1926 flood event. When he was a boy during the 1940's, flows came into this abandoned channel on a regular basis because the main channel had not been so deeply incised as to prevent the flow of water into it. Since the main channel has become more deeply incised, the abandoned channel has acted as a secondary flow channel during large flood events such as the floods of 1977, 1983, and 1993. At the time of the 1997 field visit, this abandoned channel was about 30 feet wide and had gentley sloping banks with a depth of about two feet. Smallhouse noted that it was deeper in 1997 than it had been in his youth because several flood flows have passed down it since then, and it has been used as an alternate farm road.

1930's — Conrad Gamez was born in 1928 and raised on a farm in Cascabel about 500 yards east of the San Pedro River. He remembered that, when he was about five or six years old, the water in the river was "about knee high, depending on the weather," and that the river flowed year-round in some reaches. In other reaches, the water went subsurface. He remembered that where the river was narrow, there were very steep banks, but where the river was wide, the channel depth was more shallow. Neighbors would work together to make dikes from sand and brush to divert river water into canals to irrigate their fields next to the river. During the monsoon rains, the river water would overflow to the adjacent fields. Gamez did not remember seeing any canoes or rafts on the river, but then, "nobody had time for much recreation – times were rough." He did not remember seeing any fish in the river.

1983 — The 1983 flood event destroyed the six-inch well located in the lower part of the Redington Narrows (J. Smallhouse, 1997, oral commun.).

1935-95 — Channel width, as seen in the 1995 aerial photographs, had changed very little upstream of Redington (T.12S. R.18E.) since 1934. [Refer to Plate 1.] However, the channel located downstream of Redington (T.11S. R.18E.) had widened dramatically since 1934. Several of the reaches had widths in excess of 1200 feet (i.e. in Sections 10, 11, 15, 26, and 34).

Mammoth to the Gila-San Pedro Confluence:

Date:	Description (Source):
1870-73	John J. Bourke, who served at Camp Grant from 1870 to 1873, described Camp Grant as being located at "the junction of the sand-bed of the Aravaypa [sic] with the sand-bed of the San Pedro, which complacently figured on the topographical charts of the time as creek and river respectively, but generally were dry as a lime-burner's lot excepting during the 'rainy season.'" (Bourke, 1891, as cited in "History of the San Pedro River" chapter of the 1993 Arizona Stream Navigability Study for the San Pedro River)
1877	John L. Harris performed the first cadastral survey of the Mammoth and Dudleyville areas in 1877. His survey plat maps showed several *acequias*, or irrigation ditches, along the channel between Mammoth and Dudleyville. [Refer to Plates 2 and 3 for the location of the ditch heads.] Based on Harris' survey notes, the channel had a mean width of 35 feet in T.5S. R.15E., 36 feet in T.6S. R.16E., 38 feet in T.7S. R.16E., 35 feet in T.8S. R.16E., and 40 feet in T.8S. R.17E. (Huckleberry, 1996).
1886 Aug. 14	"Reports from Dudleyville[25] say an avalanche of water swept down the river Saturday (8/7) like a wave, 6 ft high.... People in Florence Sunday saw tailings from Mammoth mill floating in canal. Brought by freshet that passed Mammoth Friday." (*Arizona Weekly Enterprise*, as cited in Hereford and Betancourt, in press)
1886	"Inconclusive evidence suggests that channeling took place upstream at Mammoth... in 1886." (Hastings, 1959, p.64)
1887 Aug. 15	"From Mammoth dated August 15: Glorious rains last week and the San Pedro is on the rampage. The cattle are all smiles." (*Arizona Weekly Enterprise*, August 20, 1887, as cited in Hereford and Betancourt, *in press*)
1887 Sept. 14	"A letter from Mammoth dated September 14: Our San Pedro has been on the rampage, with higher water than has ever been known before. Families living near the river in Neal's corral were forced to evacuate." ." (*Arizona Weekly Enterprise*, September 17, 1887, as cited in Hereford and Betancourt, *in press*)

[25] The book Arizona Place Names (Barnes, 1935), newspaper accounts, and historical survey maps indicated that Dudleyville was located about one mile south of the Gila River on the west bank of the San Pedro River in T. 5 S. R. 15 W. Sec. 25. Dudleyville was established by the family of Dudley Harrington in 1879, and a U.S. post office was established May 8, 1881 (Barnes, 1935). Between ~1949 and 1972, according to the USGS topographic maps of those dates, what is currently referred to as Dudleyville began to develop along the eastern side of the San Pedro river about five miles south of the Gila River. Field checks conducted in June of 1997 found few remains of the historic Dudleyville.

1890 Aug. 14 "Of the country down the San Pedro, from Tres Alamos to the Gila [Captain Van Alstine] . . .says, "all of it is gone, destroyed, torn up, 'vamosed' down with high water." He never saw such a destruction in all his life. . . The San Pedro never was as high as it was this time, and will not probably be for the next ten years. The losses sustained by the people will reach into the thousands." (*Arizona Daily Star*, as cited in Hastings and Turner, 1965, p.42)

1890 Aug. 15 "The river is still overflowing its banks, doing a great deal of damage. The ground about Mammoth has been flooded and many Mexicans have been compelled to vacate their houses. The river carried off a large stack of hay from Mr. John Brown's ranch, taking some fence also, and at Mr. Sellick's part of his orchard, including about 150 fruit trees, as well as part of his hay field. His house is also in danger and his family has vacated it. Mr. George Scott has had a large portion of his ranch washed away, and across the river from him the outbuildings of Theo. Gates have been taken down by the stream. The road is utterly impassable from Mammoth to Riverside, it being washed out, and in many places in holes ten ft deep." (*Arizona Daily Star*, as cited in Hereford and Betancourt, *in press*).

1890 Aug. 30 "At Dudleyville damage to the Swingle and Young Ditch is $300. George Cook has been trying to save Dudleyville by building dykes; but last flood washed away the dyke, leaving his house and store in had shape..." (*Arizona Daily Star*, as cited in Hereford and Betancourt, *in press*)

1890 Sept. 6 "At Riverside, the road is fordable for the first time in two weeks, but raining again on the San Pedro. If the San Pedro continues to rise the next thing we'll see is Dudleyville floating down the Gila. Has caved within 15 ft of Cook's place. He piled brush to divert, but now it has washed out. Mr. Bates house in danger, several of his outhouses gone. The Riverside-Globe road impassable for two weeks; is being rebuilt on Kane Springs Canyon stretch." (*Arizona Daily Star*, as cited in Hereford and Betancourt, *in press*)

1890 Oct. 2 "Recent floods at Mammoth washed the soil out in places 30 ft deep along the river bottom. Exposed area at bottom brought out in many places evidence of ancient civilizations...." (*Arizona Daily Star*, as cited in Hereford and Betancourt, *in press*)

1891 Mar. 5 "Captain Johnson, manager of the Mammoth gold mine, who is now in the city, says that the San Pedro was higher during the recent flood than the highest water mark [flood of February 23]." (*Arizona Weekly Star*, as cited in Hereford and Betancourt, *in press*)

1899 Twenty canals that diverted water from the San Pedro River in the Mammoth and Dudleyville reaches were mapped by the USGS in 1899[26] (USGS, 1901). "The period of greatest precipitation is in the months of July and August, when floods of considerable size come down San Pedro River. During the rest of the year the stream is small, winding back and forth in its sandy bed... In the lower portions of its course the river is in places dry, owing to the diversions made by a large number of small canals" (USGS, 1901, p.352). [No mention was made in this report of the presence of entrenchment or of which reaches were dry.]

1901 Aug. 10 "W.H. Clinton, who carries the mail from Riverside to Benson got through last Friday (8/2) for the first time since the floods commenced. He reports great destruction of property on the lower San Pedro between Mammoth and Riverside. He says al the ranches in the river bottoms have been injured more or less and Youtseys ranch is entirely destroyed, about half of Robles' ranch is gone and on Whetlock's ranch the river changed its channel, now being on the opposite side of the river where it used to be." (*Florence Tribune*, as cited in Hereford and Betancourt, *in press*)

1904 Feb. 27 "At Dudleyville the river bed became over a mile wide. Several times the store had to be moved to new and higher quarters because the building was removed by floods." (*Arizona Blade and Florence Tribune*, as cited in Hereford and Betancourt, *in press*)

1904 Aug. 20 "The high water in the San Pedro last week did considerable damage to the agricultural lands bordering the stream. A watermelon patch on Judge George Scott's farm at Dudleyville was entirely washed away. The river has been enroaching on his land since 1901..." (*Arizona Blade and Florence Tribune*, as cited in Hereford and Betancourt, *in press*)

1905 Jan. 21 "Greatest floods and rains since 1891 last week. P & E RR badly washed out between Florence and Winkelman. Parties coming in from the Dudleyville and Riverside country report greater damage to the farms along the Gila and lower San Pedro from the recent floods than was wrought by the great flood of 1891. The Cook, Sellick, Scott and Cunningham farms located on the east side of the San Pedro, near Dudleyville, suffered great damage, and it is reported that nearly every acre of Robert Branaman's farm on the south side of the Gila was washed away, also his dwelling house and stables." (*Arizona Blade and Florence Tribune*, as cited in Hereford and Betancourt, *in press*)

1911 Based on the U.S. Geological Survey's 1911 Winkelman Quadrangle, the San Pedro River channel had a width of ~1700 feet at its confluence with the Gila River, ~700 feet in T.5S. R.15E., ~850 feet in T.6S. R.16E. (with a dramatically wide reach of 2300 feet in Section 26), ~800 feet in T.7S. R.16E., and ~600 feet in T.8S. R.16E. and T.8S. R.17E. (Refer to Plate 2

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[26] The names, locations, and significance of the canals are provided in the fifth section of this report that describes vertical channel changes.

and Plate 3.)

1926 Sept. 30 — "Every highway and railroad bridge on the San Pedro River from the International boundary line to where it flows into the Gila River below Mammoth were either destroyed or rendered useless last Monday evening and Tuesday morning when the San Pedro River, swollen by a three day rain, went on the most destructive rampage in its entire history... Mammoth highway bridge totally destroyed." (*Tombstone Weekly Epitaph*, as cited in Hereford and Betancourt, *in press*)

1926 — Large parts of the Clark Ranch (~2 miles south of Mammoth) were removed by channel-bank erosion caused by the 1926 flood flow (Charles Clark Sr., 1997, oral commun. *via* Charles Clark Jr.).

Post-1926 — Landholders reported that some of their diversion canals were abandoned after the 1926 flood event because the river had incised well below the intake level (Jones, 1968).

1930 — Charles Clark Sr. (born in 1920) remembered that the San Pedro River ~2 miles south of Mammoth had continuous flow until he was ten years old. He also remembered seeing "sucker" fish (which he also called "trash" fish), catfish, and beaver in the river until ~1930 (Charles Clark Sr., 1997, oral commun. *via* Charles Clark Sr.).

1934 — The Soil Conservation Service performed the first systematic aerial photography of the lower San Pedro River Valley in 1934. Huckleberry (1996) determined that the channel had a mean width of 1600 feet in T.5S. R.15E., 1280 feet in T.6S. R.16E., 930 feet in T.7S. R.16E., 1120 feet in T.8S. R.16E., and 925 feet in T.8S. R.17E.

~1943-45 — Between about 1943 and 1945, Houston Evans and his family lived on the Teag Ranch located next to the San Pedro River near Dudleyville. He remembered that at that time the river had clear water, ~2-3 feet deep, flowing year-round. He remembered that there were fish in the river, but they were too small to eat. He also remembered that there were racoons and turtles in the river area. Evans never saw beaver along the San Pedro River, but he did find beaver ponds in the upper reaches of Aravaipa Creek. Evans and his childhood friends spent several of their weekends canoeing, fishing, and camping along the San Pedro River between Mammoth and Dudleyville. They would canoe on the San Pedro River from Mammoth to a lake[27] located in the middle of the river, downstream of the Aravaipa confluence, where they had a raft. They would then spend the rest of their weekend fishing on the lake and camping. There were water

[27] The lake that Evans described was probably Cooks Lake, and is shown in Photograph #7 (Appendix B) and on on Plate 3. The 1949 U.S. Geologcal Survey toporgraphical quadrangle showed a small, open body of water labelled Cooks Lake located on the northern edge of a marshy area in T.6S. R.16E. Sec.33. The 1972 U.S. Geological Survey topographical quadrangle indicated a large marshy area but no open water. In June of 1997, there was open water. Refer to Photograph #7 in Appendix B.

turtles, perch, small-mouth bass, and catfish in the lake and in a few of the deeper water holes along the river.

1983 The 1983 flood-flow filled the old channel in the area of the hard-rock crossing near the Araivaipa confluence (M. Spiess, 1997, oral commun.). "The 1983 flood swept the channel clean!" (J. Smith, 1997, oral commun.)

1993 The 1993 flood waters overflowed the banks of the San Pedro River and came through the main gate of Charles Clark Jr.'s house, which is located one foot above Mammoth's Main Street (Charles Clark Jr., 1997, oral commun.). The 1993 flood flows also resulted in extensive channel bank erosion, especially along the western bank, of the San Pedro River's steep cut-banks near Dudleyville (R. Garcia and J. Smith, 1997, oral commun.; refer to the next section of this report and Plate 3 for more detailed descriptions of the channel widening in this area).

1995 The San Pedro River's 1995 active channel, between Mammoth and the Gila confluence, is more narrow and sinuous than the 1934 channel. Refer to Plate 2, Plate 3, and the third and fourth sections of this report for a more detailed description of the channel characteristics.

SUMMARY

This report summarized a new investigation of historical channel changes along the lower San Pedro River. Information was gathered from published and unpublished references, historical maps, aerial and ground photographs, and oral histories collected from long-time residents of the lower San Pedro River Valley. The majority of the information related to the Redington and Mammoth/Dudleyville reaches of the river. All available descriptions of these reaches were compiled into chronologies and evaluated with the goal of better defining the timing of channel widening and arroyo initiation. The oral histories collected from long-time residents also provided information about streamflow characteristics. Although the gathering of such information was not a goal of this investigation, accounts that may be relevant to the issue of stream navigability, such as Houston Evans account of canoeing on the San Pedro River below Mammoth during the 1940's, were included in the chronologies.

The historical photographs and maps, and the accounts by the U.S. Geoloical Survey (1901), Bayless (as cited in Griffiths, 1901), and Cooke and Reeves (1976), all indicated that by 1912 a wide channel with a sandy bed had been established along the Redington and Mammoth/Dudleyville reaches of the lower San Pedro RIver, and along most - if not all - of the lower and upper San Pedro River. However, the different types of evidence described a more complicated history of channel entrenchment along the lower the San Pedro River.

The hypothesis that the down-cutting of the San Pedro River north of The Narrows occurred in two periods (Cooke and Reeves, 1976; Melton, 1965; and Jones, 1968) seems the most likely. The newspaper articles, the analysis of the historical movement of the Bayless Ditch intake, and Bayless' account indicated that, at the very least, several segments of the San Pedro River channel became entrenched as a result of the 1890's flood events (i.e. at the Redington Narrows and near Mammoth and Dudleyville). In contrast, accounts of the Cascabel area, and the analysis of the historical movement of the Bolen Ditch intake, indicated that some channel segments did not become entrenched until the 1926 flood event (i.e. in the Cascabel area and downstream of the town of Redington).

Newspaper accounts of the Mammoth/Dudleyville area, and Bayless' account, indicated that the widening of newly-formed arroyos and the extension of headcuts continued after the floods of the 1890's as a result of subsequent flood events. However, several lines of evidence indicated that incision as dramatic, if not more dramatic, resulted

from the 1926 flood event. The comparison of the elevations of the pre-1926 Los Angeles Ditch and the 1927 Bayless Ditch, the comparison of the pre- and post-1926 locations of the Bayless Ditch intakes, the newspaper accounts and oral histories – all indicated that the 1926 flood event widened and/or incised any segment of the Redington and Mammoth/Dudleyville reaches that had not yet been noteably entrenched.

Hereford and Betancourt (in press) noted that channel widening had probably slowed if not stopped along the lower San Pedro, and that reaches below Mammoth were presently aggrading (Hereford and Betancourt, in press). In general, their statement is true. However, the large flood events of 1977, 1979, 1983, and 1993 resulted in notable erosion of the arroyo walls in both the Redington/Cascabel and Mammoth/Dudleyville reaches of the lower San Pedro river (B. Clark, J. Smallhouse, R. Garcia, 1997, oral commun.; Plates 1, 2, and 3).

