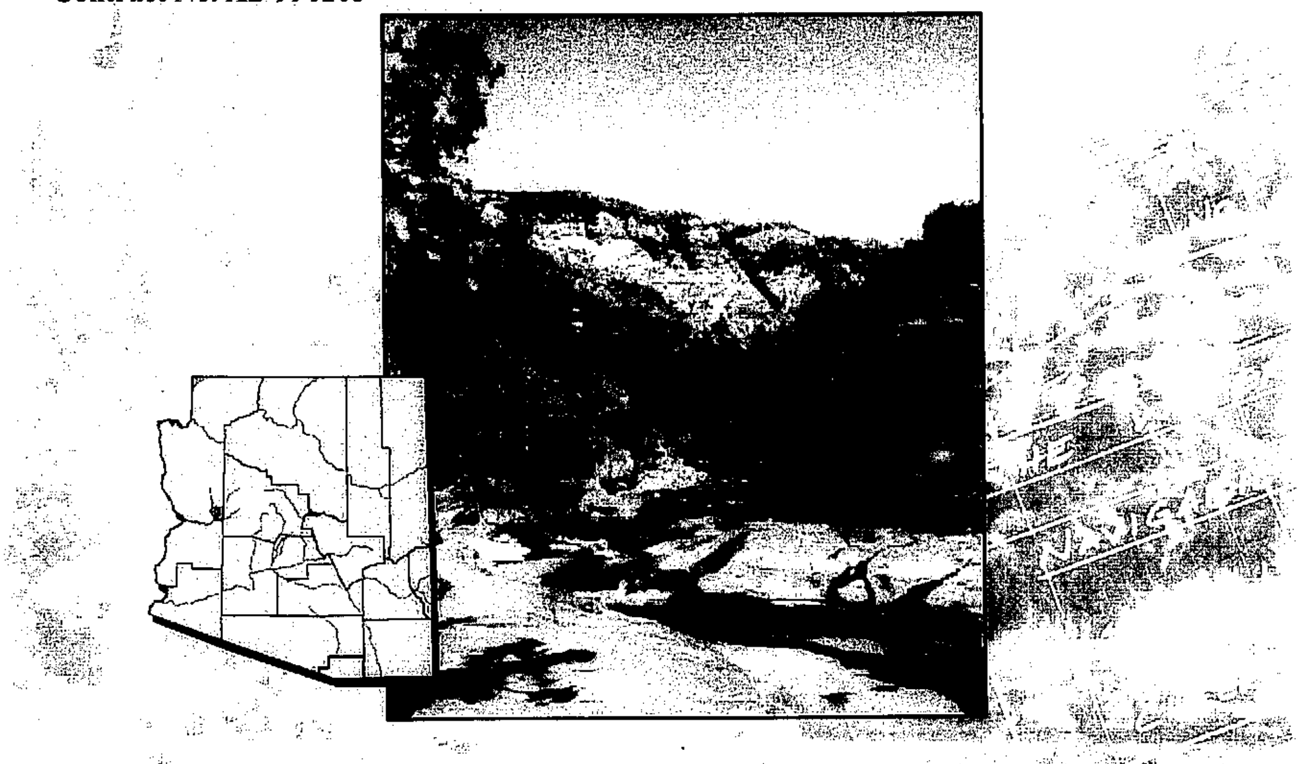
Draft Final Report
SMALL & MINOR WATERCOURSES ANALYSIS for Santa Cruz County, Arizona

Contract No. AD 990205



ARIZONA STATE LAND DEPARTMENT

June 9, 2000

Stantec Consulting Inc.
In Association with
JE Fuller/Hydrology & Geomorphology, Inc.

Stantec

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DRAFT FINAL REPORT

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for Santa Cruz County, Arizona

Contract No. AD 990205

Stantec Consulting Inc.
8211 S. 48th Street
Phoenix, Arizona 85044

in association with:

JE Fuller/Hydrology & Geomorphology, Inc.
5235 S. Kyrene, Suite 205
Tempe, Arizona 85283

June 9, 2000

SMALL AND MINOR WATERCOURSES ANALYSIS
FOR SANTA CRUZ COUNTY
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Executive Summary

The small and minor watercourses in Santa Cruz County were evaluated using the three-level evaluation process that was previously developed by the project team (Stantec, 1998 & 1999b). This evaluation process analyzes the watercourses at increasing levels of detail to assess susceptibility and evidence of stream navigability.

The results of the Level 1 analysis for the 524 watercourses in Santa Cruz County indicated 506 watercourses (see Table A-1A, Appendix A) fail every diagnostic attribute that was used in the screening process. These diagnostic attributes include *stream type, dam information, historical and modern boating accounts, the existence of fish,* and *any special watercourse status designation*. Eighteen (18) watercourses passed the Level 1 analysis to proceed to Level 2 analysis (see Table A-1B, Appendix A). For Level 2 analysis, which employs a qualitative approach, there were sixteen (16) watercourses that failed the sorting process and thus, were dropped from further study and investigation (see Table A-2A, Appendix A). Only two watercourses, Sonoita Creek and Cienega Creek, survived the Level 2 screening process (see Table A-2B, Appendix A) and were forwarded for Level 3 analysis.

Detailed studies were conducted for Cienega Creek and Sonoita Creek to further assess and evaluate the likelihood that the streams are navigated at the time of statehood.

1.0 Introduction

1.1 STUDY BACKGROUND

The State of Arizona is currently adjudicating navigability with regard to ownership interest in streambeds throughout Arizona. Claims of streambed ownership depend on whether or not a given stream was navigable or susceptible to navigation at the time of statehood in 1912. The reader is referred to the Project Background section of the report titled, *"Criteria for Assessing Characteristics of Navigability for Small Watercourses in Arizona"* (Stantec, 1998) for a complete discussion of the history of the navigability issue in Arizona.

The Arizona Navigable Stream Adjudication Commission (ANSAC) is legislatively mandated to establish administrative procedures, hold public hearings, and make recommendations to the Arizona Legislature as to which watercourses were navigable or non-navigable at the time of statehood. To date there have been 14 major river systems that have been adjudicated by the State of Arizona.

ANSAC is required to complete their legislatively mandated tasks by July 1, 2002. There are over 39,039 documented watercourses in Arizona, the vast majority of which are minor or small watercourses. In consideration of these two factors, ANSAC determined that the small watercourses should be considered separately from the major rivers in order to expedite the evaluation process to meet the target date for completion in the year 2002. ANSAC contracted with Stantec in 1997 to: (1) establish minimum technical and historical criteria for small watercourses in accordance with the legislative definition of navigability; (2) develop an evaluation system to assess watercourses utilizing the criteria; and (3) catalog in a database all documented watercourses in the state. That work was completed in 1998 and the results are summarized in *Criteria for Assessing Characteristics of Navigability for Small Watercourses in Arizona* (Stantec, 1998).

In May 1999, ANSAC authorized the Stantec project team to proceed with a Pilot Study to further test the evaluation system and apply the small watercourse criteria to a limited sample of small watercourses in selected locations. The scope of work for the Pilot Study covered Level 1 analysis for the entire State of Arizona, Level 2 analysis for Mohave, La Paz, and Yuma counties, and Level 3 analysis for three watercourses identified to represent the diverse physiographic conditions in Arizona. The project team is currently under contract with the Arizona State Land Department (ASLD) to continue this work by applying the evaluation system to all remaining small watercourses throughout the state that were not addressed in the Pilot Study. That work is scheduled for completion in June 2001.

The reporting of project results is categorized by county so that ANSAC can conduct hearings within each county for the purpose of determining stream navigability and settling streambed ownership. This report documents the navigability results for Santa Cruz County.

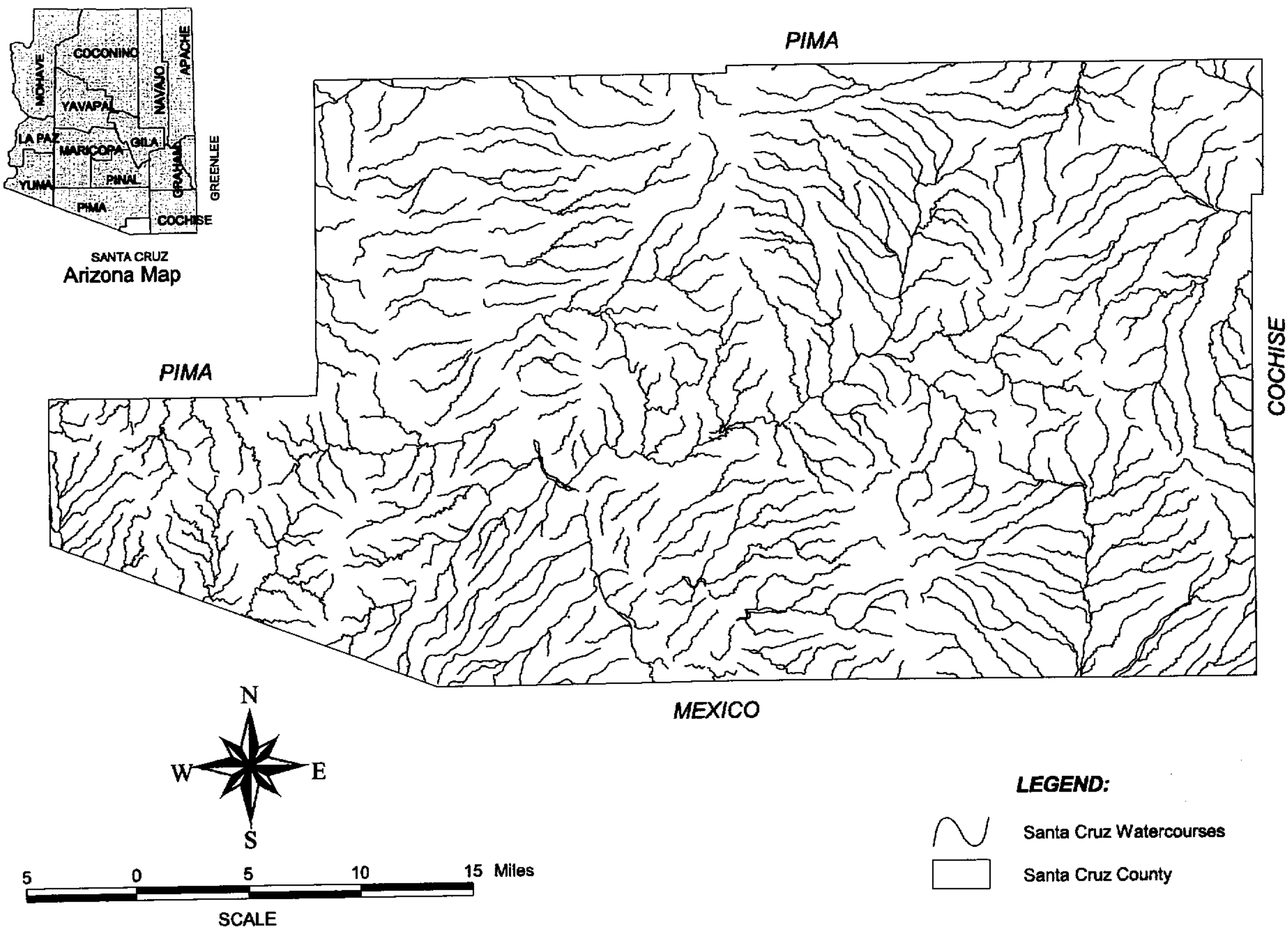
1.2 COUNTY DESCRIPTION

Santa Cruz County is located in the southern section of the State and is comprised of about 1,235 mi.^{2} land area. It borders the county of Cochise to the east, Pima county to the north and the country of Mexico to the south (see Figure 1). The county lies within the following Latitude and Longitude ranges: *31°20'00"N to 31°44'00"N and 110°25'00"W to 111°22'00"W.* There are 524 documented small and minor watercourses in Santa Cruz County of which 498 are unnamed. These watercourses, both named and unnamed, were the subject of the evaluation process involving the three levels of analysis developed by the project team (and a detailed study if any watercourse(s) passed the Level 3 analysis).

1.3 REPORT OBJECTIVES

The work plan for the small and minor watercourses project was to analyze, summarize and present the results of the three-level classification analysis comprised of the following main work tasks and activities:

FIGURE 1
Small and Minor Watercourses in Santa Cruz County



Task 1 – *Summarize and present the results of Level 1 Analysis*

This task identifies two data sets as the result of the Level 1 Analysis. They are:

(1) NRL1 data set – This data set comprises all watercourses that have at least one affirmative hit from six key stream attributes: *perennial classification, with fish, dam-impacted, with modern boating and historical boating records*, and *with special status.* This data set proceeds to the Level 2 analysis.

(2) RL1 data set – This data set comprises those watercourses that do not have any affirmative hit from the six key stream attributes. This data set is dropped from further analysis and investigation.

Task 2 – *Summarize and present results from Level 2 analysis.*

Similar to Level 1 analysis, this task identifies two data sets as the result of the Level 2 analysis. They are:

(1) NRL2 data set – This data set is comprised of the watercourses that have potential susceptibility to navigation according to the qualitative evaluation procedure used in Level 2. This data set proceeds to Level 3 analysis.

(2) RL2 data set – This data set is comprised of those watercourses that have no evidence of susceptibility to navigation based on the qualitative investigation performed in Level 2. This data set is dropped from further analysis and investigation.

Task 3 – *Summarize and present results from Level 3 analysis.*

Similar to Level 1 and Level 2 analyses, this task identifies two data sets as the result of the Level 3 analysis. They are:

(1) NRL3 data set – This data set is comprised of the watercourses that have characteristics of susceptibility to navigation upon evaluation of the geomorphologic, hydrologic, and hydraulic conditions of the watercourses and validation of these conditions with established boating criteria. This data set is recommended for a detailed study (Level 4 analysis).

(2) RL3 data set – This data set is comprised of those watercourses that fail to meet the criteria for susceptibility to navigation.

Task 4 – *Detailed Studies (Level 4 Analysis)*

Detailed study for Level 3 survivors (NRL3 watercourses) is beyond the scope of the current project. NRL3 watercourses would be investigated in a separate contract with Arizona State Land Department. Though they are not part of the existing project contract, a section is allocated in this report for their integration as their study documentation becomes available.

2.0 Data Requirements

2.1 BASELINE DATA

The watercourse database operates in a Geographic Information System (GIS) environment. This allows the user to analyze the spatial characteristics of the studied watercourses in a graphical or tabular format. The project team selected ArcView GIS, a GIS analysis and thematic map software, for its ease of use and its operational capabilities. In addition, ArcView GIS supports many of the hydrologic assessment activities that have been conducted by state, federal and local agencies. The viability of this data must meet the following criteria to be considered applicable to this project:

- Data are already in or can be readily converted to a GIS format
- Data are readily accessible, technically sound and historically accurate
- Data can be easily sorted by category or criteria.

The primary data source in the development of the master database was obtained from the Arizona Land Resource Information System (ALRIS). The surface water data sets were originally derived from baseline Digital Line Graph (DLG) maps compiled by the US Geological Survey (USGS), which were further enhanced by the US Environmental Protection Agency (EPA) in several versions called the River Reach Files. The latest version, commonly called RF3, is a federal standard for identifying and cataloging water bodies. The RF3 file was converted to a GIS ARC format by ALRIS and has been distributed and used by various public and private agencies working on water management issues.

The base GIS layer used in the master watercourse database is an ALRIS-converted RF3 data set called STREAMS. It is a line coverage of hydrography (streams) within Arizona and contains 87,735 separate watercourse segments. The STREAMS file includes several fields that were relevant in the development of the master watercourse database. They include the Hydrologic Unit Code (HUC), segment number, mileage, watercourse type, and watercourse name. A binary (yes/no) field for each criterion and a county field were added to aid in the Level 1 sorting process. All manmade water features (canals, aqueducts, flumes, etc.) were removed from the master watercourse database. The major rivers previously assessed by the ASLD for characteristics of navigability or susceptibility to navigation and subsequently adjudicated by the ANSAC were also removed. The resulting master watercourse database contains 76,166 records or stream segments (typically many stream segments comprise one watercourse).

Additional ALRIS Data Sets were used in conjunction with the STREAMS layer to allow for detailed resolution of the physical location of each watercourse. These data sets are listed in Table 1.

TABLE 1
ALRIS Data Sets

Name of Data Set	Data Type / Format	Description
AZSPRINGS	Vector: Point Format: ArcInfo	This coverage consists of spring locations in Arizona. Incorporates information extracted from both the USGS Geonames database and the USGS Digital Line Graphs (DLG).
AZTRS	Vector: Polygon Format: ArcInfo	This statewide coverage consists of the Township, Range and Section grid lines.
County	Vector: Polygon Format: ArcInfo	This polygonal Data Set consists of individual county and an appended statewide coverage.
Lakes	Vector: Polygon Format: ArcInfo	This polygon cover consists of all the lakes in Arizona.
HUCS	Vector: Polygon Format: ArcInfo	This data set consists of Hydrologic Unit Code areas (drainage basins) in Arizona.
DAMS	Vector: Point Format: ArcInfo	This data set consists of jurisdictional dams maintained by ADWR.
GAGES	Vector: Point Format: ArcInfo	This data set consists of streamflow gaging stations maintained and operated by USGS.

2.2 DATA CONVERSIONS

The processing of data during query and search operations was slow due to the large file sizes of the data sets being used. To allow for ease of data storage and manipulation, a method of reducing the file size was undertaken which would not impact the outcome of the investigation and analysis.

The largest challenge was identifying a method to combine multiple stream segments into a single watercourse. Approximately 73% (55,387 segments) of the records in the original STREAMS Data Set are without names. In addition, there are a large number of separate watercourses with the same names; (e.g., Sycamore Wash). To resolve this, the project team assigned a unique nomenclature to all unnamed and same-named watercourses. For unnamed watercourses, nomenclature was assigned by combining the HUC ID with the Segment number (e.g. H34-2300). Same-named watercourses were assigned new nomenclature by combining the name with the county within which the majority of the watercourse was located. If there were more than one same-named watercourse within the same county, an additional numerical ID was added to the name (e.g., Sycamore Creek, Yavapai 1). This naming convention enabled reliable query and display and reduced the watercourse records to 39,039.

The project team assigned township, range, and section (TRS) location attributes to the mouth of each watercourse. The project team was not successful in linking the watercourse database to latitude/longitude GIS coverages, but this was not essential as the database is linked to the TRS system for location referencing.

2.3 DEVELOPMENT OF SATELLITE DATABASES

Six satellite databases were developed for each of the criterion comprising the Level 1 evaluation screening process. These satellite databases were populated with both diagnostic data fields used for the binary queries in the ANSAC master watercourse database, and also informational fields to provide additional information relative to the Level 1 criteria where readily available. The watercourses that tested affirmatively were converted to new satellite databases (themes) based on the criterion queried and were linked to the master database by a unique watercourse name or assigned watercourse ID. Each satellite database can be layered graphically in any selected combination to facilitate watercourse evaluation and to create meaningful reports. Listed below are the six satellite databases (with thematic displays) that were created along with the source documentation associated with each database.

Perennial - Only watercourses that have been classified by both the Arizona State Parks (1995) and ALRIS (1988) as perennial are so identified in the database. The approach used in identifying these watercourses in case of classification conflict was presented and described in detail in an earlier ANSAC report by Stantec (1998). Since the original stream database (comprised of 76,166 stream segments) was recently converted into a watercourse database (comprised of 39,039 records), assignment of perennial stream type to watercourses was made for those washes and streams with at least one perennial segment.

Conflicts in the classification of watercourses beyond the two sources named above are addressed in the Level 2 analysis, which employs a qualitative approach in the evaluation procedure. The project team acquired a GIS coverage developed by the Arizona Game and Fish Department entitled Perennial Waters of Arizona (AG&F, 1995,1997). The perennial streams, originally compiled and mapped by Brown et al (1977, 1978, and 1981), are the foundation of the GIS coverage of perennial streams developed by Arizona Game and Fish Department (1995, 1997). These data are used extensively by both federal and state agencies and were used by the project team to supplement the original perennial streams classified by Arizona State Parks (1995) and ALRIS (1988). Brown's perennial streams data were not integrated into the Level 1 analysis, but were used for the qualitative assessment in Level 2 for NRL1 watercourses located in Cochise County.

Dams - The Arizona Department of Water Resources (ADWR) developed the GIS coverage in point features indicating the location of all the jurisdictional dams in Arizona. The coverage contains data fields describing essential attributes of those dams important to the agency in matters of dam safety, management and ownership. However, essential data important to the pilot study are not completely populated such as township, range, and section, county, date constructed, dam types, wash location, purpose, and other important physical attributes. The missing information plus the resolution of the dam coverage made the task of identifying dam-impacted streams very difficult. The resolution problem associated with the dam GIS coverage was largely due to inconsistent development standards of different state agencies. Most of the GIS coverages used in the project were developed by ALRIS, while the dam coverage was developed by ADWR.

There are other sources of data for dam structures built in the state of Arizona besides that provided by ADWR. The US Geological Survey (USGS) and the Federal Emergency Management Agency (FEMA) maintain a listing of dams for the entire United States. Inconsistency in the use of names for the dams and data attributes between these various sources resulted in the sole utilization of the ADWR dam database for the study. Originally, the dam coverage from ADWR was comprised of 397 records. After the deletion of dams that are used for mining tailings and those that are located off-stream (a total of 26 records), the final record count was reduced to 371 dams.

Fish - A report published by the USDA Forest Service titled *Run Wild* (Silvey et al, 1984) was used to identify the occurrence of fish species and their habitats in Arizona. Several sources validate the findings listed in the *Run Wild* document. A total of 292 watercourses were identified as having one or more species of fish. Efforts to acquire existing fish GIS database information from Arizona State University (ASU) was not successful. Instead, information gathered from a number of reliable federal and state agency sources was used. These sources are listed in the references.

Historical and Modern Boating – Published accounts of modern boating were obtained from the Greenlee County Historical Society, Coconino Historical Society, Mormon Archives, Apache County Historical Society, Arizona State Parks, Central Arizona Paddlers Club, Arizona Game and Fish

Department and professional river rafting companies. One watercourse has a documented account of historical boating while 10 others have modern boating accounts.

Special Status – The Special Status category includes water-related characteristics that make a watercourse of particular interest or concern to various organizations and/or governmental agencies. Watercourses identified as having the following designations were included in the Special Status database: In-stream Flow Application and/or Permit, Unique Waters, Wild and Scenic, Riparian, and Preserve area. Agencies issuing the Special Status designation were contacted to identify watercourses meeting the criterion.

3.0 Analytical Procedure

A three-level evaluation system shown in Figure 2 was developed by the project team under the previous phase of this project (Stantec, 1998) and adopted for use in the follow-up Pilot Study (Stantec, 1999). The approach involves a multi-level screening process of increasing refinement designed to identify watercourses least likely to meet the statutory and legal definitions of navigability. The evaluation process consists of three levels as follows:

3.1 LEVEL 1 ANALYSIS

The goal of Level 1 of the watercourse evaluation procedure is to perform an initial screening of the entire catalog of small and minor watercourses. The purpose is to eliminate the watercourses most likely to be non-susceptible to navigation and which exhibit no evidence of actual navigation in fact.