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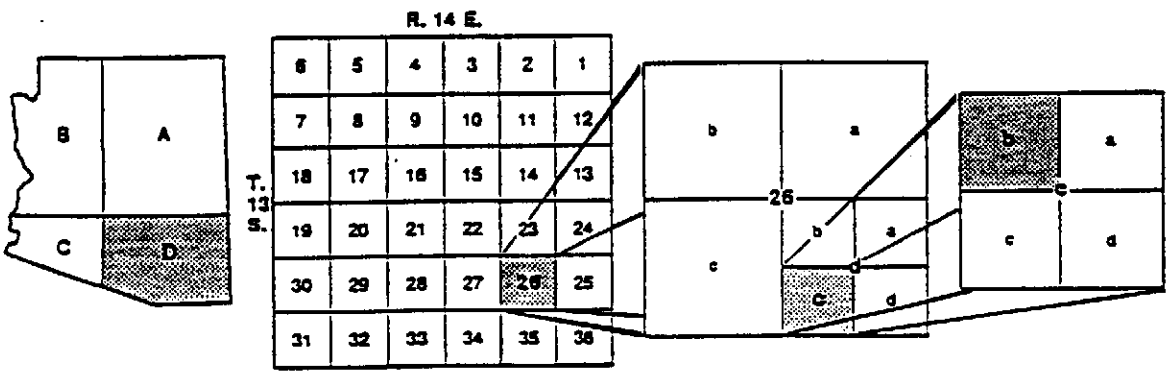
APPENDIX A

BUREAU OF LAND MANAGEMENT'S SYSTEM OF LAND SUBDIVISION

Many of the location descriptions provided in this report are based on the U.S. Bureau of Land Management's system of land subdivision. Under this system, the State is divided into four quadrants by the Gila and Salt River meridian and base line. The quadrants are designated by capital letters A, B, C, and D in a clockwise direction beginning in the northeast quarter. Because the entire San Pedro River falls within the "D" quadrant, the quadrant designation will not be included in location descriptions. The first number indicates the township, the second the range, and the third the section in which the place of interest is located. The letters A, B, C, and D after the section number indicate the location within the section. The first letter denotes a particular 160-acre tract, the second the 40-acre tract, and the third the 10-acre tract. The letters are assigned in a counterclockwise direction beginning in the northeast quarter. If the location of a place is known within the 10-acre tract, three capital letters are provided in the location description.

T.13S. R.14E. Sec.26 DCB

Quadrant D, Township 13 South, section 26, quarter section d, quarter section c, quarter section b.



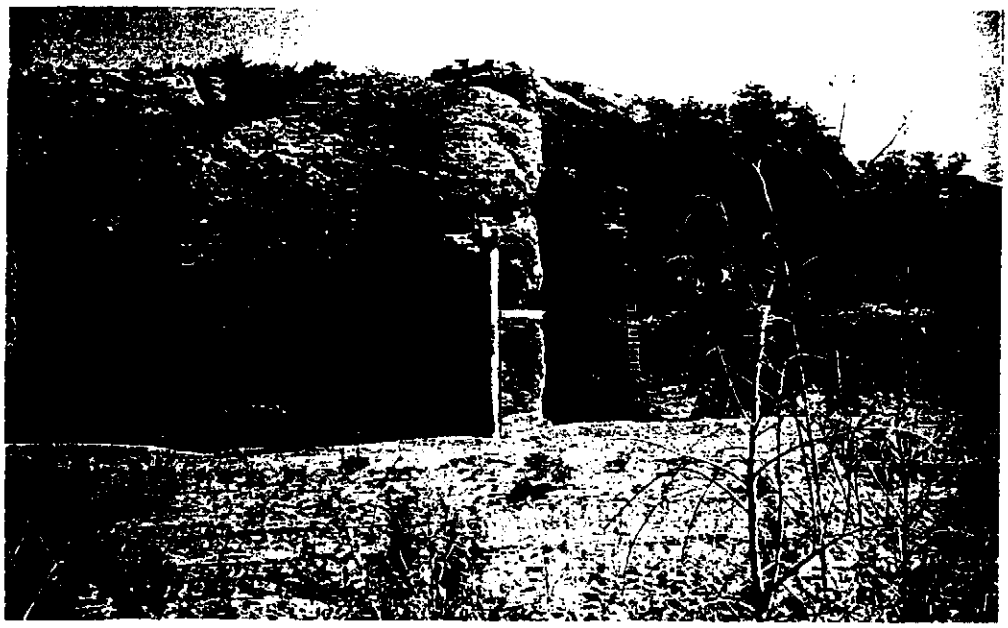
(Adapted from Tadayon (1995), U.S. Geological Survey Water-Resources Investigations Report 95-4062.)

APPENDIX B

GROUND PHOTOGRAPHS

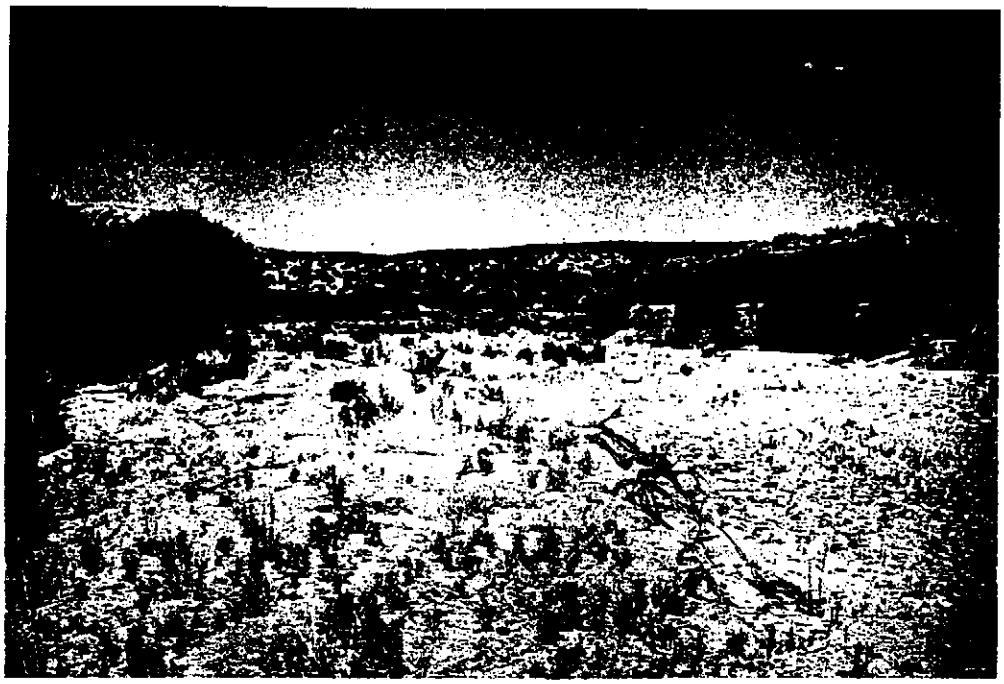
Refer to Plate 1 and Plate 3 for the photograph locations.

Photograph 1. View of the west bank of the Redington Narrows (June 1997). The Redington Gaging Station is located in the middle of the photograph. The Los Angeles Ditch is the white line of concrete perpendicular to the gage, and is 17 feet above the bottom of the channel.



Photograph 2. View of the east bank of the Redinton Narrows (June 1997). The tunnel was carved through cemented conglomerate for the Bayless Ditch in 1927. The modern Bayless ditch is located to the left of the tunnel. The bottom of the modern channel is about two feet lower than the base of the tunnel.

Photograph 3. Upstream view of the channel north of the Redington Narrows.



Photograph 4. View of an abandoned channel of the San Pedro River near Redington. It discernable as a slight dip. In the center of the photograph, barely visible in the shadows, is the remains of a cable foot bridge still tied to the tree to the left.

Photograph 5. "A round-up in old Arizona, taken on the Bayless and Berkalew Ranch, San Pedro River, fall of 1903." [AHS #21329]

Photograph 6. Same view as the historical photograph, taken in June 1997.

Photograph 7. View looking north at Cooks Lake.

Photograph 8. Downstream (northern) view of a perennial reach located near the PZ Ranch, about two miles downstream from the Aravaipa-San Pedro confluence.

Photograph 9. Close-up view of a more-densely-vegetated perennial reach located near Dudleyville.

Photograph 10. View of the perennial reach's end of flow, located about one mile downstream from the location of Photograph #9.

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Contacts

Archaeological Research Services,
Lyle Stone
520-721-4309

Archaeological Survey,
Brad Smith
520-384-0129

Arizona Department of Water Resources,
Tom Elder & Michael Winn
Information Technology Division
602-417-2400 ext. 7178

They were unable to find Arizona Water Commission maps for the lower San Pedro River.

Arizona Historical Society Museum
949 E. Second St.
Tucson, AZ 85719
520-628-5774 or 298-1705 (h)

Arizona State Land Department,
Catherine Belzano
602-542-2671

They were unable to locate Arizona Water Commission maps for the lower San Pedro River.

Arizona State University,
Dr. Will Graf
Department of Geography
602-965-7533

Because Dr. Graf tends to study the fluvial geomorphology of rivers in northern Arizona, he had no historical information for the San Pedro River. He recommended that we research the collections at the Arizona Historical Society office in Tempe. He also recommended that we contact the Mormon Church because individual churches, or "stakes," often recorded notable environmental changes that occurred in their region, sent the information to the main church, or "temple," in Salt Lake City. In addition, he noted that the EROS

Data Center in Sioux Falls, South Dakota, is the repository for all aerial photographs collected by federal agencies associated with the Department of the Interior. [Write or fax: USGS EROS Data Center, Customer Services, Sioux Falls, S.D., 57198, fax: 605-594-6589.]

Arizona State University,
Dr. Robert Ohmart
Center for Environmental Studies
602-965-4632

Dr. Ohmart recommended that we contact Will Graf (ASU Department of Geography) and Luna Leopold (UC-Berkely).

Arizona State University,
Jan Walter
Government Documents
602-965-3387

Arizona State University,
Lynda Zelmer
Head Librarian
602-965-3582

ASARCO,
Kip Gambee & Ed John
520-356-7811 ext.3383

Bateman, Jay,
Florence, AZ
520-868-6442

He did not have any relevant information. He recommended that we contact the Soil Conservation Service (Natural Resource Conservation District, NRCD) in Casa Grande.

Bennett, Elena and Emma
Benson, AZ
520-586-2679

Bingham, Faron,
Bingham-Browning Ranch,
Redington, AZ
529-212-3855

Bisbee Mining and Historical Museum,
Judy R. Reis
P.O. Box 14
Bisbee, AZ 85603
520-432-7071

The museum docents were able to find photographs for the upper San Pedro River, but not for the lower San Pedro River.

Bundy, Ted,
Tucson
520-571-8132

Mr. Bundy not only owns property along the San Pedro River, but also he was once a photo analyst for the Arizona State Historical Society Museum. He made the observation that the strip of the San Pedro River that runs through his property is shallow and unincised, like how the river was in the 1800's.

Because he is writing a book about the Tres Alamos area, which is upstream of The Narrows, Mr. Bundy has a collection of historical information about that region. While he does not have any photographs for the lower San Pedro River, he does have several historical maps that show the reach of the river upstream of The Narrows. For example, he has a pre-1877 map surveyed by the U.S. Army that shows the San Pedro River from the U.S. border to approximately the Pima/Pinal County border. He also has a GLO plat that shows the location of homesteaders in the area between Tres Alamos and The Narrows.

Mr. Bundy recommended that we contact "Henry," who works for Desert Archaeology, regarding archaeological surveys conducted in the Benson area and downstream from Mammoth. He also recommended that we review the manuscripts and maps collected by the Arizona Historical Society Museum, the University of Arizona's Map Collections and Special Collections, and the Arizona State University Library. In addition, Mr. Bundy thought that the Conklins had taken photographs of the Butterfield Stage Station downstream of Benson during the 1930's, and that we may be able to find information in the special issue of the journal, *Desert* Plants (volume 6, number 3, 1984), that focused on the location and history of cienegas.

Bundy, Winn,
Singing Winds Book Shop,
Benson, AZ
520-586-2425

Ms. Bundy recommended the book, Where the Waters Meet, published by the Central Arizona College - Aravaipa Campus. She also recommended that we contact the *Friends of the San Pedro* organization, and her son, Ted Bundy, who once was a photo analyst for the Arizona State Historical Society Museum.

Bureau of Land Management - Phoenix,
Tim Goodman
Biologist
602-780-8090

Mr. Goodman had no relevant information. However, he was able to provide Diane Lausch's current telephone number.

Bureau of Land Management - Safford,
Ben Robles
Hydrologist
520-428-4040

The only historical records that the Safford office had were the 1984 aerial photographs of the San Pedro River valley region. Mr. Robles recommended that we contact Jessie Juen at the Tucson office.

Bureau of Land Management - Sierra Vista,
Dave Krueper

He recommended that I speak to Ben Robles (BLM, Safford), Dr. Robert Ohmart (Center for Environmental Studies, Arizona State University), Russell Scott (USDA Agriculatural Research Service hydrologist), and Diane Lausch (Bureau of Reclamation biologist).

Bureau of Land Management - Tucson,
Jessie Juen
Field Office Manager
520-722-4289

Bureau of Reclamation - Phoenix,
Diane Lausch
Biologist
P.O. Box 9980
Phoenix, AZ 85068
602-395-5694

During her research of a mitigation site at the Aravaipa-San Pedro confluence, Ms. Lausch surveyed the records at the Arizona Historical Society Museum and the ASU library; however, she did not find any information relevant to our study in her search. She recommended that we contact John Smith, a rancher who owns property north of the mitigation site in the area of Cooks Lake.

Clark, Charles, Jr.,
Mammoth, AZ
520-487-2232 or 487-2335

Mr. Clark explained that his family came from England by way of New Zealand, and became established in Mammoth in 1873. His great-grandfather came west with eight children and bought a lot of land along the river. This land was split into parcels and distributed amongst the children. Little by little, the land (including the land owned by Charlie Clark, Sr., Mr. Clark's father) was sold to Magma Copper. Mr. Clark stated that his family had photographs of freight wagons, but none of the San Pedro River itself.

Mr. Clark has lived in the area since 1984. He has observed the deposition of sediments in the San Pedro River in the Mammoth area. During the 1993 flood event, water had overflowed the banks of the river and come through the main gate of his house, which is one foot above Main Street. From talking to other people who lived along the river, Mr. Clark determined that if the Aravaipa Creek and Gila River were experiencing a high flow, the San Pedro River would "back up," causing sediments to build up.

Mr. Clark recommended a book published in 1988 by the Central Arizona College - Aravaipa Campus under the direction of Dean Prichard, called The Heritage Writing Project. He said that this book contains photographs and stories written by people who had lived in the Aravaipa area for a long time. Mr. Clark also recommended that we contact Wilma Huggett of the 3C Ranch near Oracle because she has several photographs and experience with the area.

Clark, Charles, Sr.,
Mammoth, AZ

Because Mr. Clark Jr.'s father, Charlie Clark, Sr., was born in 1919, Mr. Clark thought that he may be able to provide some information. However, because Mr. Clark, Sr., had just undergone triple-by-pass surgery, he was unable to meet with AZGS

personnel. Mr. Clark, Jr., relayed the questionnaire to him and then contacted AZGS with Mr. Clark, Sr.'s response.

Mr. Clark, Sr., recalled the flood of 1926. His farm was down on the river, near the tailings pond about two miles south of Mammoth. The 1926 flood flow gouged a large chunk of the farmland. He remembered that, in general, if the river were not experiencing a heavy flood flow, the river would carry a lot of sediment and deposit it. As the river deposited sediment, it would move side to side. Mr. Clark, Sr., also remembered that he caught trash/sucker fish and catfish on from the river during his childhood. In addition, he did see beaver on the river. He said that the river had perennial flow until he was 10 years old (~1930).

Cochise County Floodplain Division,
Barry
520-432-9420

Cochise County Historical and Archaeological Society
P.O. Box 818
Douglas, AZ 85607
520-364-5226

Dawson, Mary Beth & Roy,
Redington, AZ
520-212-7667

Mrs. Dawson said that her family had no manuscripts or photographs that would describe the lower San Pedro River area. (She and her husband are primarily archaeologists.) She recommended the books Where the Waters Meet (Central Arizona College - Aravaipa Campus) and Songs My Mother Sang to Me (by Patricia Presiado, UA Press, 1992). She also recommended that we research the Soza family history because they lived on the river a long time.

Desert Archaeology,
Bill Doelle & Henry Wallace
520-881-2244

Evans, Houston,
Winkelman, AZ
520-487-2263

Mr. Evans responded to the mass-mailing letter. When he was in the third grade (~1944), he lived on Teag Ranch, which was located along the river about two miles north of the old school house near Dudleyville. Because his father was a miner, Mr. Evans moved several times to-and-from the river area during the 1940's. He joined the service at

age 17 and did not return to the San Pedro River area until ten years ago. He did not have any historical photographs, but he was able to remember the conditions of the river during the 1940's.

Mr. Evans said that the river had clear water, about two-to-three feet deep, year-round during the 1943-45 period. He also remembered that the Aravaipa Creek flowed year-round so that there was always a lot of water in the Aravaipa-San Pedro confluence area. He said that there was a large lake in the middle of the river between the Aravaipa-San Pedro confluence and Dudleyville that is no longer there. He, along with other young family members and friends, would canoe on the San Pedro River from the Mammoth area down to the lake, where they had a raft. He and his companions would then spend the weekend on the lake fishing and camping until his father would come pick them on Sunday so that they could go to school on Monday.

In the lake and other water holes on the river, Mr. Evans found water turtles, perch, small-mouth bass, and catfish. He said that he did fish some, but that the fish were too small to eat; the fish were about the size of a "good-sized goldfish."

During the 1943-45 period, Mr. Evans had trap lines which he ran all winter. He remembered catching bobcats, squirrels, coyotes, raccoons, and skunks, and even one black bear and one ring tail. He said that he no longer sees raccoons in that area, and that he never did see any beaver along the San Pedro River, although there were once beaver ponds in upstream reaches of Aravaipa Creek. He has noted that there is more dead vegetation now than when he was a child.

Mr. Evans recommended the book, Men and Animals in Arizona: 1824-1864, published by the University of Arizona. He said that this book contains a description of the San Pedro River. For example, the book states that a group "caught 39 beaver in one night" and saw "millions of birds" along a reach of the San Pedro River downstream of where Mr. Evans now lives. Mr. Evans also recommended that contact the Forest Service for historical maps, and Red Walkner, who was born and raised on the river.

Mr. Evans said that he would contact the Teag family and other people who had lived along the river for a long time and then call me.

Farrington, Dennis
Redington, AZ
520-212-2529

Mr. Farrington noted that one could see that the original river channel meanders of the San Pedro River cut by the new channel were much higher up. He recommended that we talk to: Mary Taylor; and, to his wife, Barbara Clark, about the watershed restoration project in the Cascabel area.

Forest Service,
Bill Gillispie
520-378-0311

He recommended that AZGS contact Archaeological Survey (Brad Smith), Old Pueblo Archaeology (Al Dart), and Desert Archaeology.

Gamez, Conrad
Phoenix (formerly of the San Pedro River Valley)
520-276-5452
5618 S. 9th Ave.
Phoenix, AZ 85041

Gila County Historical Museum,
Jean Stiles & Bill Haak
P.O. Box 2891
Globe, AZ 85501
520-425-7385

The Museum has information for Winkelman and Hayden, but no information regarding the water conditions on the San Pedro River.

Hugget, Wilma
Oracle

She recommended that AZGS contact a man named Acton, and research an article published by the Aravaipa Arrow in 1988. Because she had recently had a stroke, she had trouble remembering many things.

Holy Trinity Monastery,
Father Louis
1605 S. Saint Mary's Way
Saint David, AZ 85630
520-720-4642

The monastery had no relevant historical information for the lower San Pedro River. Fr. Louis recommended that I speak with Patricia Don, the curator of the Benson Historical Museum (also known as the San Pedro River Valley Arts and Historical Society Museum).

McFarland State Historic Park,
Katie
P.O. Box 109
Florence, AZ 85232
520-868-5216

Katie recommended that I contact the Pinal County Historical Museum.

Natural Resource and Conservation District - Casa Grande,
Sarah Beloshapka
Casa Grande, AZ
520-836-2048

She recommended that I contact the *Friends of the San Pedro* organization, located in Benson, and Jack Smallhouse, who lives in Redington.

Natural Resource and Conservation District - Douglas Field Office,
Geoff Parker
Route 1, Box 226
520-364-2001

Mr. Parker recommended that we contact the San Pedro NRCD field office.

Natural Resource and Conservation District - Mammoth,
Virgil Mercer
520-487-2431

Mr. Mercer said that his family had no photographs of the San Pedro River area. He observed that by 1953 almost all the families that had farmed in the Mammoth area had sold their land to the mines. He recommended that we contact the Clark family (especially Charlie Clark, Sr.) in Mammoth because they had been living along the San Pedro River since 1873. He also recommended that we research the archives held by the military, the mines, and the Department of Agriculture.

Natural Resource and Conservation District - Redington office,
Barbara Clark
520-212-2529

Ms. Clark moved to the Cascabel area in 1970. She had anecdotel information about the San Pedro River from talking to such people as the Smallhouse, Soza and Gamez families who have lived along the river for generations, and to Carrie Smith, who once taught at the school in Redington. She said that Mr. Smith learned from other residents that the channel in the Cascabel area became incised as a result of the 1926 flood event.

Ms. Clark also could show previous locations of the river channel on her property. In addition, she was able to direct AZGS to a series of historical maps on file at the Cochise County Assessor's Office. While she did not know the exact date of the maps, she speculated that they were surveyed about the time the USGS conducted the brass-cap survey in 1923.

Ms. Clark thought that Catherine Balzano, the Arizona State Land Department, might be able to help find the historical Arizona Water Commission maps that surveyed the location of all the active irrigation maps at the time of Statehood.

Natural Resource and Conservation District, San Pedro Office,
& Conservation Resource Center,
Diane Escobido
520-586-3467
880 W. 4th Street, #2
Benson, AZ, 85602

Ms. Escobido recommended that we contact Jack Smallhouse (Redington) and Barbara Clark (Natural Resources Conservation District - Redington office).

Nature Conservancy - Dudleyville,
Steve Huckett & Ralph Garcia
520-357-6076

Ralph Garcia (born ~1930) described the history since the 1940's of the Sales Ranch area, now owned by the Nature Conservancy. He said that during the 1960's the Sales family bought the ranch from Buster Noggley, who died about two years ago. He described the location of two irrigation ditches used during the 1940's, one near the mustang corrals and one that led from Leroy Springs (on "Indian territory"). Mr. Garcia remembered that flood events during the 1940's eroded a lot of land along the property.

Mr. Garcia and Mr. Huckett took Michelle Wood on a survey of the property and showed her the approximate locations of the ditches used during the 1940's, the location of modern-day springs, and flow extent within the channel. Observations made during this survey are described in the main text.

Nature Conservancy - Upper San Pedro Ecosystem Program,
Rena Anne Abolt
520-378-2640

Ms. Abolt had no historical information for the lower San Pedro River. She recommended that we contact Dave Harris at the Tucson office.

Nature Conservancy - Tucson Office,
Dave Harris & Diane Imig

Mr. Harris knew of no historical information for the lower San Pedro River. He recommended that we contact: Jack Smallhouse (Redington), the Bingham-Browning Ranch family, i.e. Jack and Louis Kelly (Louis Kelly is a descendant of the Bingham family), and Faron Bingham; and, Virgil Mercer (chair of the Winkelman NRCD and owner of a ranch in the Mammoth area).

Ms. Imig recommended that we research the photographic work of Buehman, who extensively traveled and photographed southern Arizona. She also recommended that we research the collections of Pima County Maps and Records, and of the mines in San Manuel (BHP and Asarco).

Ohnesorgen, Dora,
Benson
204 E. Walker
Benson, AZ 85602
520-586-2873

Old Pueblo Archaeology,
Al Dart & John Murray
520-798-1201

Owens, Edward
BHP - San Manual
520-385-3100

Pima County Flood Control District,
Julia Fonseca

Ms. Fonseca made available her unpublished study of historic vegetative and hydrological conditions at the Bingham Cienega Natural Preserve. The study is summarized in the main text of this report. In addition, Ms. Fonseca recommended that AZGS refer to the Arizona Department of Water Resources' Hydrographic Survey and other references related to water rights in the San Pedro River basin, as well as the U.S. Army Corp. of Engineers flood control report related to the hearing held in Benson in ~1935, and the National Archives. She also thought that the photograph collections at the UA Special Collections and the Arizona Historical Society might be useful, although she reviewed the written documents at both institutions for Bingham Cienega and the San Pedro River near Redington, and did not discover much.

Pinal County Historical Society,
Della Meadows
P.O. Box 851
Florence, AZ 85232
520-868-4382

Pratt, Jerry,
Sierra Vista
3000 Meadowlark Drive
Sierra Vista, AZ
520-458-0971

Retired wildlife biologist

San Pedro Valley Arts & Historical Society Museum,
Nedra Suderland
P.O. Drawer 1090
Benson, AZ 85602
520-586-3473

Ms. Suderland had recorded extensive oral histories from residents of the Benson area. The tapes and transcripts are archived and are open to the public at museum. She located a transcript that mentioned the 1926 flood on the San Pedro River; however, it contained no information pertinent to the study of channel characteristics of the lower San Pedro River at the turn of the century. In addition, Ms. Suderland searched the Museum's holdings for newspaper accounts describing large historical floods on the San Pedro River and made those available for this study. She suggested several people who may have more information: Dora Ohnesorgen of Benson; Kathleen Shull, a reported for the *San Pedro Valley News Sun* newspaper; Win Bundy, historian and owner of the Singing Winds Book Shop located north of Benson; and, Jack Smallhouse.

San Pedro Valley News Sun,
Kathleen Shull
Reporter
520-586-2873

Ms. Shull wrote the story, "Beavers may return to the San Pedro River," for the "Seasons" quarterly edition of the *San Pedro Valley News Sun* [Seasons, May 14, 1997]. In this article she described the history of beaver trapping on the San Pedro River in the 1800's, and the Bureau of Land Management's plan to reintroduce beaver into the San Pedro Riparian National Conservation Area, located in the upper San Pedro River basin. She provided several potential contact, reference, and research ideas: the Pacheco sisters who live on Ocotillo Road in Benson (however, she noted that they did not want to be interviewed for her report); Lt. Emory's Journal (~1860's manuscript that contained surveys and pictures]; and, irrigation projects related to the Pomerane Dam.

Smallhouse, Jack,
Bayless Ranch
Redington, AZ
520-212-5225

Mr. Smallhouse had a variety of historical maps and photographs that showed the San Pedro River in the vicinity of the Bayless Ranch south of Redington. He made these maps and photographs available to the AZGS, and helped Michelle Wood field verify the current conditions of the San Pedro River in the areas shown on the maps and photographs. Refer to the main text for a more detailed description of the maps and photographs.

Mr. Smallhouse recommended that we contact Dr. Meyers of Oracle because Dr. Meyers had a photograph hanging on his wall that showed the confluence of the San Pedro and Gila rivers at ~1900. He believed that this photograph indicated that the San Pedro River was not channelized at that time.

Smith, John,
Marana, AZ
Smith Farms
520-568-2261

Mr. Smith is a rancher and amateur historian of the lower San Pedro River area with a life-time's experience in water issues along the San Pedro (i.e. he was on the board of the Central Arizona Project and the Maricopa Irrigation District). He bought his property along the San Pedro River during the 1960's. He described channel changes of the lower San Pedro River that occurred during the last three decades. He observed that the 1983 flood event "swept the channel clean." He also said that the San Manuel mine uses some of the river water; otherwise, there were few other water uses that would affect the river's flow.

Mr. Smith took Michelle Wood on a survey of the river channel, historical structures, and the approximate location of former irrigation ditches constructed in the 1870's and 1880's on his property, his son's property, and their leased property along the lower San Pedro River. In addition, Mr. Smith showed her the historical maps that he had collected. Relevant information gathered from the maps and field visit is described in the main text. He said that he would make available the interviews he collected when he was resolving water rights for his property, and that he would provide a good contact at the mining company, American Smelting, to research the information the company contains in its water rights research files. He recommended that AZGS contact Kip Gambee at ASARCO.

Spiess, Michael E.,
Tucson
7732 North Red Wing Place
Tucson, AZ 85741
520-889-8989

Mr. Spiess responded to our mass-mailing letter. He bought property, located five miles below the hard-rock crossing near the Aravaipa-San Pedro confluence, from the Ragsdale family. He thought that the children of the previous owner had grown up on that property and that they might have the type of information needed for this project. He could not remember phone numbers of the children; however, Mr. Spiess remembered that the son of the original owner had moved to Mesa, and that one of the daughters, Ethel Stalnaker, had moved tot he Phoenix area. We were unable to locate the original owners' location based on Mr. Spiess' information. Mr. Spiess said he would research his files and get back to us.

Mr. Spiess described the more recent channel changes of the San Pedro River in the area of the Aravaipa-San Pedro confluence. He had observed that the river has been consistently moving westward and straightening out its curve. He said that the 1983 flood flow filled the old channel.

Statistical Research,
Jeff Altschul
520-721-4309

Taylor, Mary,
Redington, AZ
520-212-1314

Ms. Taylor wrote *A Bare Bones Account of Significant Happenings Along the San Pedro River,* based on oral histories she gathered from people who lived in her region. She found that people were too old to remember details about the river, were too poor to own camaras, or the pictures they took were not of the washes and river.

Ms. Taylor recommended that we research the history of the Soza Family and the C-Spear Ranch. She also recommended that we contact: the Bidegain family of Elgin; Ernest Sherman in Pomerane; the Ohnesorgen family of Benson/Tres Alamos; Johnnie Levine, the current manager of the C-Spear Ranch; and, Mary Beth and Ray Dawson, who are amatuer archaeologists and residents of the area.

Tombstone Courthouse State Historic Park,
Hollis N. Cook
Park Manager
P.O. Box 216
Tombstone, AZ 85638
520-457-3311

USDA Agricultural Research Service,
Russell Scott
Hyrologist
520-670-6380

University of Arizona,
Dr. Vance Haynes
Deparment of Anthropology
520-621-6307

University of California - Davis,
Conrad Bahre
916-752-0798

Dr. Bahre, who wrote the book Legacy of Change, was contacted in an attempt to locate the original 1901 survey conducted by D.A. Griffiths (Agricultural Experimental Research Station, Tucson) that interviewed C.H. Bayless. Dr. Bahre said that if they still existed, the notes would be archived in disorganized boxes at the University of Arizona Agricultural

Experiment Station, or perhaps in Washinton D.C. He recommended that AZGS contact Diane Hadley.

Walkner, Red,
long-time resident of the San Pedro River valley
520-473-2143 (SAS Industrial Maintainance, field office)

While Mr. Walkner was not old enough to remember the San Pedro River as it was in the earlier part of the century, he was able to recommend a few people that AZGS could contact. He refered us to: Edward Owens of BHP Copper in San Manuel, who grew up on the river near Mammoth; Jim Ragsdale, Jr., son of Mr. Ragsdale Sr. who once owned land along the river; and, his own sister, Nancy McKlinnen (520-357-6832), who would know the current location of the Ragsdale family as well as other people we could contact.

Mr. Walkner also suggested that AZGS research the history of Barkersville, the community that once existed on the western side of the San Pedro River across from Dudleyville (i.e. the location of the old school house, cemetary, and stage stop for the stage route to Florence).

Water Resources Research Center,
Barbara Tellman
University of Arizona

Dr. Tellman referred me to Julia Fonseca (Pima County Flood Control District), Mary Taylor, (author of *A Bare Bones Account of Significant Happenings Along the San Pedro River*, and Francaviglia's article in the *Cochise Quarterly* entitled, "The Upper San Pedro River Valley: A Century of Environmental Change."

Zarbin, Earl,
Phoenix
3803 E. St. Catherine Ave.
Phoenix, AZ 85040
602-437-2665

Included as an Attachment and as Part of Item 006 in the San Pedro River Case

ORIGINAL

RECEIVED 7-22-96

Winkelman Natural Resource Conservation District

96 - 004 - 001
SAN PEDRO
RIVER

July 17, 1996

Navigable Stream Adjudication Commission
1700 West Washington
Room 404
Phoenix, AZ 85007

Re: Statement Re: San Pedro River

To The Commission:

This statement is made on behalf of the Winkelman Natural Resource Conservation District, an agency of the Arizona State Land Department.

Our membership is composed of ranchers, farmers and other agricultural related persons. Many of our members have lands along the San Pedro River. It is the overwhelming consensus that the San Pedro River has never been a "navigable" waterway. Personally, my own family settled outside of Mammoth, Arizona in the 1880's, and a portion of our ranch is on the San Pedro. In all my family history there has never been a report of the San Pedro being used as a navigable waterway.

This issue was discussed this date at the quarterly meeting of the WNRCD, with approximately 30 people in attendance. The membership agreed to submit this letter as part of the evidence you will review concerning the San Pedro River. If you have any questions, please contact me.

Sincerely,

Virgil E. Mercer

Virgil E. Mercer
Chairman

6-II-4

Virgil E. Mercer, Chairman, P.O. Box 158, Mammoth, AZ 85618
Voice (520) 487-2431, Fax (520) 487-2270

33d Congress, 2d Session. | SENATE. | Ex. Doc. No. 78.

96 - 004 - 002
SAN PEDRO
RIVER
001

ORIGINAL

RECEIVED
10-10-96

REPORTS

OF

EXPLORATIONS AND SURVEYS,

TO

ASCERTAIN THE MOST PRACTICABLE AND ECONOMICAL ROUTE FOR A RAILROAD

FROM THE

MISSISSIPPI RIVER TO THE PACIFIC OCEAN.