The Level 1 analysis is a binary, quantitative sorting process utilizing the data queries programmed into the database catalog. Those queries are the digital expression of the technical and historical criteria considered diagnostic for evaluating watercourses for susceptibility to navigation and for navigation in fact, respectively. The minimum criteria include *stream type, dam information, historical and modern boating accounts, the existence of fish,* and *any special watercourse status designation (see* Figure 3).

The Level 1 screening process is applied to all small watercourses in the database catalog using available information from existing databases compiled by various agencies. Only those watercourses that test negatively to all six criteria are rejected at Level 1 as most likely to be non-susceptible to navigation. All watercourses, which test affirmatively to one or more of the criteria comprising the data queries, require further evaluation at Level 2.

Figure 2
THREE-LEVEL WATERCOURSE EVALUATION PROCEDURE

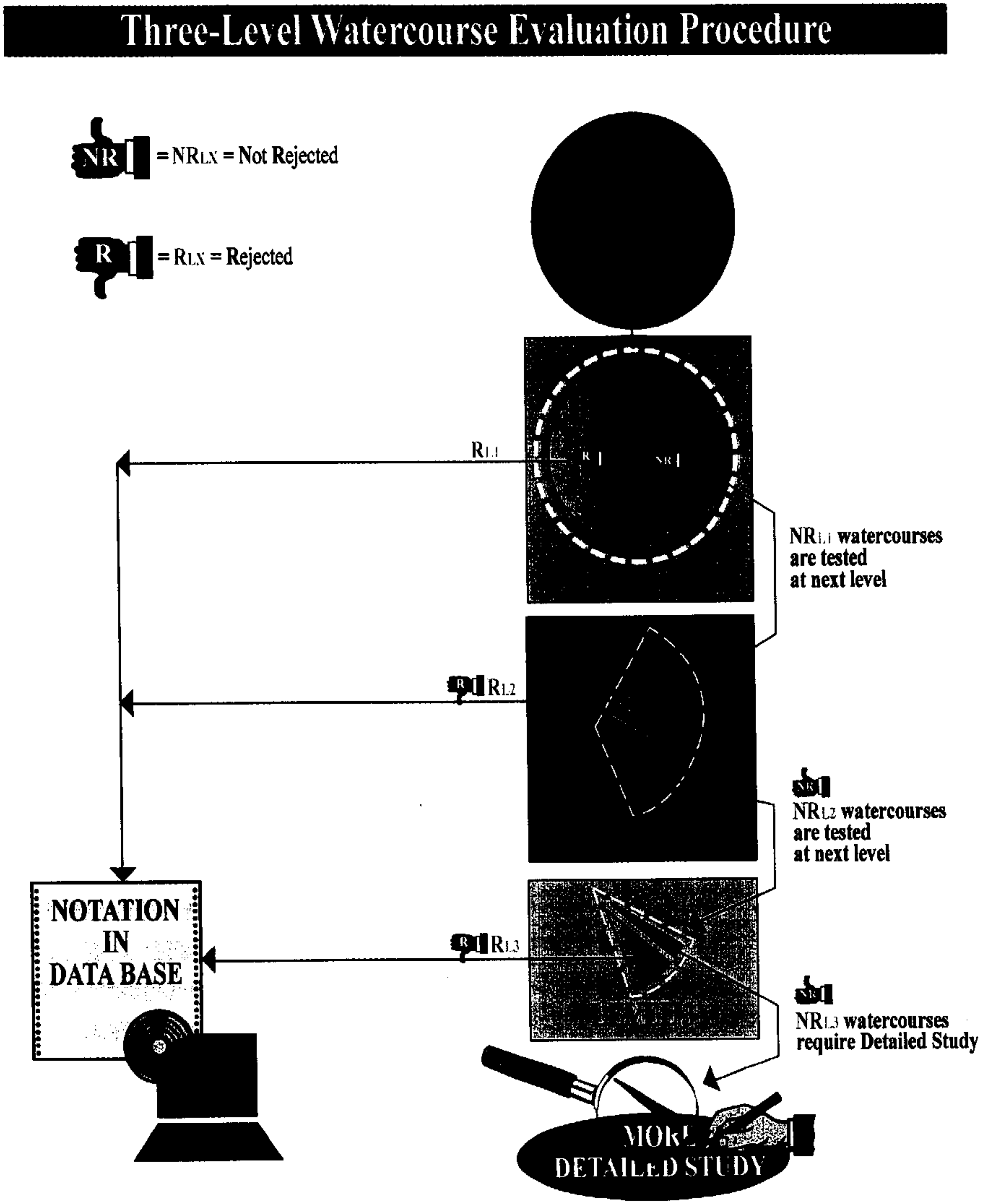
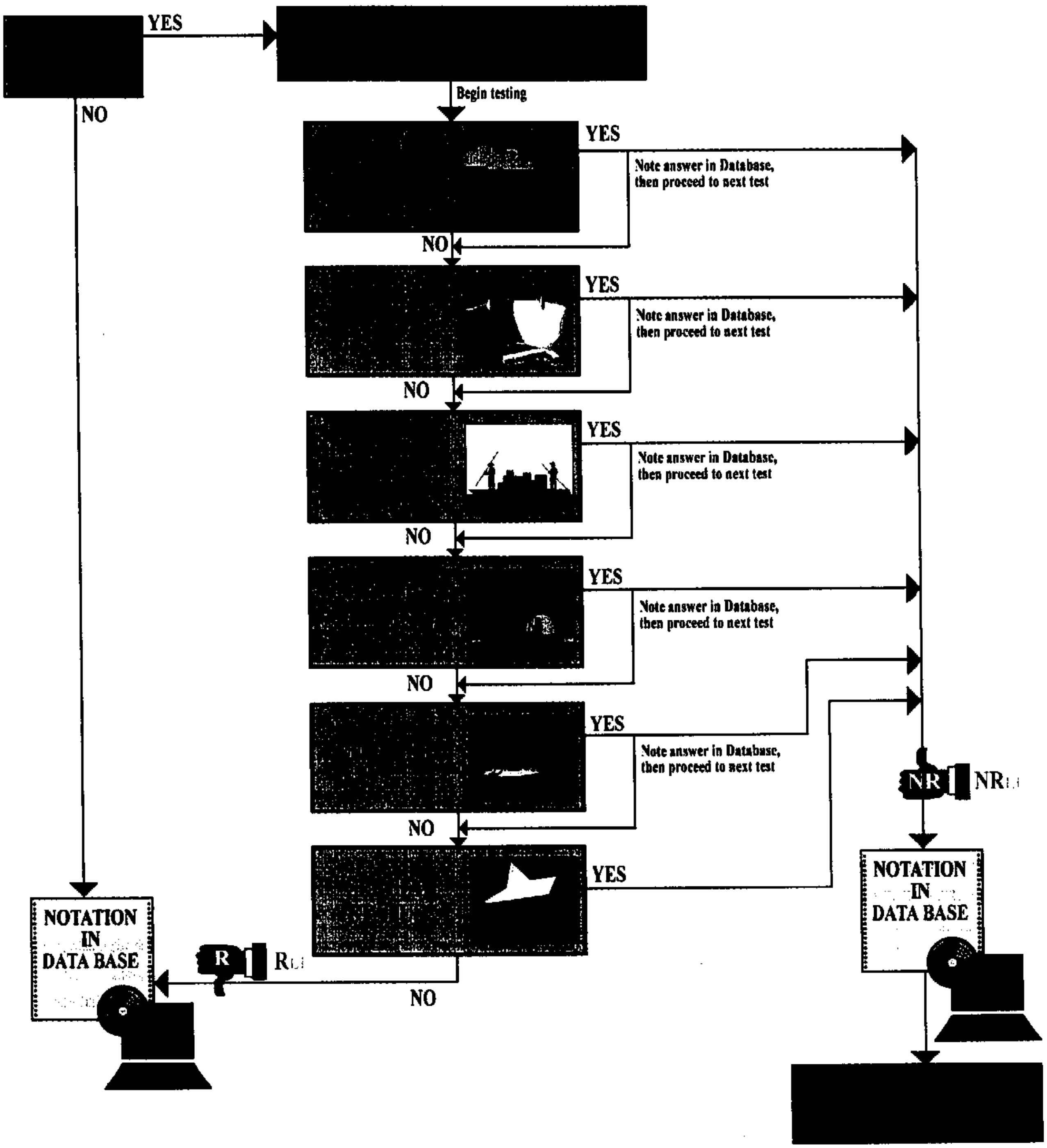


Figure 3
LEVEL 1 SCREENING PROCEDURE

Level 1 Screening Procedure



3.2 LEVEL 2 ANALYSIS

The goal of the Level 2 watercourse evaluation procedure is to perform a refined screening to eliminate the watercourses unlikely to be susceptible to navigation. Contiguous watercourse segments were combined to form study reaches to be evaluated in Level 2.

The Level 2 method of approach is more qualitative than the binary data queries employed at Level 1. Level 2 assessment involves the qualitative review of watercourse location, typical watershed characteristics, and typical watercourse characteristics, among other features, for verification and interpretation of the reason(s), which caused them to advance from Level 1. The recommended Level 2 methodology involves the further assessment of those watercourse characteristics that tested positively at Level 1 in two parts as shown in Figure 4 and described below:

1. The first-cut filter individually analyzes each criterion that caused a particular watercourse to advance to Level 2 – referred to herein as "affirmative responses" – for information salient to the navigability question as shown in Figure 5. Those watercourses are categorized into three groups as follows:

   Category A – Potentially Susceptible to Navigation

   Category B – Not Likely Susceptible to Navigation

   Category C – Not Susceptible to Navigation

   All watercourses with documented boating accounts - historical and/or modern - will automatically advance to *Category A* comprised of watercourses potentially susceptible to navigation. These watercourses are forwarded for Level 3 analysis.

   The streams classified as *Category C,* which comprised of watercourses not susceptible to navigation, are rejected at Level 2 and will not be investigated further.

2. The second cut filter analyzes *Category B* watercourses with multiple affirmative hits on multiple segments for diagnostic hit combinations that are evidence of navigation in fact or are indicative of susceptibility to navigation as shown in Figure 6. In addition, a rating system is applied to rank the Level 2 watercourses and identify those watercourses that merit further evaluation at Level 3. The application of the rating system is based on the premise that the six criteria used in the classification analysis of the small and minor watercourses do not carry equal weights as far as establishing potential susceptibility of any given watercourse to navigation.