MADE UNDER THE DIRECTION OF THE SECRETARY OF WAR, IN

1853-4,

ACCORDING TO ACTS OF CONGRESS OF MARCH 3, 1853, MAY 31, 1854, AND AUGUST 5, 1854.

VOLUME I.

WASHINGTON:
BEVERLEY TUCKER, PRINTER.
1855.

Exhibit 1

The region between the Rio Grande and the Pimas villages on the Gila, just above which point the latter leaves the mountain region, may be described as a great plain, interrupted irregularly and confusedly by bare, rugged, abrupt, isolated mountains or short ranges, around or through the passes in which a railroad may be constructed with quite practicable grades. The mean elevation of this plain, or series of basins into which the ridges divide it, is about 4,100 feet; the mean elevation of the summits of the passes through the ridges is 4,700 feet, the highest, through the Chiricahui range, being 5,180 feet. Except through the passes, the surface is so smooth as to require but little preparation to receive the superstructure of a railroad; and even in the two most difficult of the passes, the natural slope of the ground may be used for a railroad until the construction of the road reduces the cost of materials and supplies to the lowest rates. In one of these two passes (the Chiricahui) the steepest natural slope is 194 feet per mile for 2¼ miles. In the second pass the steepest natural slope is 240 feet per mile for three-fourths of a mile. Both these grades are within the power of a thirty-ton engine, carrying 200 passengers and baggage.

In one case deep cutting in rock, or a tunnel near the surface, at the summit, with heavy side cutting and high embankments for short distances; and, in the other, a short cut of 60 feet, probably through rock, are proposed by Lieut. Parke, to attain grades of 45 feet and 90 feet per mile, or less by increasing distance.

The great difficulty experienced in crossing this district is in the long distances over which no water is found at certain seasons. The survey by Lieut. Parke was made during the dryest season of the year, and, irrespective of the springs found at intermediate points, the whole distance between the two rivers, Rio Grande and Gila, may be divided into five spaces, varying from 80 to 53 miles in length, at the termination of which large permanent supplies of water are found at the most unfavorable season of the year.

These spaces and points are—

From the Rio Grande to the Rio Mimbres	71 miles.
From the Rio Mimbres to the stream of the Valle de Sauz	72 "
From the Valle de Sauz to the San Pedro	80 "
From the San Pedro to Tucson	53 "
From Tucson to the Gila	79 "

Not counting the stream of the Valle de Sauz, the distance from the Rio Mimbres to the San Pedro is 152 miles; which distance is not so great that railroad trains could not cross it without water, special arrangements having been made for the purpose. But this is the worst aspect of the case. At other seasons the supply of water is more abundant, and lakes and ponds are formed upon the plains, which may be drained into tanks; and the geological formation is such as to indicate the existence of sufficient supplies of water beneath the surface, which may be brought to it by artesian wells.

The line proposed by Lieut. Parke leaves the Rio Grande near Fort Fillmore, 35 miles from Molino, between which points the river, where confined to one channel, is about 300 yards wide, crosses the district just described, and enters the valley of the Gila near the Pimas villages, the elevation above the sea being 1,365 feet. The route then follows this river to its junction with the Colorado, a distance of 223 miles, with a general slope of 5.6 feet per mile. The Gila, in this distance, flows through a plain with occasional mountains, ridges, and peaks; its valley is highly favorable to cheap construction from its generally smooth surface, and from not being liable to freshets.

From the point now attained, the nearest port in our territory is San Diego, but the passes of the intervening Coast range are very difficult, if not impracticable, and the route is forced northward to the San Gorgonio Pass, which is much the most favorable of the passes in the Coast range explored by Lieut. Williamson for this route. It is an open valley, from two to five miles wide, the surface smooth and unbroken, affording, in its form and inclination, every facility to the building of a railroad. The entrance of this pass is 133 miles from the mouth

33d Congress, 3d Session. } HOUSE OF REPRESENTATIVES. { Ex. Doc. No. 91.

96 - 004 - 002
SAN PEDRO
RIVER
002

ORIGINAL

RECEIVED 10-10-96

REPORTS

OF

EXPLORATIONS AND SURVEYS,

TO

ASCERTAIN THE MOST PRACTICABLE AND ECONOMICAL ROUTE FOR A RAILROAD

FROM THE

MISSISSIPPI RIVER TO THE PACIFIC OCEAN.

MADE UNDER THE DIRECTION OF THE SECRETARY OF WAR, IN

1853-4,

ACCORDING TO ACTS OF CONGRESS OF MARCH 3, 1853, MAY 31, 1854, AND AUGUST 5, 1854.

VOLUME II.

WASHINGTON:
A. O. P. NICHOLSON, PRINTER.
1855.

Exhibit

analogous to a meteoric mineral that I described as forming the chief part of the Bishopsville (S. C.) meteoric stone. It is this feature that makes your iron entirely peculiar. To see this trait, you have only to polish a little surface, and etch with hydrochloric acid, when the surface becomes speckled over with the white earthy mineral, imparting to it a porphyritic character; but to see this *well*, will require the aid of a microscope.

"Large quantities of the white mineral remain undissolved after the solution of the main mass in the acid; and floating among the residuum may be seen also a dark gray flocculent matter, which I took to be the meteoric mineral I have named Dyslytite. Much of the white earthy mineral is thus seen to be in grains, perfectly rounded; some of which are transparent and resemble hyalite; other portions of them are milk-white and nearly opaque. These last are soft, and precisely resemble chladnite."

February 22.—Again got under way, starting about noon; but, instead of taking the emigrant route via the mission of San Javier del Bac to the Cienega de los Pimas, thereby making a great détour, travelling first south, and then due east, we took a course direct for the gap, there intervening apparently a smooth and uniformly ascending plain; camped without water, but an abundance of grass. The officers of the garrison, and Inspector General Gomez, accompanied us to the camp; thus adding another to the list of polite attentions and serviceable offices rendered us by these gentlemen, for which we are under many obligations.

February 23.—Soon after leaving camp this morning, we were compelled to diverge from our course, owing to the thick growth of cactus, and were finally compelled to cut a road through it. Reaching the emigrant road, we turned almost due east, and travelled over an undulating country, the swells increasing as we neared the entrance of the gap, where we encountered a cañon debouching from this pass and opening out into a broad drain or valley to the northwest. Entering this cañon we commenced its ascent, travelling through deep and heavy sand, alternating with contracted meadow patches, hemmed in by walls, approaching verticality, of irregular, shapeless masses of rock, generally of a metamorphic character; limestone, granite, copper-green, and a pudding-stone, all being found without any marked characteristics or apparent order of superposition. Camped at the first water, with grass and wood, having made 18.4 miles.

February 24.—Made an examination of the country adjacent to the camp, and found that this cañon is the main drain of the gap or depression, and that the slopes on either side are rough and broken up by deep ravines and washes. Our teams started at nine and a half, and were soon forced to the hills by the narrowing of the cañon, rendering it impassable for wagons without much labor bestowed on removing the obstacles. Avoiding this cañon by a rough and rugged road, we again entered the valley, and thus continued through long, smooth meadows, and over rough and steep pitches (fortunately not high) for nine miles, when we ascended the table-land on our left and commenced the approach to the divide, following a set of wagon-trails. On the table-land had a good road over a red gravelly soil of decomposed igneous rock, yielding a rich growth of grama grass, which, although not in season, is nevertheless very nutritious, being perfectly cured hay, standing as it grew. Camped near the divide between the waters of the Tuczon and those of the San Pedro, without water and but little wood, having made 13.5 miles.

February 25.—Last night was cold and squally, a rain setting in immediately after dark. Started early and soon made the summit of the divide, whence we had a view of the San Pedro valley—a dry, parched-looking plain, bounded on the east by a low, bare ridge, beyond which loomed up in the blue distance the Dos Cabezas, the most striking and prominent landmark in this region. The trail bearing too much to the south, we left it, and turning eastward descended to the San Pedro, where we camped. From the summit there is a gradual slope to the valley proper, or bottom, which we entered by an abrupt descent of about sixty feet. This bottom is bounded on both sides by an irregular zigzag step, much indented by deep washes, and is at this point about three miles wide. It is covered with a growth of grass, now dry and

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

February 26.—Started down the stream about two miles to the ford, Lieutenant Stoneman having despatched a fatigue party to improve it; but in spite of this and the great exertion of Lieutenant S., we had no little trouble in effecting a crossing. There being no trail leading eastward from the river, the party again encamped, while I started to examine the several gaps in the ridge on our front. Leaving the river-bottom, we followed up a lateral valley; but finding it narrowing as we advanced, becoming a tortuous dry sand-bed or arroyo, bounded by steep slopes, we took to the table-land; and after a few miles of rough riding reached the gap immediately to the east of our camp, and found it not only impracticable for our wagons, but presenting no advantages for our profile beyond the mere direction. We then skirted the western base of this ridge southerly, and found a cañon leading directly through it, with walls of rounded masses of granite, which formed in many places, also, quite a step-like bottom. Passing through this cañon, we continued on the east slope, southward, and found that the ridge terminated, leaving a very inviting and apparently feasible pass between it and the terminus of an overlapping ridge from the south. In this pass we found comparatively fresh wagon-trails. Returned by following these trails to the river, and thence down to camp, arriving at midnight with our mules broken down.

February 27.—Lieutenant Stoneman and myself examined the fourth gap on the north of those examined yesterday, through which I am now satisfied that Mr. Nugent must have passed. We found the approaches difficult and hazardous to attempt with loaded wagons, according well with Mr. Nugent's notes: "a succession of steep hills and rocky ravines."

From the river bottom to the base of this ridge extends a foot-slope, appearing as if once smooth and of uniform ascent, but now cut up into a perfect labyrinth of washes and gullies, ramifying and branching into a multitude of arms as we ascend. Returning to camp, I determined to take the gap through which we passed last night. Packing up, we followed the river until striking the wagon trails, then turned eastward up a large sandy ravine, and camped at sundown without water, but a sufficiency of grass. Made fourteen miles.

February 28.—Left the ravine near the mountains, the road leading over a smooth, rolling, prairie-like surface through the pass, the summit of which we reached at 11 o'clock. Before us lay an extended plain, in the middle of which is the Salt lake, Playa de los Pinas, and beyond this the Chiricahui ridge, with its lofty Dos Cabezas; to the north the massive Mount Graham, with an apparently continuous ridge extending northwestward till lost below the horizon. Between this ridge and that over which we have just passed there is a wide opening towards the mouth of the San Pedro, apparently a continuation of the plain Playa de los Pinas. To the north of the Chiricahui ridge is a wide gap between it and Mount Graham; and immediately to the south of the Dos Cabezas is a third gap, Puerto del Dado, which is very inviting, and, lying directly on our course, I determined to travel through it.

From the summit we had a perfectly smooth road over a reddish soil, covered with grass, and devoid of trees with the exception of a few scattering palmettos down to the Playa, which, at present, is a hard, smooth, and apparently level area of about fifteen miles in length by nearly ten in width, without a particle of vegetation, it being the perfection of sterility. These playas, in my opinion, have no outlet, and are so nearly level that the rain and drain waters are spread over a large surface; and there being but little absorption and very rapid evaporization, it is left smooth and baked. In some places it is much cracked, and covered by a nitrous efflorescence, which gives rise to the ordinary name for all like places—"Salt lake." On the Playa we crossed two very large trails leading from south to north, doubtless those of

face, or mesa, has an average altitude above the river-bottom of three to six hundred feet, and is connected with it by an irregular slop of a loose, light soil, extending to a point opposite, and a short distance below Fort Fillmore, where, in place of the deep-washed, loamy slope, is found an outcrop of a black, igneous rock, with a foot-slope of its angular debris. To descend to the river-bottom will require a diagonal trace, hugging the mesa slope, until a distance is made sufficient to overcome the difference in altitude; the direction of this depending upon location of route to the eastward, whether leaving the valley at the pass near Doña Ana, or on the south at El Paso.

The supply of timber along the route is very limited. Cotton-wood, the only growth of size sufficient to answer the purposes of sills, is found in but four localities; on the Gila, at Tucson, on the Mimbres, and Rio Bravo. Water being so essential to the very existence of this tree, it only grows on the banks of streams, and disappears with the sinking of the waters, as is the case at Tucson and Rio Mimbres. At Tucson I was informed that a variety of the pine is found in the cañadas of Sierra de Santa Catarina to the east and northeast of the town. In the mountains, about fifteen or twenty miles north of the crossing of the Mimbres, the pine also exists. But the plains are entirely destitute of trees of any description, and the mountains have a general appearance of sterility and ruggedness, yielding in the concealed nooks and valleys a meagre growth of cedar and dwarfish evergreen oak.

The rocks are generally of a metamorphic character, but there is found at many points along the line stone answering well the purposes of construction. Granite appears in the Cienega de los Pimas, in the ridge to the east of the San Pedro, outcropping in the Puerto del Dado, and overlying masses of secondary limestone in the ridge east of the Valle de Sauz. Sandstone and limestone are both found in the Puerto del Dado. Near the Rio Bravo both limestone and gypsum are found, the veins or seams of the anhydrous variety of the latter being exposed in the clayey walls of the ravine leading down to the river.

There is a great scarcity of water along the line, there being but nine localities where the supply could be said to be permanent. These are: 1st, at Tucson—a clear running stream, but disappearing a few hundred yards below the town; 2d, in the Cienega de los Pimas—fine springs, but the water soon sinks into the sand, as is the case at camp No. 16; 3d, the Rio San Pedro, a turbid stream, winding its way to the Gila; 4th, a spring near camp No. 22, in the Puerto del Dado—the water cold and very palatable, but the supply very limited, our animals having entirely exhausted the basin before they had a sufficiency; 5th, in the bottom of the Valle de Sauz—a stream of clear but slightly brackish water, spreading out into a marsh and extending towards the Gila in a succession of pools; 6th, a hole near camp No. 25, where, although the water rose in the bottom, still every other feature would indicate that a blind drain of mere surface-water had been tapped; 7th, the Ojo de Vaca—a spring of slightly sulphureous water, rising in the open plain and forming a marsh, beyond the limits of which there is no appearance or indication of the existence of water; 8th, Rio Mimbres—a rippling mountain stream of clear cold water at the crossing, being the more beautiful from the contrast with the state of things a few miles below, where the water is absorbed by the parched plain, the trees disappear, and there is nothing left but the dry, gaping bed; 9th, Cook's spring—is of similar character to the Ojo de Vaca, and bears more of a resemblance to a pond-hole than to a spring.

In addition to the above constant waters, there are holes or depressions on the plains intervening, which are filled by the rains of the wet season, and thus often afford relief to the anxious and solicitous traveller. These holes are lined with a clay allowing but little absorption; but, being generally shallow and broad-surfaced, evaporization soon empties them of that necessary which one requires, but has to be deprived of in order fully to appreciate it.

At Tucson the rainy season commences in April, and continues for three or four months; so that the emigrant who passes this point during the summer months finds himself in this country in the most favorable season with water abundant and grass green and nourishing, whereas we were there, and *en route*, about the end of the dry season, as our experience proved, meeting

IN THE SUPERIOR COURT OF THE STATE OF ARIZONA

IN AND FOR THE COUNTY OF MARICOPA

96 - 004 - 002
SAN PEDRO
RIVER
003

ORIGINAL RECEIVED 10-10-96

MARICOPA COUNTY, et al. and ARIZONA CENTER FOR LAW IN THE PUBLIC INTEREST, et al., and CALMAT CO. OF ARIZONA, et al.,

Plaintiffs-Intervenors,

vs.

STATE OF ARIZONA, ARIZONA STATE LAND DEPARTMENT, M. JEAN HASSEL, and MILO J. HASSELL, et al.,

Defendants.

NO. C 569870

DEPOSITION OF JIM SLINGLUFF

NOVEMBER 23, 1987

TUCSON, ARIZONA

BOULEY, SCHLESINGER, DI CURTI & SCHIPPERS
Registered Professional Reporters
601 Pioneer Plaza
100 North Stone Avenue
Tucson, Arizona 85701
(602) 623-7573

Exhibit

A This are my mine, but I focused in on the, I would use that as my base mark, the six class thing.

Q The International Rating Scale?

A Correct.

Q I wonder if you can tell me -- most of these streams if not all of the streams that you've included in your affidavit and that we have talked about here today are in at least north-central Arizona. Are there any streams in southern Arizona that you canoe at all?

A I have had, now I have had my eye on the San Pedro, the section that the feds just took control of for their project down there between -- what is it -- it is from Sierra Vista to Bisbee. I have scouted that at a couple points, and I believe it's boatable by my level of boating. But I have not in fact boated it.

Q Can I stop you and ask you to either use this map or some other map --

A Use this map.

Q -- and just try to describe generally for the record -- since this isn't an exhibit, maybe you can show me where that is.

MR. KOLSRUD: For the record, you are referring to the Arizona Highway Map?

THE WITNESS: Yes.