Figure 4
Level 2 Screening Concept

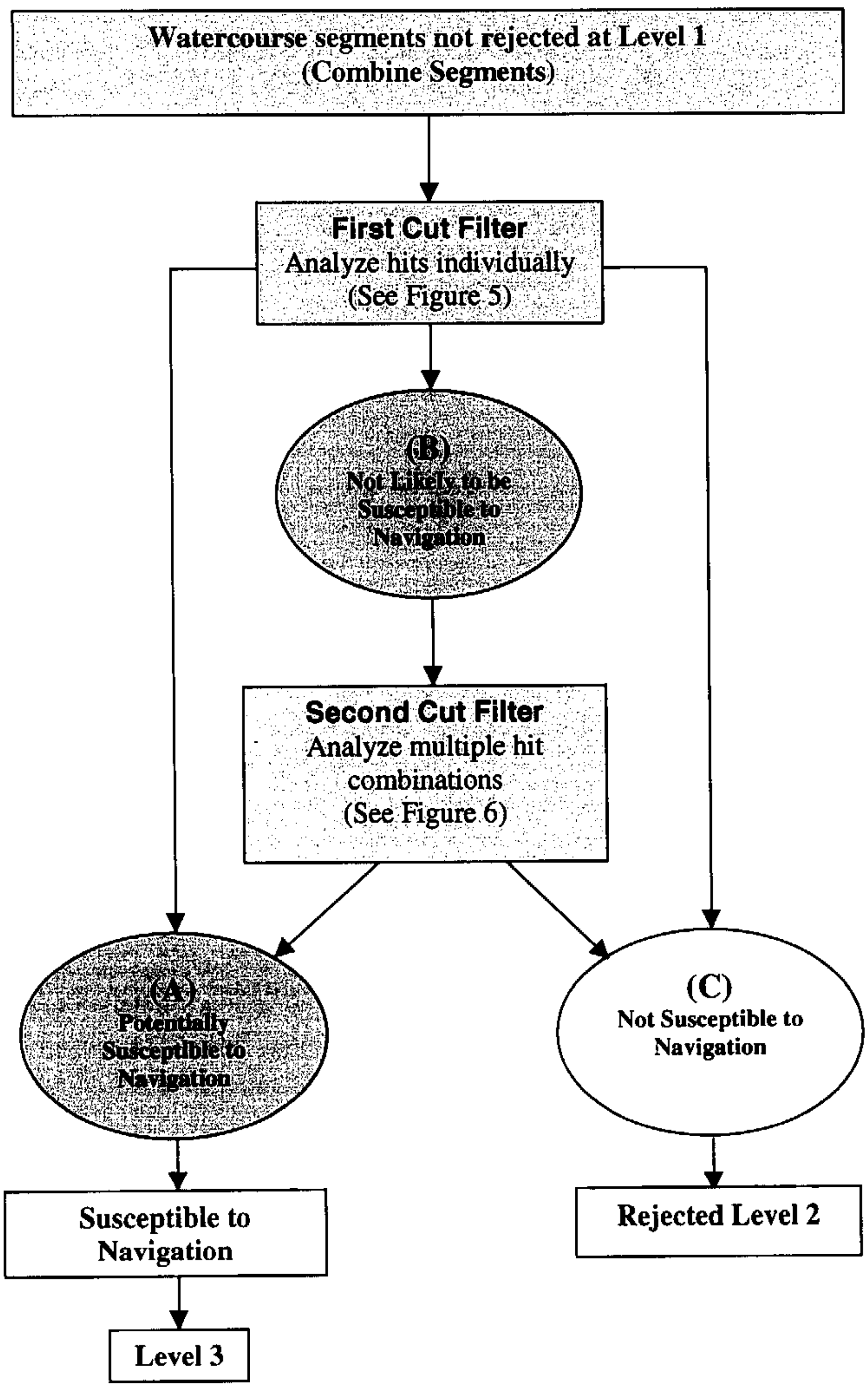


Figure 5
Level 2 Watercourse Screening
First Cut Filter

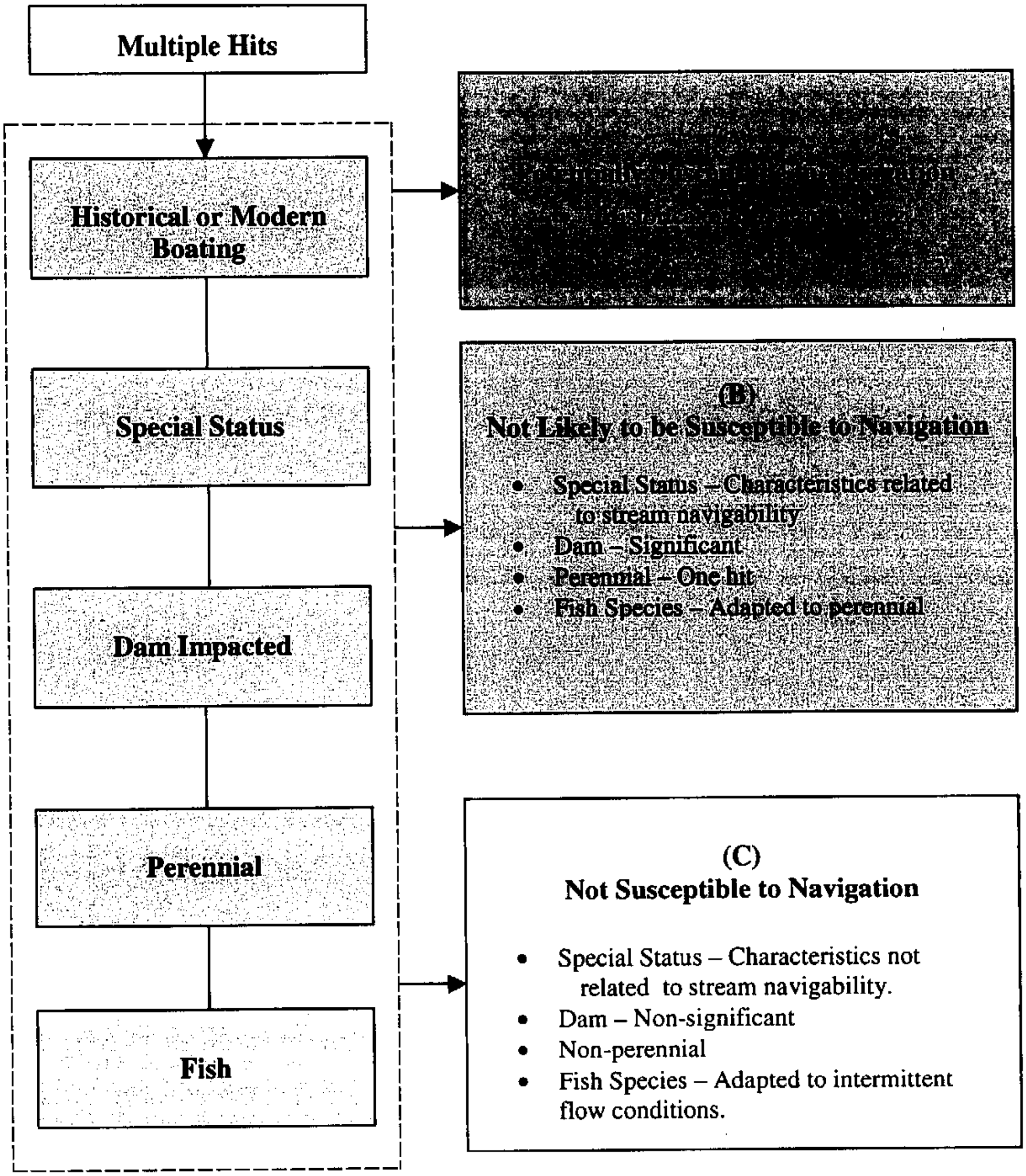
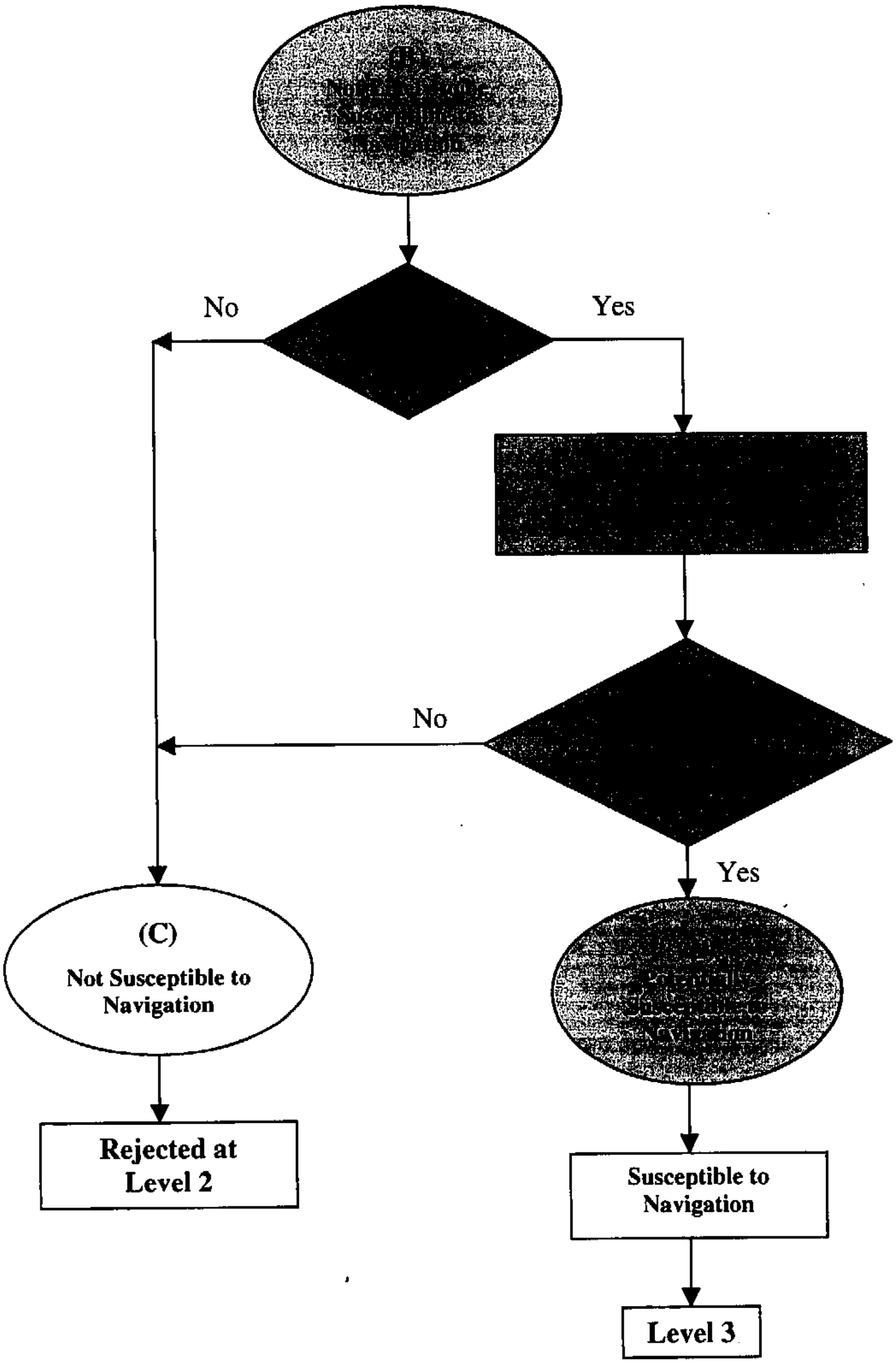


Figure 6
Level 2 Watercourse Screening
Second Cut Filter



Ultimately, the second cut filter classifies the watercourses into two categories (i.e., *Category A* and *Category C*) based on their likelihood of being susceptible to navigation. Watercourses with multiple hits indicative of susceptibility on contiguous segments and with evaluated total ratings of more than 11.0 are classified under *Category A*. *Category A* watercourses, which merit quantitative engineering analysis, are potentially susceptible to navigation and thus, forwarded for Level 3 analysis.

Watercourses, which are determined upon visual and/or manual inspection to exhibit physical characteristics incompatible with successful navigation (such as high elevations or steep slopes), and which received total ratings of 11.0 and below, are classified under *Category C*. *Category C* watercourses are rejected at Level 2 and are eliminated from further consideration in the study.

In the establishment of the rating system for the watercourses in Level 2, a cut-off number could be determined that helps separate the watercourses that are rejected at Level 2 and those that are forwarded for Level 3 analysis. The problem of not using a rating system for the watercourses is the assumption that the six criteria for the classification analysis carry the same weight as far as assessing their role to the stream navigability question. For example, historical boating, which is perceived to have the greatest bearing to stream navigability from among the six criteria, should carry the greatest weight possible.

Assigning associated weights to each of the six criteria based on their relevance to stream navigability aids in establishing a ranking system for the watercourses. The ranking system for the watercourses prioritizes the streams as follows: (1) those watercourses that show evidence of potential susceptibility to navigation which are forwarded to Level 3; and (2) those watercourses that show limited or weak susceptibility to navigation which are rejected at Level 2.

In order to assign numerical weights to the six criteria, a rating system was adopted with the goal of ranking the 1025 watercourses statewide to be evaluated in Level 2. The rating system was created by applying the criteria scoring matrix used for value engineering evaluation as shown in Figure B-1 (see Appendix B).

The procedure involves the identification of all the criteria to be used in the analysis. For the current study, the criteria are: *(a) historical boating, (b) modern boating, (c) perennial, (d) dam-impacted, (e) special status,* and *(f) fish.* Each criterion is compared with the rest of the criteria by assigning relative numerical values based on the preference scale provided below.

Value	Degree of Preference
4	*Major Preference*
3	*Medium Preference*
2	*Minor Preference*
1	*No Preference*
	(Each criterion scores one point).

For example, if three criteria (say *X, Y,* and *Z*) are being compared for the purpose of assigning numerical weights to them, each criterion must be individually compared to each of the other criteria (say *X vs. Y, X vs. Z, and Y vs. Z*). In each comparison there are only two possible choices, i.e., either one criterion is superior or preferred over the other criterion, or both criteria are on par - that is, no criterion is superior or preferred. For the first choice (where one criterion is superior or preferred), alphanumeric ratings similar to the examples below could be used:

X4 - indicates that criterion *X* is a *major preference* over criterion *Y* or criterion *Z*, whichever criterion *X* is being compared against.

Z3 - indicates that criterion *Z* is a *medium preference* over criterion *X* or criterion *Y*, whichever criterion *Z* is being compared against.

Y2 - indicates that criterion *Y* is a *minor preference* over criterion *X* or criterion *Z*, whichever criterion *Y* is being compared against.

For the second choice (where no criterion is superior or preferred), alphanumeric ratings similar to the examples below could be used:

X,Y1 - indicates that criterion *X* and criterion *Y* are on par (no preference) assigning one point for each criterion.

Y,Z1 - indicates that criterion *Y* and criterion *Z* are on par (no preference) assigning one point for each crietrion.

When all possible comparison scenarios are exhausted, the assigned numerical values are summed up for each criterion. The criterion that receives the highest total raw score should carry the highest numerical weight. Ranking all the criteria based on the raw scores evaluated, numerical weights from 0 to 10 are assigned accordingly. A numerical weight of 10 should be assigned to the criterion with the largest raw score, 9 or a lower rating to the second largest raw score, and so on.

3.3 LEVEL 3 ANALYSIS

The goal of the Level 3 sorting process is to eliminate watercourses that are non-susceptible to navigation utilizing quantitative engineering methodologies. The primary objective of the Level 3 engineering methodologies is to provide technically sound data from which typical channel characteristics and flow rates for each watercourse can be estimated and used to determine susceptibility to navigation. Additionally, any physical obstacles to successful navigation along a watercourse will be identified and assessed at Level 3.

The recommended methodologies for the Level 3 screening process involve application of quantitative hydrologic and hydraulic analyses that require a significant level of effort to meet the requirements of the adjudication process. The availability of streamgage data significantly impacts the level of effort required to quantify discharge rate and hydraulic geometry for evaluation of watercourse susceptibility to navigation. The recommended methodologies include:

1. Quantitative analysis of US Geological Survey (USGS) streamflow records or USGS regression-type methodologies based on streamflow records or extrapolation of gage data to adjacent watersheds to estimate discharge in the subject watercourse; and

2. Use of USGS rating curves or Manning's ratings to estimate flow characteristics such as depth, width and velocity in the subject watercourse.

The Level 3 screening process is applied only to those watercourses not rejected at Level 2 (NRL2 data set). The watercourses with no evidence of actual navigation in fact and determined to be not susceptible to navigation are rejected at Level 3. All remaining watercourses merit Detailed Study (Level 4) comparable to that performed for the major river studies and advance to the final level of the watercourse evaluation system.

4.0 Results

4.1 LEVEL 1 ANALYSIS

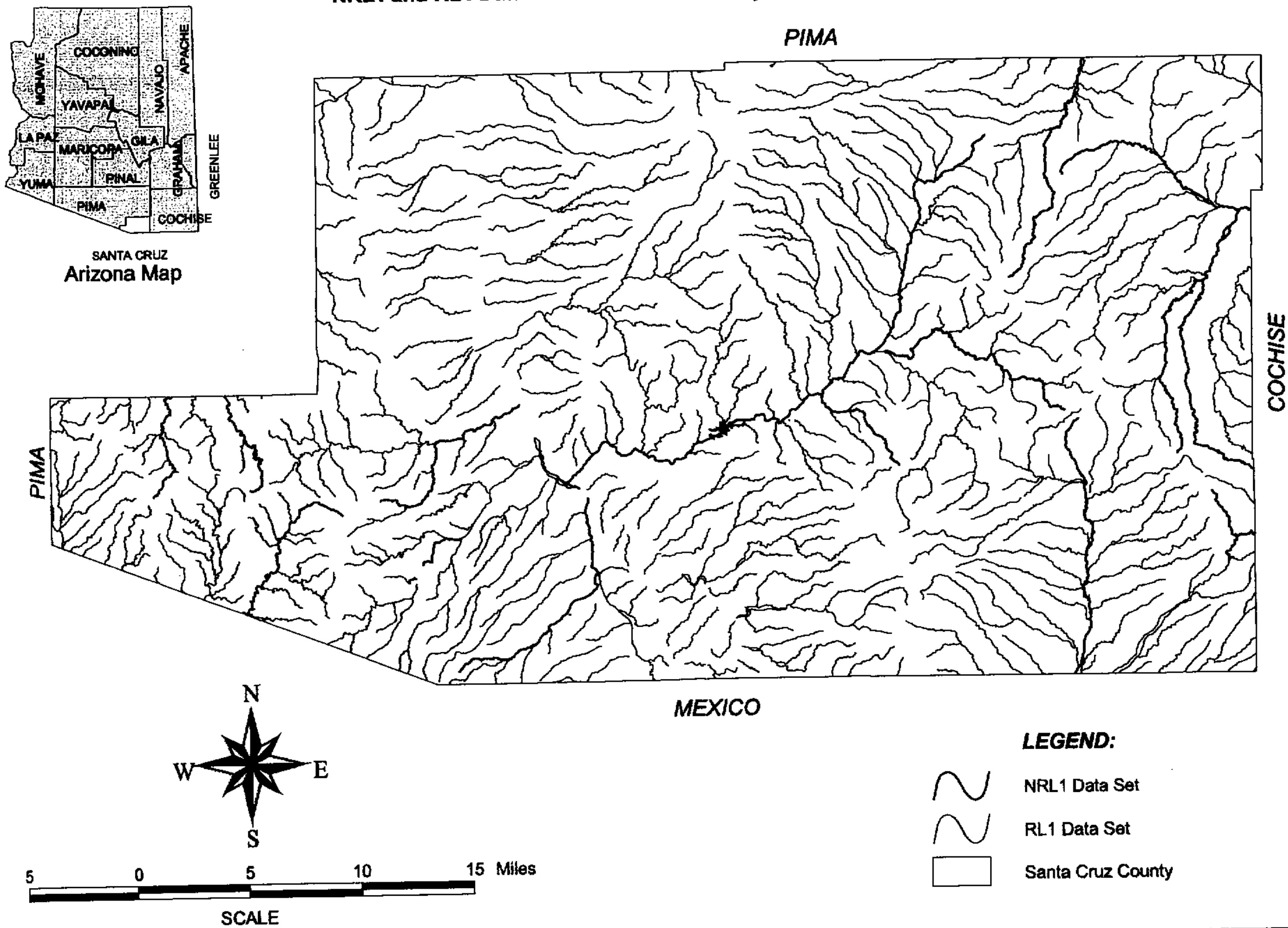
The application of the Level 1 sorting procedure to all small and minor watercourses in Santa Cruz County resulted into two data sets. The RL1 data set is comprised of all watercourses that test negatively for each criterion used in the Level 1 database query. This indicates that no characteristics of stream susceptibility to navigation are exhibited based upon known records and information. Level 1 analysis results indicate a significant percentage of the watercourses (96.6% or 506 records out of 524 total) test negatively to all Level 1 criteria and, therefore, do not justify further evaluation at Level 2.

The NLR1 data set is comprised of those watercourses that exhibit some characteristics of susceptibility to navigation based upon at least one affirmative response (hit) to the six criteria used in the Level 1 evaluation. Results of the analysis indicate that there are 18 watercourses (approximately 3.4%) in Santa Cruz County, which justify analysis at Level 2.

The summary listings for RL1 and NRL1 data sets are presented in Tables A-1A and A-1B in Appendix A. Ten (10) of the NRL1 watercourses are one-hitters and eight (8) watercourses tested affirmatively to more than one of the Level 1 criteria used in the database query.

The maps of RL1 and NRL1 data sets determined from the Level 1 sort are shown in Figure 7.

FIGURE 7
NRL1 and RL1 Data Sets from Level 1 Analysis for Santa Cruz County



4.2 LEVEL 2 ANALYSIS

The NRL1 data set resulting from Level 1 analysis contains 18 watercourses. Results from the application of the Level 2 approach to the 18 watercourses are presented and discussed in the sections that follow. Employing the first-cut screening process shown in Figure 5 for the NRL1 data set leads to the classification of the watercourses as follows:

1. Stream *Category B* – navigation possible, not likely.

    a. Babocomari River – Santa Cruz
    b. Cienega Creek
    c. O' Donnell Canyon
    d. Parker Canyon
    e. Sonoita Creek
    f. Sycamore Canyon – Santa Cruz
    g. Turkey Creek – Santa Cruz
    h. 1 unnamed wash

2. Stream Category C – navigation unlikely.

    a. Alum Gulch
    b. Cedar Creek 2
    c. Oro Blanco Wash
    d. Peck Canyon Creek
    e. Potrero Creek
    f. Redrock Canyon
    g. 4 unnamed washes

Employing the second-cut filter screening process shown in Figure 6 and the criteria scoring matrix presented in Figure B-1 (see Appendix B) to establish a ranking system for the watercourses leads to the identification of a cut-off number that separates those watercourses rejected at Level 2 and those that are forwarded for Level 3 analysis. All watercourses with total ratings equal to or lesser than the cut-off number of 11.0 are classified under *Category C.* These watercourses comprise the RL2 data set, which are not forwarded for Level 3 analysis. On the other hand, the watercourses with total ratings more than the cut-off number of 11.0 are classified under *Category A.* These watercourses comprise those that are potentially susceptible to navigation and hence, are forwarded for Level 3 analysis.