AFFIDAVIT

ORIGINAL

RECEIVED 10-10-96

96 - 004 - 002
SAN PEDRO
RIVER
004

STATE OF ARIZONA)
) ss
County of Pima)

My name is James Anthony Slingluff. I have twenty-two years of canoeing experience. I have canoed extensively in Arizona since 1984.

I have canoed each of the following sections of Arizona rivers on multiple occasions (exceptions noted) and believe each to be very suitable for river travel in the seasons indicated at the boating skill level noted.

1. Salt River:

A. Highway 60 bridge to Horseshoe Bend; all seasons; intermediate boating skills.

B. Horseshoe Bend to Highway 288 bridge; all seasons; beginning boating skills.

C. Stewart Mountain Dam to Granite Reef Dam; subject to dam releases (ordinarily in summer); beginning boating skills.

2. Verde River:

A. Perkinsville to TAPCO power plant (Clarkdale); all seasons; beginning boating skills (except for two particular rapids).

B. Dead Horse Park to Thousand Trails Campground; Fall/Winter/Spring; beginning boating skills.

C. Beasely Flat to Childs; Fall/Winter/Spring; intermediate boating skills.

Exhibit 4

D. Childs to Horseshoe Lake; Fall/Winter/Spring; beginning boating skills.

3. Little Colorado River, Grand Falls to Black Falls; snowmelt, monsoons; beginning boating skills.

4. Wet Beaver Creek:

A. Ranger Station to Montezuma Castle, one trip; snowmelt, monsoons; advanced boating skills.

B. Montezuma Castle to confluence with Verde; snowmelt, monsoons; beginning boating skills.

5. Dry Beaver Creek, Highway 179 to Interstate 17, one trip; snowmelt, monsoons; intermediate boating skills.

6. Oak Creek:

A. YMCA Camp to Page Spring, one trip; snowmelt, monsoons; intermediate boating skills.

B. Page Spring to Cornville; Fall/Winter/Spring; beginning boating skills.

C. Cornville to confluence with Verde; all seasons; beginning boating skills.

I have encountered other recreationists (boaters, hikers, and/or fishermen) on all the aforementioned sections of the Salt, Verde, Little Colorado, Wet Beaver, Dry Beaver and Oak Creek.

Further affiant saith not.

Dated this 15 day of July, 1987.

James Anthony Slingluff

Subscribed and sworn to before me this 15th day of July, 1987.

Lela R. Chapman

Notary Public

My commission expires: My Commission Expires February 5, 1989

96 - 004 - 002
SAN PEDRO
RIVER
005

ORIGINAL

ARIZONA CENTER FOR LAW IN THE PUBLIC INTEREST

1840 East River Road
Suite 207
Tucson, Arizona 85718-5892
(520) 529-1798
FAX (520) 529-2927

RECEIVED 10-10-96

October 10, 1996

BY FAX (602) 542-9220

Chistina Waddell
Stream Adjudication Commission
1700 West Washington, Room 404
Phoenix, AZ 85007

RE: San Pedro River evidence

Dear Ms. Waddell:

We offer the following evidence regarding navigability of the San Pedro River:

1. Government surveys from the 1850's describe the San Pedro as a "permanent" river with a flow about 18 inches deep and 12 feet wide. Exhibit 1 (attached hereto); Exhibit 2.

2. An experienced Arizona river runner believes the San Pedro is currently boatable at times on the stretch from Sierra Vista to Benson. Exhs. 3 & 4.

3. Please incorporate by reference Exhibit 2 from our January 13, 1994 Exhibits Submitted in Admin. Docket No. 94-1 on the Salt River. That Exhibit is a 1978 U.S. Fish and Wildlife Service paper entitled: "Methods of Assessing Instream Flows for Recreation."

Sincerely,

David S. Baron
Assistant Director

Printed on recycled paper.

ARIZONA CENTER FOR LAW IN THE PUBLIC INTEREST

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Tucson, Arizona 85718-5892
(520) 529-1798
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FROM: David Baron

TO:
Christina Waddell 602-542-9220

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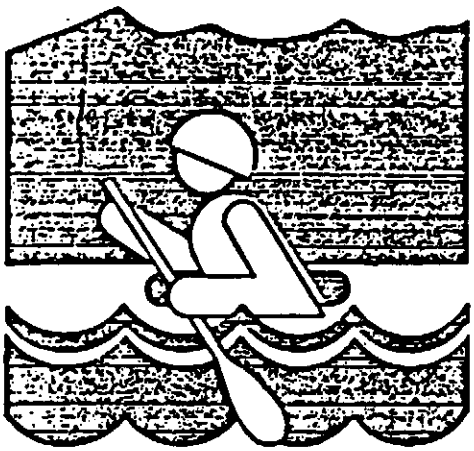

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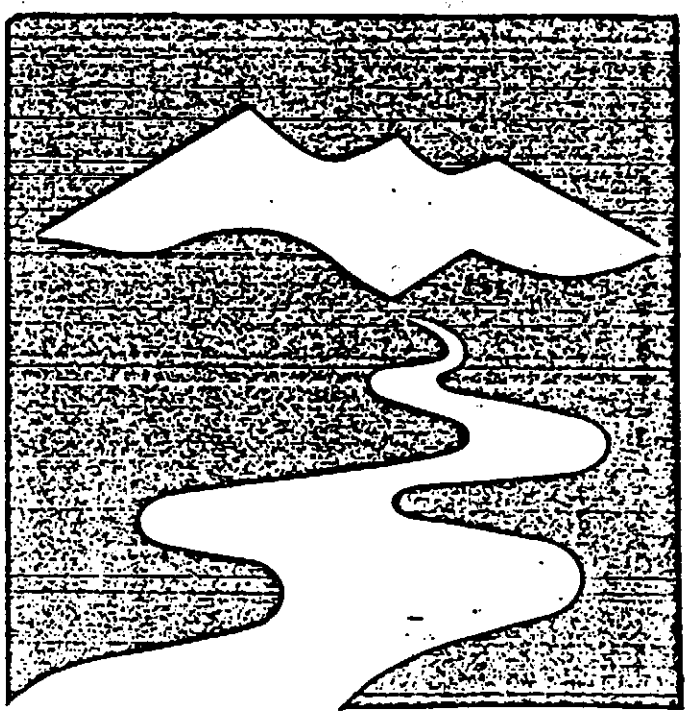

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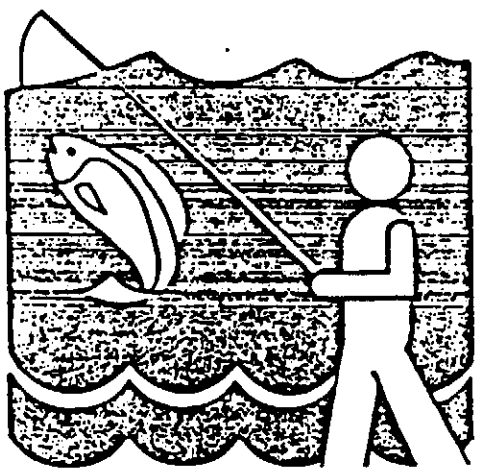

Cooperating Agencies:

Fish and Wildlife Service
Environmental Protection Agency
Heritage Conservation and Recreation Service
Bureau of Reclamation

FWS/OBS-78/34
June 1978

METHODS OF ASSESSING INSTREAM FLOWS FOR RECREATION

Instream Flow Information Paper No. 6

by

Ronald Hyra[1]
Cooperative Instream Flow Service Group
Creekside Building
2625 Redwing Road
Fort Collins, Colorado 80526

This study was financed in part through the Water Resources Council under provisions of the Federal Non-Nuclear Energy Research and Development Act of 1974

Cooperative Instream Flow Service Group
Western Energy and Land Use Team
Office of Biological Services
Fish and Wildlife Service
U.S. Department of the Interior

[1]Detailed to the Cooperative Instream Flow Service Group from the Heritage Conservation and Recreation Service.

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ABSTRACT

The Instream Flow Group (IFG) has conducted research into methods of quantifying instream flow needs for fish, wildlife, and recreation. This paper describes two techniques developed by IFG for performing recreational instream flow studies. The single cross section method is relatively simple and provides a base flow figure which will provide for the boating activities which make use of the of river. The incremental method is more sophisticated and may be used to develop recommendations regarding streamflows required for various types of recreation, or to provide a recreation analysis of any streamflow. Streamflow suitability criteria for recreation are presented for both methods.

INTRODUCTION

It has been long recognized that there are many competing demands for the use of stream water. Diverting stream water for irrigation, water supply, and energy developments can deplete streamflows to the point where opportunities for recreation and the associated environmental values of the stream are seriously impaired. Numerous water planning studies, both basin-wide and project oriented, have emphasized the need to quantify the amount of water required to support recreation, fish and wildlife resources, and to maintain aesthetic conditions.

The tools and techniques for estimating streamflows required for recreation and aesthetics, and for insuring reasonable consideration of recreation and aesthetics in the allocation of stream water, are currently undergoing study. Instream flow requirements and values for recreation, in the past, have often been based only upon the amount required to maintain a fishery. However, several studies have indicated that recreation and aesthetic requirements, at times, may not be the same as for a fishery.

This paper presents the techniques of assessing instream flows for recreation. These techniques were developed by the Cooperative Instream Flow Service Group and closely parallel techniques used to assess instream flows for fisheries. The data collection procedures, the physical and hydraulic simulation of the stream, and the computer models which analyze the data are the same for both fisheries and recreation. The major difference between the two techniques is the response of the individual fish or recreationist to various physical parameters of

stream flow. These responses to stream flow by different user groups are the criteria which are basic to the methods introduced here.

The first method is called the single cross section approach. This method is useful primarily for identifying flows below which a recreation activity is not feasible and results in a so called "minimum" flow recommendation.

The second method is called the incremental method. With this method the recreation planner is able to analyze various flows and determine the recreation potential of a stream at different flows.

This paper is being distributed with four objectives in mind. These are:

1. To bring the problem of preserving instream flows to the attention of recreation agencies and the research community in order to encourage more research in this vital and neglected area.

2. To discuss the development of the recreation probability-of-use curves and of recreation criteria in general, which are necessary for quantifying instream water requirements for recreation.

3. To obtain review and comment on the recreation criteria and probability-of-use curves, and to request data which may be used to test or improve the criteria or curves.

4. To describe the two approaches for assessing stream flows and discuss how various recreation planning processes can be served by their application.

Both methods of instream flow analysis discussed in this paper utilize computer modeling techniques. Both approaches also require that streamflow data be collected. The single cross section approach, as its name implies, requires that information be collected at only one location on the stream. The incremental method requires that data be collected at multiple locations on the stream. In addition to cross sectional data, data relating the streamflow parameters to recreation potential are necessary. These data are termed recreation criteria.

Recreation criteria for instream flow methodologies are the recreation activity information bases necessary to describe a relationship between the quantity of water flowing in a stream, and the quantity and

quality of a particular recreation activity which takes place in the stream.

SINGLE CROSS SECTION METHOD

This method requires that only a single cross sectional measurement be taken across a stream. The product of such an approach is a determination of the lowest flow acceptable for recreation. The approach is based on the assumption that a single cross section, properly located, can define a minimum flow requirement. Such a cross section is located at an area displaying the least depth across the entire stream. When this area provides minimum depths for boat passage, the flow at this level may be defined as a minimum acceptable flow. It is assumed that when sufficient water to support boating is available in these critical areas, other areas will have sufficient water to support most of the other instream recreation activities. This approach is best applied to those streams in which flows are expected to be higher than the minimum most of the time.

Criteria for this approach are set forth in Table 1. Criteria have been developed for boating activities only, but for various types of boating craft. Only minimum criteria are presented because this approach provides information on "minimum flows." Criteria are measured in terms of stream depth and width. Velocity is not considered because a minimum velocity is not considered necessary for this approach.

Table 1. Required stream width and depth for various recreation craft as determined by single cross section method.

Recreation Craft	Required depth (ft)	Required width (ft)
Canoe-kayak	0.5	4
Drift boat, row boat-raft	1.0	6
Tube	1.0	4
Power boat	3.0	6
Sail boat	3.0	25

The criteria of Table 1 are minimal and would not provide a satisfactory experience if the entire river was at this level. However, the cross section measured for this method is the shallowest in the stream reach. Therefore, these minimum conditions will only be encountered for

a short time during a boating trip, and the remainder of the trip will be over water of greater depths and widths. An important assumption is that all water greater than the minimum is equally useful for the activity (i.e., more is better until bank-full stage).

A computer program (IFG-1) has been developed which predicts width and depth across the transect of any stage (water surface elevation). The output shows discharge and the width with depth equal to or greater than a specific depth. Different water surface elevations may be put into the computer model which are translated into flow in cubic feet per second. When a flow provides the minimum width and depth necessary for an activity, discharge may be considered minimum. Such a minimum indicates that significant losses, if not elimination of this activity, will occur if minimum flow is not equaled or exceeded.

THE INCREMENTAL METHOD

This method, more sophisticated than the single cross section method, describes a relationship between the amount of water in a reach of stream and the associated recreation potential. The incremental method can describe the potential for any recreation activity at any streamflow. A major difference between the methods is that the single cross section method can only be used to identify low flow and cannot be used to assess the recreation potential at any other flow; the incremental method can be used to assess the potential at other flows or to calculate the change in receation potential caused by a change in stream flow..

The incremental method involves a modeling procedure whereby the surface area of a stretch of stream is calculated. In addition to the total surface area of the reach of stream, the area which has certain depths and velocities is calculated. The usable surface area for each activity is then calculated by use of depth and velocity requirements.

It is necessary to make three assumptions regarding the relationship between the quantity of water and the recreation uses of the water: (1) water depth and water velocity are the two streamflow components which are most important in determining whether or not a certain recreation activity may be safely and pleasurably engaged in[1]; (2) there are

[1]Other parameters such as water quality and temperature are also very important in determining the amount of instream recreation use but in many cases are not significantly influenced by flow. Width is also important but is considered outside of the computer model (i.e., width is not a part of the calculation of usable surface area).

ATTENTION:

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ANSAC STAFF

ARIZONA CENTER FOR LAW IN THE PUBLIC INTEREST

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(520) 529-1798
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FAX (520) 529-2927

October 10, 1996

BY FAX (602) 542-9220

Chistina Waddell
Stream Adjudication Commission
1700 West Washington, Room 404
Phoenix, AZ 85007

RE: San Pedro River evidence

Dear Ms. Waddell:

We offer the following evidence regarding navigability of the San Pedro River:

1. Government surveys from the 1850's describe the San Pedro as a "permanent" river with a flow about 18 inches deep and 12 feet wide. Exhibit 1 (attached hereto); Exhibit 2.

2. An experienced Arizona river runner believes the San Pedro is currently boatable at times on the stretch from Sierra Vista to Benson. Exhs. 3 & 4.

3. Please incorporate by reference Exhibit 2 from our January 13, 1994 Exhibits Submitted in Admin. Docket No. 94-1 on the Salt River. That Exhibit is a 1978 U.S. Fish and Wildlife Service paper entitled: "Methods of Assessing Instream Flows for Recreation."

Sincerely,

David S. Baron
Assistant Director

Printed on recycled paper.

33d Congress, 2d Session. | SENATE. | Ex. Doc. No. 78.

REPORTS

OF

EXPLORATIONS AND SURVEYS,

TO

ASCERTAIN THE MOST PRACTICABLE AND ECONOMICAL ROUTE FOR A RAILROAD

FROM THE

MISSISSIPPI RIVER TO THE PACIFIC OCEAN.

MADE UNDER THE DIRECTION OF THE SECRETARY OF WAR, IN

1853-4,

ACCORDING TO ACTS OF CONGRESS OF MARCH 3, 1853, MAY 31, 1854, AND AUGUST 5, 1854.

VOLUME I.

WASHINGTON:
BEVERLEY TUCKER, PRINTER.
1855.

Exhibit 1

The region between the Rio Grande and the Pimas villages on the Gila, just above which point the latter leaves the mountain region, may be described as a great plain, interrupted irregularly and confusedly by bare, rugged, abrupt, isolated mountains or short ranges, around or through the passes in which a railroad may be constructed with quite practicable grades. The mean elevation of this plain, or series of basins into which the ridges divide it, is about 4,100 feet; the mean elevation of the summits of the passes through the ridges is 4,700 feet, the highest, through the Chiricahui range, being 5,180 feet. Except through the passes, the surface is so smooth as to require but little preparation to receive the superstructure of a railroad; and even in the two most difficult of the passes, the natural slope of the ground may be used for a railroad until the construction of the road reduces the cost of materials and supplies to the lowest rates. In one of these two passes (the Chiricahui) the steepest natural slope is 194 feet per mile for 2¼ miles. In the second pass the steepest natural slope is 240 feet per mile for three-fourths of a mile. Both these grades are within the power of a thirty-ton engine, carrying 200 passengers and baggage.

In one case deep cutting in rock, or a tunnel near the surface, at the summit, with heavy side cutting and high embankments for short distances; and, in the other, a short cut of 60 feet, probably through rock, are proposed by Lieut. Parke, to attain grades of 45 feet and 90 feet per mile, or less by increasing distance.

The great difficulty experienced in crossing this district is in the long distances over which no water is found at certain seasons. The survey by Lieut. Parke was made during the dryest season of the year, and, irrespective of the springs found at intermediate points, the whole distance between the two rivers, Rio Grande and Gila, may be divided into five spaces, varying from 80 to 53 miles in length, at the termination of which large permanent supplies of water are found at the most unfavorable season of the year.

These spaces and points are—

From the Rio Grande to the Rio Mimbres	71 miles.
From the Rio Mimbres to the stream of the Valle de Sauz	72 "
From the Valle de Sauz to the San Pedro	80 "
From the San Pedro to Tucson	53 "
From Tucson to the Gila	79 "

Not counting the stream of the Valle de Sauz, the distance from the Rio Mimbres to the San Pedro is 152 miles; which distance is not so great that railroad trains could not cross it without water, special arrangements having been made for the purpose. But this is the worst aspect of the case. At other seasons the supply of water is more abundant, and lakes and ponds are formed upon the plains, which may be drained into tanks; and the geological formation is such as to indicate the existence of sufficient supplies of water beneath the surface, which may be brought to it by artesian wells.

The line proposed by Lieut. Parke leaves the Rio Grande near Fort Fillmore, 35 miles from Molino, between which points the river, where confined to one channel, is about 300 yards wide, crosses the district just described, and enters the valley of the Gila near the Pimas villages, the elevation above the sea being 1,365 feet. The route then follows this river to its junction with the Colorado, a distance of 223 miles, with a general slope of 5.6 feet per mile. The Gila, in this distance, flows through a plain with occasional mountains, ridges, and peaks; its valley is highly favorable to cheap construction from its generally smooth surface, and from not being liable to freshets.

From the point now attained, the nearest port in our territory is San Diego, but the passes of the intervening Coast range are very difficult, if not impracticable, and the route is forced northward to the San Gorgonio Pass, which is much the most favorable of the passes in the Coast range explored by Lieut. Williamson for this route. It is an open valley, from two to five miles wide, the surface smooth and unbroken, affording, in its form and inclination, every facility to the building of a railroad. The entrance of this pass is 133 miles from the mouth

33d Congress, 3d Session. } HOUSE OF REPRESENTATIVES. { Ex. Doc. No. 91.

REPORTS

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VOLUME II.

WASHINGTON:
A. O. P. NICHOLSON, PRINTER.
1855.

Exhibit 2

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

February 26.—Started down the stream about two miles to the ford, Lieutenant Stoneman having despatched a fatigue party to improve it; but in spite of this and the great exertion of Lieutenant S., we had no little trouble in effecting a crossing. There being no trail leading eastward from the river, the party again encamped, while I started to examine the several gaps in the ridge on our front. Leaving the river-bottom, we followed up a lateral valley; but finding it narrowing as we advanced, becoming a tortuous dry sand-bed or arroyo, bounded by steep slopes, we took to the table-land; and after a few miles of rough riding reached the gap immediately to the east of our camp, and found it not only impracticable for our wagons, but presenting no advantages for our profile beyond the mere direction. We then skirted the western base of this ridge southerly, and found a cañon leading directly through it, with walls of rounded masses of granite, which formed in many places, also, quite a step-like bottom. Passing through this cañon, we continued on the east slope, southward, and found that the ridge terminated, leaving a very inviting and apparently feasible pass between it and the terminus of an overlapping ridge from the south. In this pass we found comparatively fresh wagon-trails. Returned by following these trails to the river, and thence down to camp, arriving at midnight with our mules broken down.

February 27.—Lieutenant Stoneman and myself examined the fourth gap on the north of those examined yesterday, through which I am now satisfied that Mr. Nugent must have passed. We found the approaches difficult and hazardous to attempt with loaded wagons, according well with Mr. Nugent's notes: "a succession of steep hills and rocky ravines."

From the river bottom to the base of this ridge extends a foot-slope, appearing as if once smooth and of uniform ascent, but now cut up into a perfect labyrinth of washes and gullies, ramifying and branching into a multitude of arms as we ascend. Returning to camp, I determined to take the gap through which we passed last night. Packing up, we followed the river until striking the wagon trails, then turned eastward up a large sandy ravine, and camped at sundown without water, but a sufficiency of grass. Made fourteen miles.

February 28.—Left the ravine near the mountains, the road leading over a smooth, rolling, prairie-like surface through the pass, the summit of which we reached at 11 o'clock. Before us lay an extended plain, in the middle of which is the Salt lake, Playa de los Pimas, and beyond this the Chiricahui ridge, with its lofty Dos Cabezas; to the north the massive Mount Graham, with an apparently continuous ridge extending northwestward till lost below the horizon. Between this ridge and that over which we have just passed there is a wide opening towards the mouth of the San Pedro, apparently a continuation of the plain Playa de los Pimas. To the north of the Chiricahui ridge is a wide gap between it and Mount Graham; and immediately to the south of the Dos Cabezas is a third gap, Puerto del Dado, which is very inviting, and, lying directly on our course, I determined to travel through it.

From the summit we had a perfectly smooth road over a reddish soil, covered with grass, and devoid of trees with the exception of a few scattering palmettos down to the Playa, which, at present, is a hard, smooth, and apparently level area of about fifteen miles in length by nearly ten in width, without a particle of vegetation, it being the perfection of sterility. These playas, in my opinion, have no outlet, and are so nearly level that the rain and drain waters are spread over a large surface; and there being but little absorption and very rapid evaporization, it is left smooth and baked. In some places it is much cracked, and covered by a nitrous efflorescence, which gives rise to the ordinary name for all like places—"Salt lake." On the Playa we crossed two very large trails leading from south to north, doubtless those of

face, or mesa, has an average altitude above the river-bottom of three to six hundred feet, and is connected with it by an irregular slop of a loose, light soil, extending to a point opposite, and a short distance below Fort Fillmore, where, in place of the deep-washed, loamy slope, is found an outcrop of a black, igneous rock, with a foot-slope of its angular debris. To descend to the river-bottom will require a diagonal trace, hugging the mesa slope, until a distance is made sufficient to overcome the difference in altitude; the direction of this depending upon location of route to the eastward, whether leaving the valley at the pass near Doña Ana, or on the south at El Paso.

The supply of timber along the route is very limited. Cotton-wood, the only growth of size sufficient to answer the purposes of sills, is found in but four localities; on the Gila, at Tucson, on the Mimbres, and Rio Bravo. Water being so essential to the very existence of this tree, it only grows on the banks of streams, and disappears with the sinking of the waters, as is the case at Tucson and Rio Mimbres. At Tucson I was informed that a variety of the pine is found in the cañadas of Sierra de Santa Catarina to the east and northeast of the town. In the mountains, about fifteen or twenty miles north of the crossing of the Mimbres, the pine also exists. But the plains are entirely destitute of trees of any description, and the mountains have a general appearance of sterility and ruggedness, yielding in the concealed nooks and valleys a meagre growth of cedar and dwarfish evergreen oak.

The rocks are generally of a metamorphic character, but there is found at many points along the line stone answering well the purposes of construction. Granite appears in the Cienega de los Pimas, in the ridge to the east of the San Pedro, outcropping in the Puerto del Dado, and overlying masses of secondary limestone in the ridge east of the Valle de Sauz. Sandstone and limestone are both found in the Puerto del Dado. Near the Rio Bravo both limestone and gypsum are found, the veins or seams of the anhydrous variety of the latter being exposed in the clayey walls of the ravine leading down to the river.

There is a great scarcity of water along the line, there being but nine localities where the supply could be said to be permanent. These are: 1st, at Tucson—a clear running stream, but disappearing a few hundred yards below the town; 2d, in the Cienega de los Pimas—fine springs, but the water soon sinks into the sand, as is the case at camp No. 16; 3d, the Rio San Pedro, a turbid stream, winding its way to the Gila; 4th, a spring near camp No. 22, in the Puerto del Dado—the water cold and very palatable, but the supply very limited, our animals having entirely exhausted the basin before they had a sufficiency; 5th, in the bottom of the Valle de Sauz—a stream of clear but slightly brackish water, spreading out into a marsh and extending towards the Gila in a succession of pools; 6th, a hole near camp No. 25, where, although the water rose in the bottom, still every other feature would indicate that a blind drain of mere surface-water had been tapped; 7th, the Ojo de Vaca—a spring of slightly sulphureous water, rising in the open plain and forming a marsh, beyond the limits of which there is no appearance or indication of the existence of water; 8th, Rio Mimbres—a rippling mountain stream of clear cold water at the crossing, being the more beautiful from the contrast with the state of things a few miles below, where the water is absorbed by the parched plain, the trees disappear, and there is nothing left but the dry, gaping bed; 9th, Cook's spring—is of similar character to the Ojo de Vaca, and bears more of a resemblance to a pond-hole than to a spring.

In addition to the above constant waters, there are holes or depressions on the plains intervening, which are filled by the rains of the wet season, and thus often afford relief to the anxious and solicitous traveller. These holes are lined with a clay allowing but little absorption; but, being generally shallow and broad-surfaced, evaporization soon empties them of that necessary which one requires, but has to be deprived of in order fully to appreciate it.

At Tucson the rainy season commences in April, and continues for three or four months; so that the emigrant who passes this point during the summer months finds himself in this country in the most favorable season with water abundant and grass green and nourishing, whereas we were there, and *en route*, about the end of the dry season, as our experience proved, meeting

IN THE SUPERIOR COURT OF THE STATE OF ARIZONA

IN AND FOR THE COUNTY OF MARICOPA

MARICOPA COUNTY, et al. and ARIZONA CENTER FOR LAW IN THE PUBLIC INTEREST, et al., and CALMAT CO. OF ARIZONA, et al.,

Plaintiffs-Intervenors,

vs.

STATE OF ARIZONA, ARIZONA STATE LAND DEPARTMENT, M. JEAN HASSEL, and MILO J. HASSELL, et al.,

Defendants.

NO. C 569870

DEPOSITION OF JIM SLINGLUFF

NOVEMBER 23, 1987

TUCSON, ARIZONA

BOULEY, SCHLESINGER, DI CURTI & SCHIPPERS
Registered Professional Reporters
601 Pioneer Plaza
100 North Stone Avenue
Tucson, Arizona 85701
(602) 623-7573

Exhibit

A This are my mine, but I focused in on the, I would use that as my base mark, the six class thing.

Q The International Rating Scale?

A Correct.

Q I wonder if you can tell me -- most of these streams if not all of the streams that you've included in your affidavit and that we have talked about here today are in at least north-central Arizona. Are there any streams in southern Arizona that you canoe at all?

A I have had, now I have had my eye on the San Pedro, the section that the feds just took control of for their project down there between -- what is it -- it is from Sierra Vista to Bisbee. I have scouted that at a couple points, and I believe it's boatable by my level of boating. But I have not in fact boated it.

Q Can I stop you and ask you to either use this map or some other map --

A Use this map.

Q -- and just try to describe generally for the record -- since this isn't an exhibit, maybe you can show me where that is.

MR. KOLSRUD: For the record, you are referring to the Arizona Highway Map?

THE WITNESS: Yes.

analogous to a meteoric mineral that I described as forming the chief part of the Bishopsville (S. C.) meteoric stone. It is this feature that makes your iron entirely peculiar. To see this trait, you have only to polish a little surface, and etch with hydrochloric acid, when the surface becomes speckled over with the white earthy mineral, imparting to it a porphyritic character; but to see this *well*, will require the aid of a microscope.

"Large quantities of the white mineral remain undissolved after the solution of the main mass in the acid; and floating among the residuum may be seen also a dark gray flocculent matter, which I took to be the meteoric mineral I have named Dyslytite. Much of the white earthy mineral is thus seen to be in grains, perfectly rounded; some of which are transparent and resemble hyalite; other portions of them are milk-white and nearly opaque. These last are soft, and precisely resemble chladnite."

February 22.—Again got under way, starting about noon; but, instead of taking the emigrant route via the mission of San Javier del Bac to the Cienega de los Pimas, thereby making a great détour, travelling first south, and then due east, we took a course direct for the gap, there intervening apparently a smooth and uniformly ascending plain; camped without water, but an abundance of grass. The officers of the garrison, and Inspector General Gomez, accompanied us to the camp; thus adding another to the list of polite attentions and serviceable offices rendered us by these gentlemen, for which we are under many obligations.

February 23.—Soon after leaving camp this morning, we were compelled to diverge from our course, owing to the thick growth of cactus, and were finally compelled to cut a road through it. Reaching the emigrant road, we turned almost due east, and travelled over an undulating country, the swells increasing as we neared the entrance of the gap, where we encountered a cañon debouching from this pass and opening out into a broad drain or valley to the northwest. Entering this cañon we commenced its ascent, travelling through deep and heavy sand, alternating with contracted meadow patches, hemmed in by walls, approaching verticality, of irregular, shapeless masses of rock, generally of a metamorphic character; limestone, granite, copper-green, and a pudding-stone, all being found without any marked characteristics or apparent order of superposition. Camped at the first water, with grass and wood, having made 18.4 miles.

February 24.—Made an examination of the country adjacent to the camp, and found that this cañon is the main drain of the gap or depression, and that the slopes on either side are rough and broken up by deep ravines and washes. Our teams started at nine and a half, and were soon forced to the hills by the narrowing of the cañon, rendering it impassable for wagons without much labor bestowed on removing the obstacles. Avoiding this cañon by a rough and rugged road, we again entered the valley, and thus continued through long, smooth meadows, and over rough and steep pitches (fortunately not high) for nine miles, when we ascended the table-land on our left and commenced the approach to the divide, following a set of wagon-trails. On the table-land had a good road over a red gravelly soil of decomposed igneous rock, yielding a rich growth of grama grass, which, although not in season, is nevertheless very nutritious, being perfectly cured hay, standing as it grew. Camped near the divide between the waters of the Tuczon and those of the San Pedro, without water and but little wood, having made 13.5 miles.

February 25.—Last night was cold and squally, a rain setting in immediately after dark. Started early and soon made the summit of the divide, whence we had a view of the San Pedro valley—a dry, parched-looking plain, bounded on the east by a low, bare ridge, beyond which loomed up in the blue distance the Dos Cabezas, the most striking and prominent landmark in this region. The trail bearing too much to the south, we left it, and turning eastward descended to the San Pedro, where we camped. From the summit there is a gradual slope to the valley proper, or bottom, which we entered by an abrupt descent of about sixty feet. This bottom is bounded on both sides by an irregular zigzag step, much indented by deep washes, and is at this point about three miles wide. It is covered with a growth of grass, now dry and

AFFIDAVIT

STATE OF ARIZONA)
) ss
County of Pima)

My name is James Anthony Slingluff. I have twenty-two years of canoeing experience. I have canoed extensively in Arizona since 1984.

I have canoed each of the following sections of Arizona rivers on multiple occasions (exceptions noted) and believe each to be very suitable for river travel in the seasons indicated at the boating skill level noted.

1. Salt River:

A. Highway 60 bridge to Horseshoe Bend; all seasons; intermediate boating skills.

B. Horseshoe Bend to Highway 288 bridge; all seasons; beginning boating skills.

C. Stewart Mountain Dam to Granite Reef Dam; subject to dam releases (ordinarily in summer); beginning boating skills.

2. Verde River:

A. Perkinsville to TAPCO power plant (Clarkdale); all seasons; beginning boating skills (except for two particular rapids).

B. Dead Horse Park to Thousand Trails Campground; Fall/Winter/Spring; beginning boating skills.

C. Beasely Flat to Childs; Fall/Winter/Spring; intermediate boating skills.

Exhibit 4

D. Childs to Horseshoe Lake; Fall/Winter/Spring; beginning boating skills.

3. Little Colorado River, Grand Falls to Black Falls; snowmelt, monsoons; beginning boating skills.

4. Wet Beaver Creek:

A. Ranger Station to Montezuma Castle, one trip; snowmelt, monsoons; advanced boating skills.

B. Montezuma Castle to confluence with Verde; snowmelt, monsoons; beginning boating skills.

5. Dry Beaver Creek, Highway 179 to Interstate 17, one trip; snowmelt, monsoons; intermediate boating skills.

6. Oak Creek:

A. YMCA Camp to Page Spring, one trip; snowmelt, monsoons; intermediate boating skills.

B. Page Spring to Cornville; Fall/Winter/Spring; beginning boating skills.

C. Cornville to confluence with Verde; all seasons; beginning boating skills.

I have encountered other recreationists (boaters, hikers, and/or fishermen) on all the aforementioned sections of the Salt, Verde, Little Colorado, Wet Beaver, Dry Beaver and Oak Creek.

Further affiant saith not.

Dated this 15 day of July, 1987.

James Anthony Slingluff

James Anthony Slingluff

Subscribed and sworn to before me this 15th day of July, 1987.