The listing of watercourses classified under stream *Category A* and *Category C* for the second cut filter screening process are provided as follows:

3. Stream *Category A* – potentially susceptible to navigation.

    a. Cienega Creek
    b. Sonoita Creek

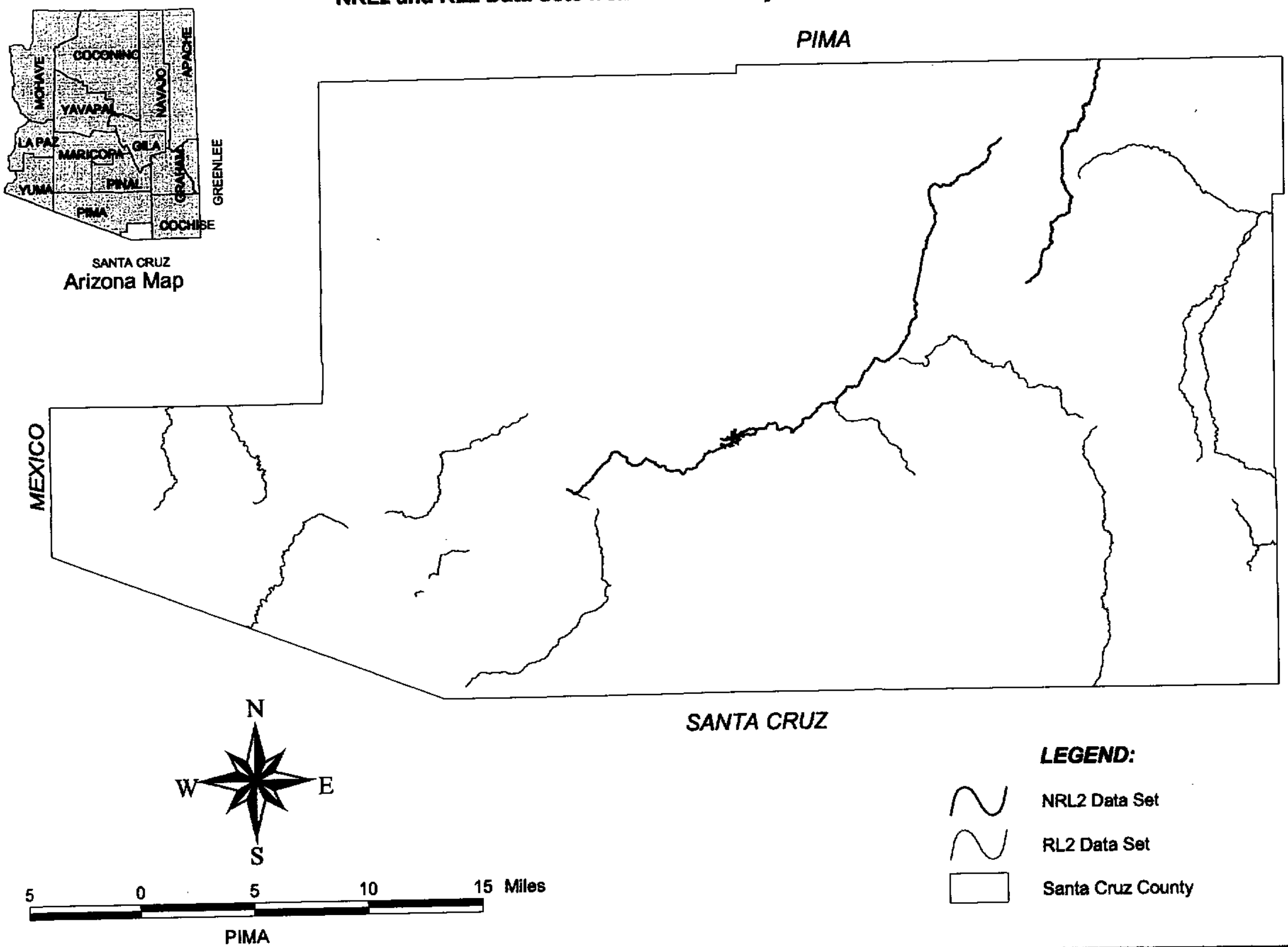
4. Stream Category C – navigation unlikely.

    a. Babocomari River – Santa Cruz
    b. O' Donnell Canyon
    c. Parker Canyon
    d. Sycamore Canyon – Santa Cruz
    e. Turkey Creek – Santa Cruz
    f. 1 unnamed wash

A summary listing of the RL2 data set is presented in Tables A-2A (see Appendix A). The map associated with the RL2 data set evaluated from Level 2 is shown in Figure 8.

The numerical weights assigned to the six criteria were based on the average values evaluated from the use of the criteria scoring matrix. This numerical weights are used as multipliers for the six criteria in calculating the total rating associated with each watercourse. The summary table listing the numerical weights assigned to the six criteria from a pool of seven participants is shown in Table B-1 (see Appendix B - Criteria Weight Evaluation).

FIGURE 8
NRL2 and RL2 Data Sets from Level 2 Analysis for Santa Cruz County



4.3 LEVEL 3 ANALYSIS

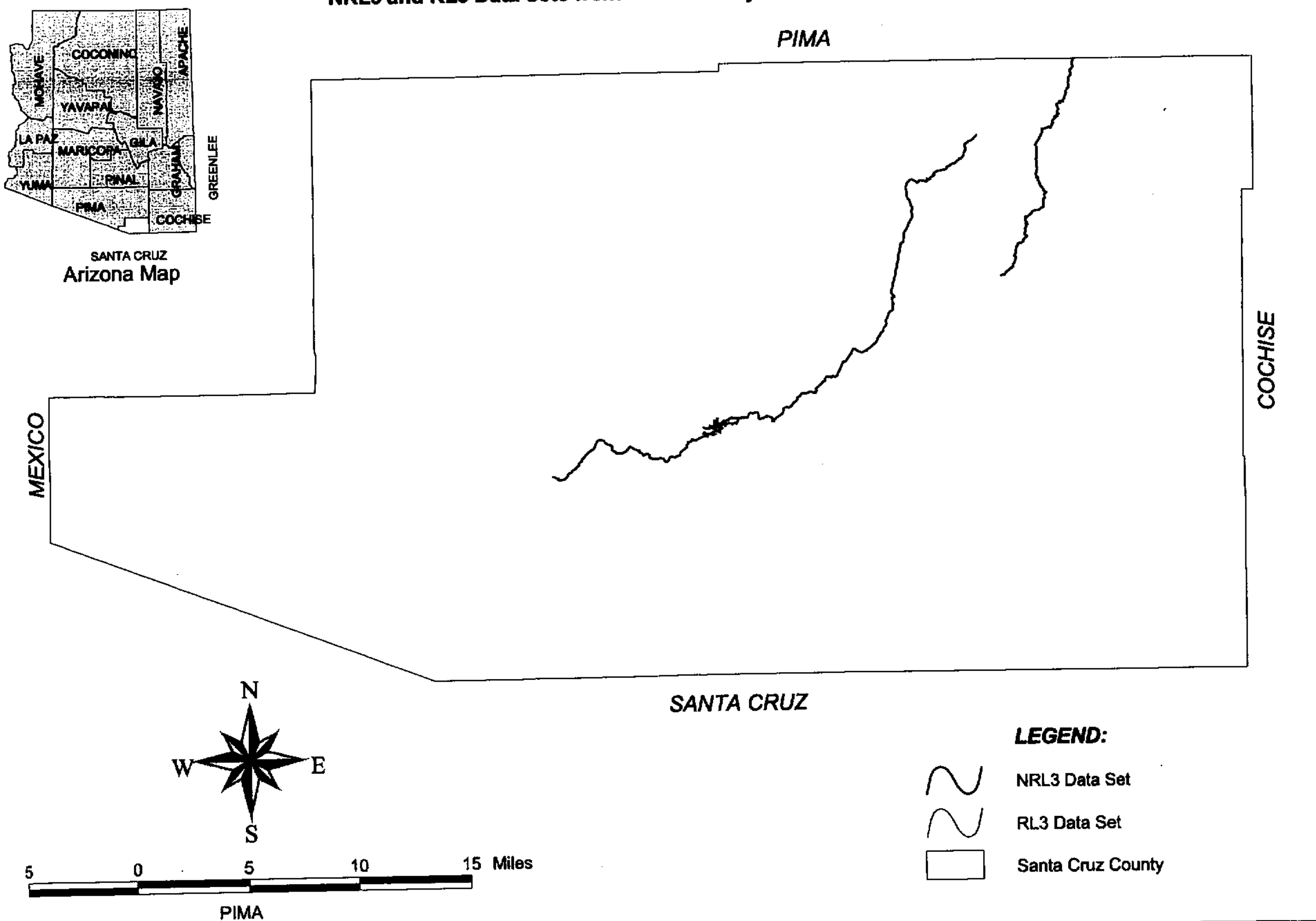
Two watercourses, represented by NRL2 data set, were further evaluated at Level 3. The selected watercourses are described below and details of the analysis plus a presentation of the Level 3 analysis results for each of the two watercourses follows:

4.3.1 Cienega Creek trends from the northeastern section of Santa Cruz county in the Canello Hills to the southeastern side of Pima County east of the Empire Mountains. It is a tributary to Pantano Wash.

4.3.2 Soinota Creek in southeastern Arizona is a tributary to Santa Cruz River. It trends from the headwaters in the northeastern section of Santa Cruz county and flows in southwesternly direction until it joins Santa Cruz River about 36.9 miles downstream.

The map associated with the NRL3 data set evaluated from Level 3 analysis is shown in Figure 9.

FIGURE 9
NRL3 and RL3 Data Sets from Level 3 Analysis for Santa Cruz County



Level 3 Analysis for Cienega Creek
Counties: Pima and Santa Cruz
Hydrologic Unit: 15050302

Introduction

The following summarizes the Level 3 navigability analysis for Cienega Creek. The purpose of the Level 3 analysis is to provide basic technical data regarding stream characteristics from which ANSAC can make a recommendation of navigability or non-navigability.

"Cienega" is a Spanish word meaning a marsh or swamp. Literally, the word means "hundred (cien) waters (agua)" and carries the connotation of a rich combination of flowing water, stagnant water, stream flow, springs, and shallow groundwater. Cienega Creek was named for the cienegas that were once found along its river valley prior to settlement of the area by Anglo-Americans.

Stream Geomorphology

Cienega Creek is located in Pima and Santa Cruz Counties in southeastern Arizona (Figure 4.3.1.1). The 457 square mile watershed extends from a point near Vail, Arizona where the stream changes name to Pantano Wash, south to the headwaters located in the Canelo Hills of Santa Cruz County, Arizona (Figure 4.3.1.2). The watershed is bounded by the Rincon Mountains to the north, the Whetstone Mountains to the east, the Canelo Hills to the south, and the Santa Rita Mountains to the west. The vegetation near Cienega Creek includes ponderosa pine in the upper elevations of the Santa Rita Mountains while the lower elevations include oak, juniper, agave and extensive grasslands. Elevations within the basin range from 3,200 feet at the Colossal Cave Road crossing to over 9,400 feet on Mt. Wrightson in the Santa Rita Mountains. Table 4.3.1.1 shows watershed characteristics for Cienega Creek measured at the USGS stream gauges (Figure 4.3.1.2)[1].

For the purposes of this report, Cienega Creek was considered as a single reach. The main channel of Cienega Creek has an average slope of about 0.9 percent (0.09 ft./ft.), and consists of a sand and gravel-bedded channel and low banks lined by riparian vegetation or grassland. A longitudinal profile of the stream is shown in Figure 4.3.1.3.

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[1] The USGS refers to this gauge as the Pantano Wash Near Vail. However the gauge location corresponds roughly to the downstream limit of the Cienega Creek as defined in this report.