Leta R. Chapman

Notary Public

My commission expires: My Commission Expires February 5, 1989

received
10/11/96

ORIGINAL

96 - 004 - 003
SAN PEDRO
RIVER

503 E Medlock Dr
Phoenix, AZ 85012
542-7331 W

October 6, 1996

Arizona Navigable Stream Adjudication Commission
1700 W Washington; Room 404
Phoenix, Arizona 85007

Re: San Pedro River, navigability

Dear Commissioners:

In response to your request for evidence regarding characteristics of navigability of the San Pedro River, I submit the following information.

I have boated the San Pedro River on one occasion. Accompanying me on this kayak float trip was Dick Juetten. We launched at the Highway 92 bridge crossing at Palominas, takeout point was at the bridge crossing at Hereford Road. (Trip date: August 9th and 10th, 1992). According to personnel we spoke with at the BLM office in Fairbank, the flow of the river on those two days was 12 cfs, a figure that we can confirm. On this trip we dragged our boats about as often as we paddled them. If we had had more time or higher flows that week, we would have boated further north on the river.

From Az Highway 77 I have often observed navigable flows lasting for one or two weeks at a time in the reach from San Manuel to Winkelman during the winter and springtime rainy period. I am certain that these flows also would allow for navigation in the southernmost reaches of the San Pedro River.

The low and unpredictable flows make the San Pedro River difficult, but not impossible, to navigate. However, the San Pedro River is more than "navigable"; it is actually "navigated," albeit infrequently. Boating was an excellent way to monitor water quality and the household trash along the river (especially at the lower end of this reach), and to observe the diverse birdlife in the jungle-like riparian area. I consider the entire length of the San Pedro River as navigable.

Sincerely,

Timothy J Flood

Timothy J Flood

ORIGINAL

96-004-004
San Pedro
River

RECEIVED 10-19-96

Central Arizona Paddlers Club
Boating Survey of Arizona Rivers
1992

(Approximately 20% of our membership responded to the survey.)

River	Segments our members have boated
Salt	K&M Mine to Hwy. 60
	→ Alma School Rd. to Mill Ave. (Mesa/Tempe)
	Hwy. 60 to Roosevelt Lake
	→ Granite Reef to McKellips Rd. (Past Tri-City Landfill)
	Saguaro Lake to Granite Reef (Tuber's Run)
	Hwy. 60 Bridge to Hwy. 288 Bridge (Bridge to Bridge)
	Upper Salt
	Lower Salt
	Horseshoe Bend
	→ 100% of Salt River including normally dry & lakes
	→ All Sections
	→ Country Club Rd. to 35th Ave.
	→ Source to Phoenix
	→ Granite Reef to Gilbert Road
	→ Lower Salt through town
	→ Upper, Middle, Lower, and In Town
Verde	Perkinsville to Clarkdale
	Camp Verde to Childs
	Beasley Flats to Childs
	Childs to Horseshoe Lake
	Rio Verde to Salt River
	Camp Verde to Sheep Bridge
	Needle Rock to Beeline Hwy.
	Lower Verde
	Upper Verde
	Camp Verde to Beasley
	Needle Rock to Salt River
	Horseshoe Lake to Salt
	All of Verde from Camp Verde down
	All Sections
	Camp Verde to Horseshoe Lake
	Clarkdale to Horseshoe Lake
	Between Horseshoe and Bartlett and below Bartlett
East Verde	Doll Baby to Verde to Horseshoe Lake
San Pedro	Palominas to Hereford Rd.

Agua Fria	Black Canyon/New River Area
	Black Canyon City to above Lake Pleasant
Gila	Gila Box
	115 Ave. in Phoenix to Estrella Parkway
	91st Ave. in Phoenix (Salt River) to Estrella
	Mineral Springs to Ashurst Hayden Dam
	Old Bridge (near Clifton) to Safford (Gila Box)
	Confluence of San Francisco to Safford
	San Carlos Dam to Ashurst Hayden Dam
	10 miles above Winkelman to Winkelman
	Most of the Gila (dry parts too) through Arizona
	Winkelman to Ashurst Hayden Dam
	Winkelman to Kearny
	Gillespie Dam to Painted Rock Dam
	Below San Carlos Dam
	Clifton to Solomon, Arizona (Gila Box)
	Clifton to Safford
	Christmas to Winkelman
San Francisco	New Mexico to Clifton
	Clifton to Confluence of Gila
Colorado	Lee's Ferry to Phantom Ranch
	Diamond Creek to Pierce's Ferry
	Lee's Ferry to Pierce's Ferry
	Grand Canyon
	Below Hoover Dam
	Through Topock Canyon
	Hoover Dam to Yuma
	Parker to Lake Havasu
	Topock to Lake Havasu
	Below Hoover Dam (Black Canyon)
	Parker Dam to Martinez Lake
	Glen Canyon to Lee's Ferry
	All Sections
Little Colorado	
Blue	
Black	Bonita Creek to Black River Crossing
	Point of Pines to Salt River
	Source to Salt

White	Indian Reservation to K&M Mine Road White River Crossing to Salt River
Sycamore Creek	Hwy. 87 Bridge to Sugarloaf Mountain
Tonto Creek	Gisela to south of Jake's Corner Rye Creek to Roosevelt Lake Gisela to SRP Gauge Gisela to Roosevelt Tonto Box Rye Creek to Jake's Corner
Bonita Creek	Tonto Creek to Black River
Cherry Creek	
Fish Creek	
Burro Creek	
Indian Bend Wash	

Arizona
State Land Department
1616 WEST ADAMS
PHOENIX, ARIZONA 85007

FIFE SYMINGTON
GOVERNOR

M.J. HASSELL
STATE LAND COMMISSIONER

96-004-005
San Pedro
River
001

December 16, 1996

Christina Waddell
Arizona Navigable Streambeds Adjudication Commission
1700 West Washington, Room 404
Phoenix, Arizona 85007

ORIGINAL

RECEIVED 12-19-96

RE: Streambed Studies Submitted as Evidence

Dear Ms. Waddell:

The Drainage & Engineering Section of the Arizona State Land Department would like to verify that you still have the following documents that were submitted to the previous Commission:

HASSAYAMPA RIVER: Gila River Confluence to Headwaters

SAN PEDRO RIVER: Gila River Confluence to the Mexican Border

VERDE RIVER: Salt River Confluence to Sullivan Lake

All three documents were prepared by CH^{2}MHILL in November, 1993.

If you are unable to locate your copies of these river studies, please contact us immediately so that we may submit additional copies of each document as soon as possible.

Thank you.

V. Ottozawa-Chatupron by SH

V. Ottozawa-Chatupron, P.E., Ph.D
Section Manager
Drainage and Engineering Section

VOC:sh

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STATE OF ARIZONA
NAVIGABLE STREAM ADJUDICATION COMMISSION
1700 WEST WASHINGTON, PHOENIX, ARIZONA 85007
PHONE (602) 542-9214 FAX (602) 542-9220
CHRISTINA WADDELL
Executive Director

96-004-005
San Pedro
River
002

December 19, 1996

ORIGINAL

RECEIVED 12-19-96

V. Ottozawa-Chatupron, P.E., Ph.D.
Section Manager
Drainage and Engineering Section
Arizona State Land Department
1616 West Adams
Phoenix, Arizona 85007

Dear Mr. Ottozawa-Chatupron:

This is written in response to your letter dated December 16, 1996.

The evidence received from the "previous" commission does not contain the following CH_2MHILL reports:

Hassayampa River: Gila River Confluence to Headwaters

San Pedro River: Gila River Confluence to the Mexican Border

Verde River: Salt River Confluence to Sullivan Lake

The only CH_2MHILL report we received from the "previous" commission is the 1993 Salt River: Granite Reef Dam to the Gila River Confluence. As per your letter, we are requesting that the reports on the Hassayampa River, the San Pedro River and the Verde River be resubmitted to the Arizona Navigable Stream Adjudication Commission office for their inclusion as evidence in the proceedings. If you have any questions, please feel free to call.

Thank you.

Thomas J. Vogt
Research and Statistical Analyst

ORIGINAL RECEIVED 2-18-97 ORIGINAL

96-004-007
San Pedro
River

TESTIMONY RELEVANT TO ALL WATERCOURSES

Presented by Arizona Center for Law in the Public Interest

to the

Arizona Navigable Stream Adjudication Commission ORIGINAL

February 18, 1997

The Arizona Center for Law in the Public Interest offers the following testimony relevant to all findings and recommendations of the Commission on whether watercourses were navigable as of statehood. We made many of these points in preliminary testimony to the Commission on February 6, 1996.

As amended, the state statute governing Commission proceedings contains grossly illegal and inaccurate standards for the determination of navigability and non-navigability. Federal law, as developed by the federal courts, sets the test for determining title to the beds of watercourses. Arizona Center for Law v. Hassell, 837 P.2d 158, 164-65 (Ariz. App. 1991). That test is a liberal one: Whether the waterway was at statehood susceptible for use as a highway for transporting people or goods. Utah v. United States, 403 U.S. 9, 11 (1971). A river may be found navigable for title purposes despite occasional impediments such as sand or gravel bars, and despite the fact that it is only navigable a few months out of the year. State of Oregon v. Riverfront Protective Association, 672 F.2d 792, 795 (9th Cir. 1982). Actual use for boating, whether commercial or sporting, can demonstrate susceptibility as a highway for public passage. Utah v. United States, 403 U.S. at 11. Although state ownership turns on navigability at the time of statehood, evidence of current recreational use by small craft such as canoes is probative of navigability at statehood. North Dakota v. Andrus, 671 F.2d 271, 277-78 (8th Cir. 1982).

The remoteness of a river and lack of actual use at statehood does not defeat a finding of navigability: The question is whether the river was susceptible of transporting people or goods. United States v. Utah, 283 U.S. 64, 83 (1931). A river is deemed navigable if it could transport people or goods by any conveyance - not merely those in use at the time of statehood. State of Alaska v. Ahtna, Inc. 891 F.2d 1401, 1405 (9th Cir. 1989). In fact, present-day use of a river for guided recreational trips can provide conclusive evidence of navigability at statehood. Id. at 1405. Conversely, the fact that dams or diversions render a waterway non-navigable today does not matter, as long as it was passable in its original condition. See Frank, Forever Free, 16 U.C. Davis L. Rev. 579, 586 (1983).

Under the standards set forth above, the Arizona Court of Appeals concluded in 1991 that there was substantial evidence from which a factfinder might conclude that portions of rivers and streams other than the Colorado met the applicable standard of navigability at the time Arizona became a state. Hassell, 837 P.2d at 165. In reaching that conclusion, the Court had before it much of the same evidence that is now before this Commission. If anything, the Commission has before it even more substantial evidence of navigability than was before the Court, due to extensive studies conducted by the State Land Department since the Court's decision, and other evidence offered by various parties.

Unfortunately, the Legislature has tried to restrict this Commission's ability to find watercourses navigable by imposing a number of tests and presumptions that are flatly contrary to the federal test of navigability. These include the following:

1. A presumption that the entire watercourse was nonnavigable if any determination of nonnavigability in a public proceeding exists for the watercourse or a portion thereof. ARS §37-1128.B. The presumption can be overcome only by "clear and convincing evidence." There is absolutely no such presumption under the Federal test, and the presumption is absurd on its face. The mere fact that a "public proceeding" took place does not mean that the state's title claims were properly adjudicated (or even represented). Moreover, the state does not have the authority to relinquish its public trust ownership where the watercourse was in fact navigable at statehood. Illinois Central RR v. Illinois, 146 U.S. 387 (1892). Further, the mere fact that a small reach of a river was found nonnavigable hardly means that another reach (which could be hundreds of miles away) is presumptively non-navigable. It is also violative of the public trust doctrine for the state to place a higher burden of proof on itself to show navigability than applies in an order civil case.

2. A requirement that the Commission must find and recommend a watercourse was nonnavigable, if as of statehood it either was not used or susceptible of being used for both commercial trade and travel; or flowed only in direct response to precipitation and was dry at all other times. ARS 37-1128.C. There are absolutely no such restrictions on finding navigability under the federal test. As noted above, the federal test merely requires susceptibility for use as a highway for the transportation of people or goods. There is no requirement that such transportation be "commercial." Nor does the federal test in any way prohibit a finding of navigability where a watercourse flows "only in direct response to precipitation." The issue under the federal test is susceptibility for use for transportation -- if that susceptibility is due to rain events, then the test is met.

3. A presumption of non-navigability, defeatable only by clear and convincing evidence, if any of the following applied: i)

no sustained trade and travel occurred both upstream and downstream in the watercourse; ii) no profitable commercial enterprise was conducted; iii) vessels customarily used for commerce in 1912, such as keelboats, steamboats or powered barges, were not used on the watercourse; iv) diversions were made from the watercourse for various purposes that would have been inconsistent with or impediments to navigation; v) any boating or fishing was for recreational and not commercial purposes; vi) any flotation of logs or other material that occurred or was possible on the watercourse was not for commercial purposes; vii) there were structures constructed in or across the watercourse that would have inconsistent with or impediments to navigation; viii) transportation in proximity to the watercourse was customarily accomplished by methods other than by boat; ix) the United States did not regulate the watercourse under the rivers and harbors act of 1899. ARS §37-1128.D.

None of the above create any sort of presumption of non-navigability under the federal test, let alone the kind of presumption against navigability imposed by ARS 37-1128.D. As the above discussion of the federal test shows, the federal test does not require evidence of actual use for travel at all, let alone commercial use by large vessels of the period. Moreover, the federal test looks to the watercourse's **ordinary and natural** condition - not its condition when altered by human activity. The fact that floating of logs, boating, and fishing occurred is probative of **navigability** under the federal test: it does not become evidence of **non-navigability** merely because it was not commercial. Nor does the federal test create any presumption of non-navigability merely because a rivers was not regulated under the rivers and harbors act, or because travel near the watercourse was customarily done other than by boat. The test is susceptibility for use in travel, not whether the watercourse was regulated under other laws or whether boats were the preferred mode of travel.

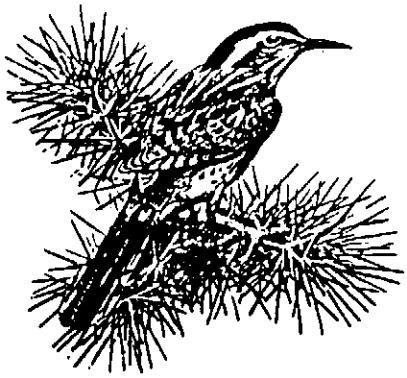
4. A bar on consideration of: a) previously appropriated water as being within the ordinary and natural condition; b) use of ferries; c) fishing from the banks; d) use under flood conditions. ARS §37-1128.E. There is absolutely nothing in the federal test that allows these types of exclusions. Federal law looks to whether the watercourse was navigable in fact - it does not impose artificial restrictions on what can be considered in making that determination. For example, federal courts have explicitly relied on ferry travel as evidence of navigability. City of Centralia v. FERC, 851 F.2d 278 (9th Cir. 1988). They also routinely consider evidence of actual boating and fishing use, and do not bar such evidence based on the conditions or location of use.

5. A requirement to considers dams and diversions and other human uses as part of the ordinary and natural condition of the watercourse. Such a requirements is not a part of the federal test, and conflicts with the plain meaning of the word "natural."

For all the foregoing reasons, any determination of non-navigability by this Commission under the tests set out in ARS §37-1128 will have no legal validity or persuasive value in establishing ownership of streambeds. Accordingly, we urge the Commission to: a) suspend further proceedings to determine navigability or non-navigability of watercourse; b) refrain from making any findings or recommendations on navigability or non-navigability; and c) advise the legislature that there is no point in conducting further proceedings or making findings and recommendations unless and until the standards for determining navigability in ARS 37-1128 are changed to accurately reflect federal law.

DATED this 18th day of February, 1997.

David S. Baron
Assistant Director
Arizona Center for Law
in the Public Interest
1840 E. River, Suite 207
Tucson, AZ 85718
(520) 529-1798



ARIZONA AUDUBON COUNCIL

Huachuca Audubon Society, Maricopa Audubon Society
Northern Arizona Audubon Society, Prescott Audubon Society
Tucson Audubon Society, Yuma Audubon Society
White Mountain Audubon Society

RECEIVED 1-27-98

ORIGINAL

96 - 004 - 009
San Pedro River

97 - 004 - 004
Santa Cruz River

December 26, 1997

Navigable Stream Adjudication Commission
1700 West Washington Street, Rm. 404
Phoenix, Arizona 85007

Dear Sirs,

The Arizona Audubon Council has researched the navigability conditions of the Santa Cruz and San Pedro Rivers. We have determined that both of these rivers were navigable during the period when Arizona joined the United States of America.

The Arizona Audubon Council requests to be on the mailing list to receive information and updates pertaining to this adjudication process.