Figure 4.3.1.1
Cienega Creek Location Map

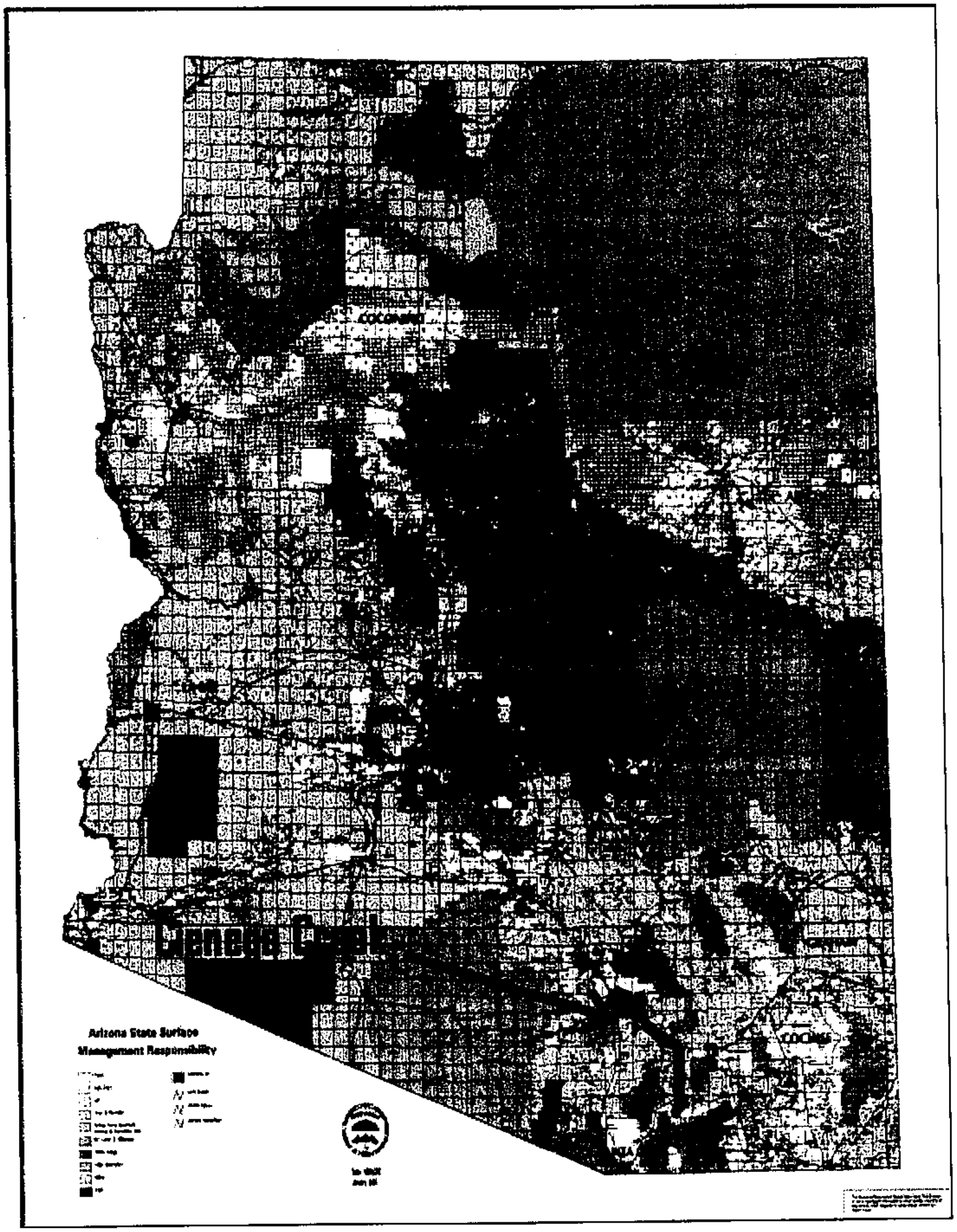


Figure 4.3.1.2
Cienega Creek Watershed Location Map

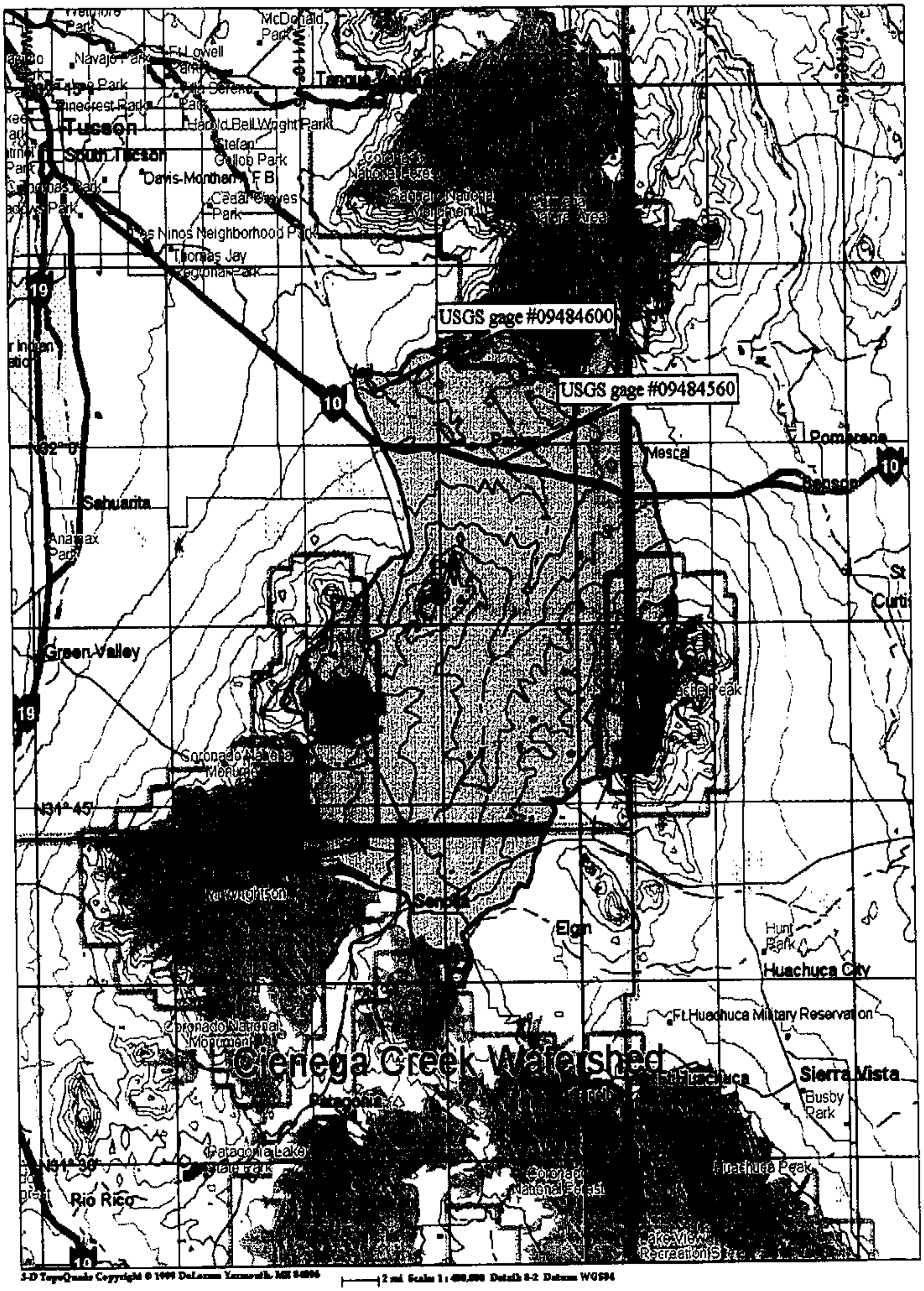
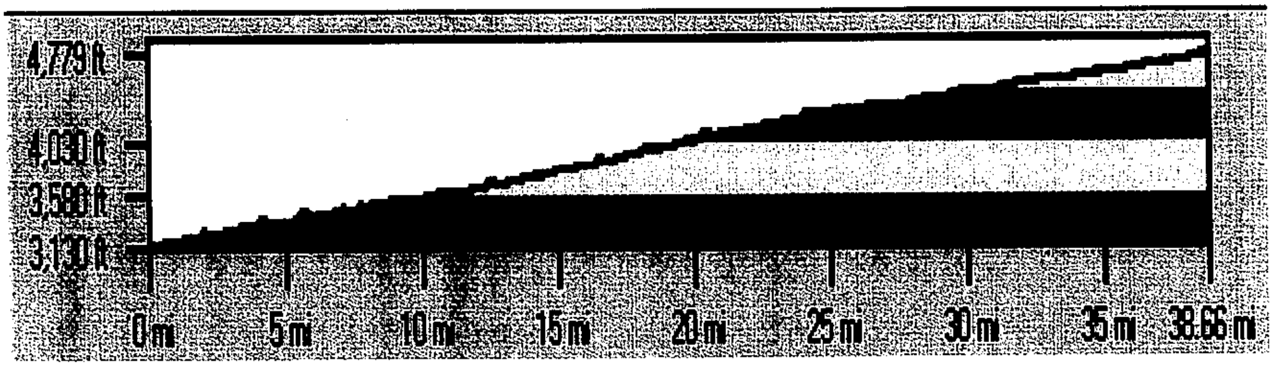


Figure 4.3.1.3
Longitudinal Profile of Cienega Creek



The main channel of Cienega Creek is straight to slightly sinuous, and consists of single and braided channel reaches. Downstream of I-10, Cienega Creek flows within a well-defined canyon, while upstream of I-10 the stream is shallower with a less well-defined transition to the surrounding grasslands. Historical data suggest that the Cienega Creek experienced arroyo cutting during the late 1800's and early 1900's (Eddy and Cooley, 1983). Based on recent field investigation, arroyo cutting appears to be continuing today in the upper reaches of the Cienega Creek in Santa Cruz County.

Representative photographs of Cienega Creek are provided at the end of this report.

Hydrology

USGS stream gages provide a systematic record of stream flow at two sites on Cienega Creek. Tables 4.3.1.2 to 4.3.1.4 provide summaries of stream flow data and flood frequency predictions based on the USGS gauge records (Pope et. al., 1998). The locations of the two gauges within the study area are shown on Figure 4.3.1.2. Figures 4.3.1.4 to 4.3.1.6 provide graphical depictions of annual peak and mean discharge values for the two gauges. The Cienega Creek near Pantano gauge provides only peak discharge data (i.e., no daily discharge data available).

Table 4.3.1.1 Cienega Creek Navigability Study Stream Characteristics		
Watershed Characteristic	**Pantano Wash near Vail**	**Cienega Creek near Pantano**
Stream length	43.5 mi.	31.2 mi.
Main channel slope	46.3 ft./mi.	59.8 ft./mi.
Mean basin elevation	4500 ft. msl	4890 ft. msl
Mean annual precipitation	15.4 in.	16.6 in.
Forested area	15 %	13 %
Drainage area	457 $mi.^2$	289 $mi.^2$

Table 4.3.1.2 Cienega Creek Navigability Study Mean Monthly Streamflow Data for Pantano Wash at Vail (#09484600)												
Month	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**
Mean	8.4	4.7	3.4	2.1	1.3	1.2	12	20	12	1.9	1.2	6.4
Max	111	36	18	5.2	2.0	3.6	50	93	105	6.7	3.0	50
Min	0.10	0.10	0.12	0.32	0.19	0.07	0.66	0.52	0.16	0.10	0.10	0.10
Period of Record: 1959-1974, 1975-1989 and 1989-1998												

Table 4.3.1.3 Cienega Creek Navigability Study Streamflow Statistics for Pantano Wash at Vail (#09484600)	
Flow Characteristic	**Flow Rate**
Annual Mean Flow	6.2 (cfs)
Maximum Annual Mean	13 (cfs)
Minimum Annual Mean	1.8 (cfs)
Lowest Daily Mean (numerous occurrences)	0 (cfs)
Highest Daily Mean (Sep. 10, 1964)	2,230 (cfs)
Max. Instantaneous Peak Flow (Aug. 11, 1958)	38,000 (cfs)
Annual Mean Runoff	4,489 (acre-feet)
Flow value exceeded 10% of the time	4.7 (cfs)
Flow value exceeded 50% of the time	1.4 (cfs)
Flow value exceeded 90% of the time	0.43 (cfs)

Table 4.3.1.4 Cienega Creek Navigability Study Peak Discharges for Cienega Creek						
Gauge	**2-Year**	**5-year**	**10-year**	**25-year**	**50-year**	**100-year**
Pantano Wash at Vail (#09484600)	2,600	6,450	10,400	17,200	23,900	32,100
Cienega Creek near Pantano (#09484560)	1,880	4,020	6,150	9,930	13,700	18,500

The USGS gauge data summarized in Tables 4.3.1.1 to 4.3.1.4 and Figures 4.3.1.4 to 4.3.1.6 indicate that Cienega Creek is a perennial stream at the gauge near Vail. The highest seasonal flow rates occur during the summer monsoon in July through September. A slight rise in flow rate also occurs during the winter months of December, January and February, probably due as much to decreased evapotranspiration as to seasonal rainfall or snowmelt. The average annual flow rate is 6.2 cfs at Vail, although the flow at the gauging station is impacted by a small dam upstream which forces groundwater to the surface and increases the low flow rate. However, since the dam was built in 1911, this forced flow condition is representative of conditions as of the time of statehood. The 50% flow duration, or median flow rate, is 1.4 cfs. Comparison of the 50% flow duration and the average annual flow rate indicates that the average annual flow rate is skewed upward by floods. That is, much of the annual flow volume is provided by floods rather than low flows, a condition similar to many ephemeral streams in Arizona.