Sincerely,

Al Anderson
Secretary, AAC

3305 Eagle Ridge Drive, Sierra Vista, Arizona, 85635 (520) 378-2460 fax (520) 378-2107

RECEIVED
2-9-98

6 Feb 1998

ORIGINAL

96 - 004 - 010
San Pedro
River

Dear Navigable Stream Comm.

My father Came to San Pedro Valley in 1872 They settled on land that was given to the Boquillas Land Co by the King of Spain some time before 1872. They didnt know the land belonged to spain when they settled there. So in about 1905 all the mormons moved to the Gila Valley. "Nearly all" In 1935 I worked for the Forest Service and was in the Cochise Strongholts and met an old man named Rockefellow who said he was the chief of the Survey Crew who laid out the land Grant He said they surveyed and were weary trying to find the north Boundary of the land Grant. One Morning a man named Curtis rode out to this camp on a mule with a Shotgun. He had built a fence E + W across part of the Valley where he claimed property. He pointed to the fence with the shot gun and Mr Rockefellow heard him say "that is the boundary of the north part of the land Grant." Curtis owned this land and the home of many pioneers in San Pedro Valley. The river in 1872 was about 8 feet wide. after a few years the river is 50 feet wide due to over grazing. I do not think anyone in his right mind would try to make a Navigable Stream anywhere on the old San Pedro River. Oh! Rockefeller said "I'm very happy to know where the north boundary was and that is where they put the boundary" I am 95 and dont write too good Joseph Nahum Curtis was the man on the mule, my Grandfather Brother

Respectfully yr A Keith Curtis

RECEIVED 2-9-98

6 Feb 1998

96 - 004 - 010
San Pedro River

Dear Navigable Stream Comm.

My father Came to San Pedro Valley in 1872 They settled on land that was given to the Boquillas Land Co by the King of Spain some time before 1872. They didnt know the land belonged to Spain when they settled there. So in about 1905 all the Mormons moved to the Gila Valley. "Nearly all" In 1935 I worked for the Forest Service and was in the Cochise Strongholts and met an old man named Rockefellow who said he was the chief of the Survey Crew who laid out the land Grant He said they surveyed and were weary trying to find the north Boundary of the Land Grant. One Morning a man named Curtis rode out to this camp on a mule with a Shotgun. He had built a fence E + W across part of the Valley where he Claimed property. He pointed to the fence with the shot gun and Mr Rockefellow heard him say "that is the boundry of the north part of the Land Grant." Curtis saved this land and the home of many pioneers in San Pedro Valley. The river in 1872 was about 8 feet wide. after a few years the river is 50 feet wide due to over grazing. I do not think anyone in his right mind would try to make a Navigable Stream anywhere on the old San Pedro River. Oh! Rockefeller said They were happy to know where the north boundary was and that is where they put the boundry" I am 95 and dont write too good Joseph Nahum Curtis was the man on the mule, my Grandfathers brother

Respectfully yours A Rex Curtis

96 - 004 - 011
San Pedro
River

ORIGINAL

Richard Lee Duncan
3108 N. 43rd Drive
Phoenix, Arizona 85031
Telephone 269-1761

RECEIVED 2-23-96

97 - 004 - 007
Santa Cruz
River

BEFORE THE
ARIZONA NAVIGABLE STREAMBED ADJUDICATION COMMISSION

IN THE MANNER OF THE NAVIGABILITY OF THE SAN PEDRO, AND SANTA CRUZ RIVERS ETAL.

Admin. Docket No. _____

COMMENTS AND EXHIBITS

The National Encyclopedia, Collier & Son, 1950, Page 370, Vol. 1.

Arizona. The lower reaches of the Colorado River, the western boundary of the state, are its only navigable waters.

Howell v. Johnson et al. 89 Fed. Rep. 556, (1898) Knowles, District Judge.

In the case of Basey v. Gallagher, 20 Wall. 670, The supreme court said in regard to this act: "The act of congress of 1866 recognized the right to water by prior appropriation for agricultural and manufacturing purposes as well as mining;" and also decided that if the right to appropriate water for any of the purposes named was recognized by either local customs, or by the legislation of any state or territory, or by the decisions of the court, it would be sufficient.

...A state, upon its admission into the Union, acquires, by virtue of its sovereign powers, the title to the beds of all navigable rivers, lakes, and tide waters within its boundaries,...This title gives it, to some extent, a control over the waters of such rivers and lakes, and the power to establish and determine what shall be riparian rights...

The idea that there can arise any international water right question in the case of the appropriation of the waters...cannot be maintained. The right to such waters...must always be a question pertaining to private persons.

Arizona Territorial Statutes 1863, Bill of Rights Art. 22; All streams, lakes, and ponds of water capable of being used for the purpose of navigation OR irrigation, ar hereby declared to be public property;...

Revised Statutes 1901 Sect.4174(civil Code): " All rivers, creeks, and streams of running water in the Territory of Arizona are hereby declared to be public, and applicable to the purposes of irrigation and mining as hereafter provided."

TITLE XXI Eminent Domain Sect. 2445 (2);...The right of eminent domain may be exercised in behalf of the following uses: 4. Wharves, docks, ferries,

for public transportation, and for floating logs and lumber on streams not navigable.

Hill v. Lenormand 2 Ariz 354 (1888) Wright, C.J.-...The...plaintiffs... appropriated the waters of the San Pedro river,...As is very generally the case in the Pacific states and territories, the conditions are so changed that riparian rights do not attach. In the case at bar, riparian rights do not apply.

Boquillas v. Curtis 213 U.S. 339 (1908) Mr. Justice Holmes; This is a bill in equity brought by the appellant to prevent the defendants from withdrawing water from the San Pedro River...

It is not denied that what is called the common law doctrine of riparian water rights does not obtain in Arizona...

...In this Territory irrigation was practiced in the Santa Cruz Valley prior to the cession and it is well known the right of appropriation without regard to the riparian character of the lands was there in force probably from the time when the Spaniards first settled in the valley. Our statutes, as well as those of New Mexico, seem to have had their origin in the Mexican law as modified by custom.

I will present something at this time that may not seem relevent, except for GAT, and NAFTA, in which the Federal Government gave away water rights to Mexico it may not have held title to. Water Rights of the Western States, Bancroft-Whitney Company (1911) Vol.I, Page 221: The case (Boquillas V. Curtis) is an unequivocal decision in support of the Colorado doctrine so far as it affects the rights of riparian proprietors....if riparian rights do not exist, the United States has no more right to waters on its lands than other land owners.

Blackstone, Modern american Law, Vol.VI, (1917) Page 47,49: Property is the right of a person to a thing and consists in the right of use or enjoyment of the thing and the disposal and transfer of the same right to others. Rights to the use of water acquired by appropriation come within this definition. Indeed, the term "right" itself, when used in this connection,imports a property right, and carries with it all the elements of property. 16 Colo. 61

The property right acquired by the appropriation is not in the corpus of the water, but in the incorporeal right of diversion and use, and the right itself is an incorporeal hereditament. 18 Colo. 298

The right is usufructuary: it is a right to divert and use water belonging to the stream and does not attach primarily to the body of the water in the stream. 3 Cal. 249

In December,1846, at the Gila, Lt. George Stoneman decided to perform a naval experiment on that shallow stream. Lashing together some cottonwood logs, he set sail with about twenty-five hundred pounds of food and supplies. He hadn't traveled far when the craft sank. Stoneman went down with his ship then walked ashore declaring the river unsuitable for navigation. In 1862 Stoneman was made Major General, and was governor of California 1883-87. Diamond in the Rough, Marshall Trimble,1988.

Collier's Encyclopedia, Vol. 11, 1986, Page 99: In the San Carlos Reservation the Gila was dammed (Coolidge Dam) to provide water for irrigation, and there are several other irrigation projects along its lower course. The dam was complete in 1928.

The rest of the streams, washes, lakes, rivers, etc., of this State, are to numerous for me to cite individual case law, at this time. I shall include all of them, and the before mentioned, now.

U.S. v. Rio Grande Irrigation Co. 174 U.S. 690,705,706, (1989): March 3, 1877, an Act, c. 107, was passed for the sale of desert lands, which contained in its first section this proviso, 19 Stat. 377:

...water of all lakes, rivers, and other sources of water supply upon the public lands and not navigable, shall remain and be held free for the appropriation and use of the public for irrigation, mining, and manufacturing purposes subject to existing rights.

...To infer therfrom that Congress intended to release its control over the navigable streams of this country and to grant in aid of mining industries and the reclamation of arid lands the right to appropriate the waters on the sources of navigable streams..., is to carry those statutes beyond what their fair import permits.

Fletcher v. Peck, 10 U.S. (6 Cranch.)87, (1810)...If an act be done under a law, a succeeding legislature cannot undo it. The past cannot be recalled by the most absolute power.

Supra. 4174; All rivers, etc, in the Territory of Arizona are...applicable to the purpose of irrigation and mining...

ARIZ. CONST. ART.XXII Sect. §1. No rights,...claims,... existing at the time of the admission of this state into the union, shall be affected by a change in the form of government, from territory to state, but all shall continue as if no change had taken place;...

ART. XVII §1. The common law doctrine of riparian water rights shall not obtain or be of any effect in the state.

THE RECORDS OF THE ARIZONA CONSTITUTIONAL CONVENTION OF 1910, November 29, afternoon; Mr Kingan: I would like to ask the gentleman from Maricopa a question. What is the reason for inserting that (ART XVII, §1) in the constitution? It is the law of this territory and has been for forty or fifty years, and it seems to me it is a matter purely segislative.

Mr. Baker: The answer is that it is purely fundamental. If a future legislature should undertake to establish a common law doctrine of water rights in this territory, they could do so. I want it fixed so that no legislature can ever do that thing.

There may be riparian rights,even if there are no navigable streams in a state, in order to claim a stream bed; but, there can be no claim to navigabilty if riparian rights do not exist. The state may only derive its rights and powers from those that exist in the people.

Richard L. Duncan

22FEB98

Richard Lee Duncan TEL.269-1761
3108 N. 43rd Drive
Phoenix Arizona 85031

Last paragraph my thoughts. RLD

ORIGINAL ORIGINAL

RECEIVED 9-19-97

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96-004-012
San Pedro
River
001

September 19, 1997

VIA HAND-DELIVERY

Christina Waddell, Executive Director
State of Arizona Navigable Stream
Adjudication Commission
1700 W. Washington, Room 404
Phoenix, AZ 85007

Re: **Historic Evidence Regarding Statewide Water Course Non-Navigability**

Dear Christina:

On behalf of our clients, various insureds of Chicago Title Insurance Company, we are submitting the following evidence for use and consideration by the Arizona Navigable Stream Adjudication Commission ("ANSAC") in connection with its determinations/recommendations with respect to navigability on the various watercourses which the Commission is addressing pursuant to its authority under A.R.S. § 38-431.01, et. seq.:

1. Seven (7) copies of the relevant portions of a document entitled "Map of the Navigable Waterways of the United States." This map, dated December 14, 1914, was prepared by the Chief of Engineers, USA. We have enclosed copies of both the legend to the map and that portion relating to the State of Arizona. As is readily apparent from examination of the legend and the portion with regard to the State of Arizona, by failing to identify any watercourse in the Arizona with any of the colors indicated in the legend, the Chief of Engineers has indicated his determination that none of Arizona's

waterways were deemed to be "navigable" in accordance with the definition utilized by the Chief of Engineers for purposes of preparing the map.

2. Seven (7) copies of a map entitled "Official Map of the Territory of Arizona" compiled by Richard Gird, C.E. Commissioner, dated October 23, 1864. This map is of significance in that it depicts the alignment of various watercourses at or about the date on which the Territory of Arizona was created. In addition, the members of ANSAC should note that the map contains a specific reference to the "present head of navigation" and "supposed head of navigation" at two locations on the Colorado River in the northwest corner of the then-Territory. Those two notations with regard to navigability are in stark contrast to the absence of any other indications of navigability with respect to the balance of the waterways in the Territory.[1]

We appreciate your assistance in making copies of both of these maps available to the members of ANSAC.

Very truly yours,

MARISCAL, WEEKS, McINTYRE
& FRIEDLANDER, P.A.

By _____
James T. Braselton

JTB/tg
Enclosures
cc: Richard Marsh (w/out enc.)
Burt Levinson (w/out enc.)
F:\USERS\JTB\-L3864.WAD

[1] For ease of reference, we have highlighted the two notations with regard to navigation in yellow.

ORIGINAL

ORIGINAL

96-004-012
San Pedro
River
002

MAP
OF THE
NAVIGABLE WATERWAYS
OF THE
UNITED STATES
SHOWING IN COLORS THE DEPTHS OF PROJECTS ADOPTED BY CONGRESS

Prepared under the direction
of the
CHIEF OF ENGINEERS, U.S.A.
December 1914

Scale 50 Miles to 1 Inch

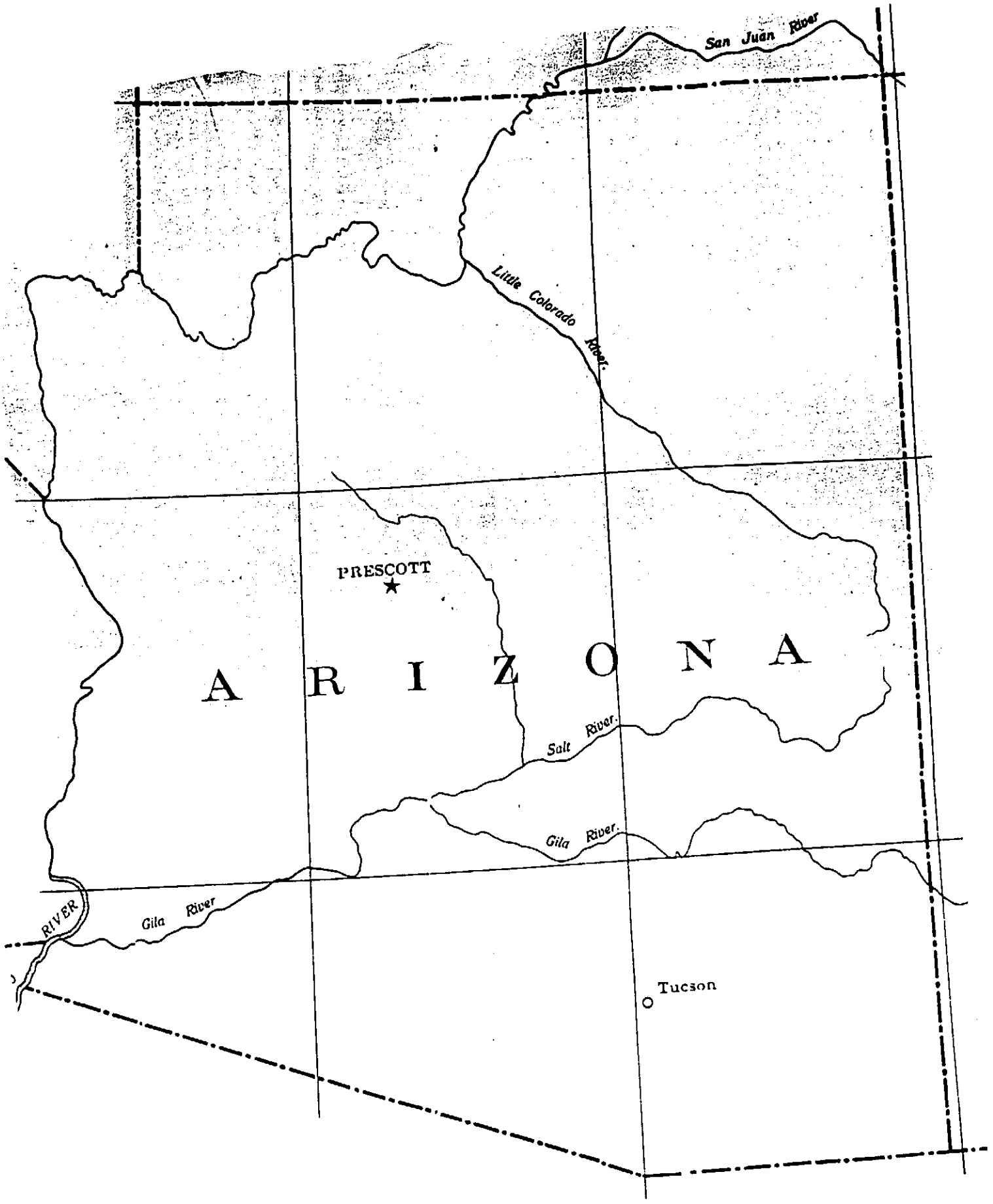
50 0 50 100

LEGEND

- less than 6 feet deep
- 6 feet to 12 " "
- 12 " " 18 " "
- 18 " " 30 " "
- 30 " deep and over
- Dams completed
- " under construction
- " projected

29°
27°
25°
23°

ORIGINAL


San Juan River
Little Colorado River
PRESCOTT
A R I Z O N A
Salt River
Gila River
RIVER
Gila River
Tucson