The average monthly flow rates are all above zero flow, indicating that periods of zero flow are brief, and may be related to seasonal groundwater pumping or other withdrawals. The typical flow rate is less than 4.7 cfs about 90 percent of the time, except in July, August, and September during summer flash floods, and winter months like December and January. The average annual flow rate is only 6.2 cfs, although the median flow rate (50% duration) is only 1.4 cfs.

Figure 4.3.1.4
Flow Duration Curve for Cienega Creek

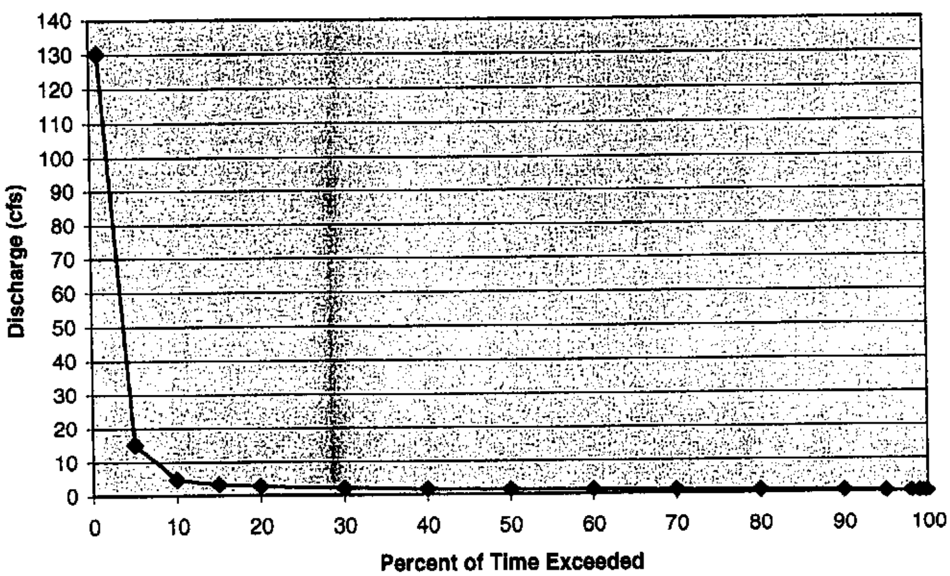


Figure 4.3.1.5
Average Monthly Flow for Cienega Creek

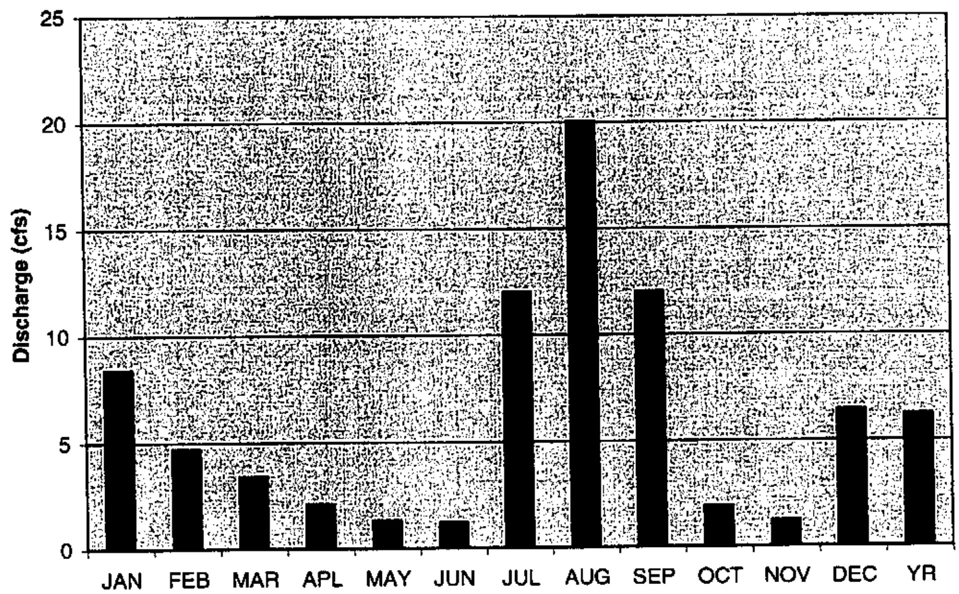
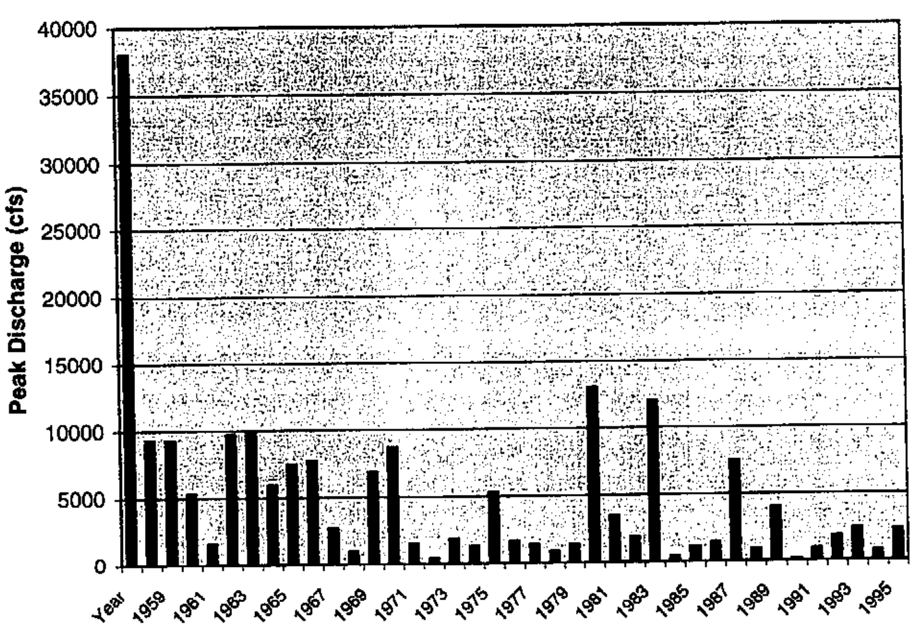


Figure 4.3.1.6
Annual Peak Discharges for Cienega Creek



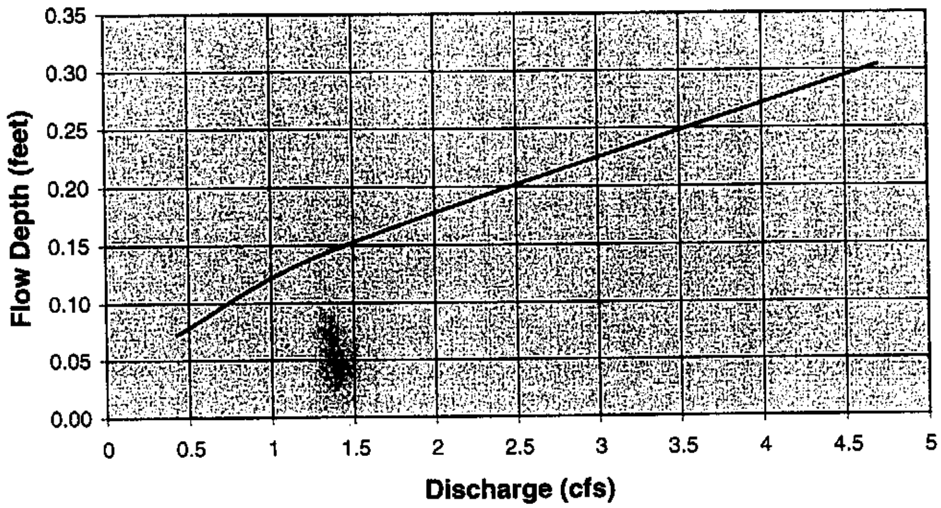
Hydraulics

Measured data for hydraulic flow characteristics at the time of statehood were not available. However, estimated hydraulic characteristics were developed based on observed stream conditions and historic stream flow data available from the USGS stream gauge at Vail (#09484600). Table 4.3.1.5 provides a summary of the resulting range of values for estimated stream depth, width, and velocity. It should be noted that the hydraulic parameters shown below are not specific to any one location along the stream and assume that the stream flow characteristics for the referenced gauge would be relevant at all locations within the study area. Because the stream channel is somewhat confined at the gauge, the flow depths may be slightly higher than will occur elsewhere in the study area. A rating curve for an assumed cross section developed from field observations is shown in Figure 4.3.1.7.

Table 4.3.1.5
Cienega Creek Navigability Study
Estimated Range of Hydraulic Characteristics

Flow Duration	Discharge (cfs)	Flow Depth (ft)	Average Velocity (ft/s)	Flow Width (ft)
10 %	4.7	0.2 – 0.4	1.2 – 1.9	6 – 20
50 %	1.4	0.1 – 0.2	0.7 – 1.2	6 – 20
90 %	0.43	0.0 – 0.1	0.5 – 0.7	6 – 20
Average Annual	6.2	0.2 – 0.5	1.3 – 2.1	6 – 20
2-Year Flood	2,600	9 – 18	15 – 24	6 – 20

Figure 4.3.1.7
Cienega Creek Depth-Discharge Rating Curve



Boating Criteria

The boating criteria cited below were reported in previous detailed navigability studies prepared for the Arizona State Land Department, and are based on the following references:

1. Cooperative Instream Flow Service Group, 1978. Methods of Assessing Instream Flows for Recreation. Instream Flow Information Paper: No. 6. FWS/OBS-78/34. June. Report prepared by U.S. Fish and Wildlife Service, U.S. Environmental Protection Agency, Heritage Conservation and Recreation Service, and Bureau of Reclamation.
2. Jason M. Cortell and Associates, Inc., 1977, Recreation and Instream Flow, Vol. 1: Flow Requirements, Analysis of Benefits, Legal & Institutional Constraints. Report submitted to U.S. Department of the Interior, Bureau of Outdoor Recreation #BOR D6429. July.
3. Walter B. Langbein, 1962. Hydraulics of River Channels as Related to Navigability. U.S. Geological Survey Water-Supply Paper 1539-W.
4. Jim Slingluff, 1987. Deposition of Jim Slingluff for No. C 569870, Maricopa County, et al and Arizona Center for Law in the Public Interest, et al., and Calmat Co. of Arizona, et al, v. State of Arizona, Arizona State Land Department, M. Jean Hassel, and Milo J. Hassel, et al. November 23, 1987.

The following tables summarize navigability criteria information from references 1 to 4. Note that these data reference recreational boating, not necessarily commercial boating.

Table 4.3.1.6 Minimum Required Stream Width and Depth for Recreation Craft[1]		
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
[1] After reference #1		

Table 4.3.1.7 Minimum and Maximum Conditions for Recreational Water Boating[1]						
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
[1] After reference 2.						

Table 4.3.1.8 Flow Requirements for Pre-1940 Canoe Boating[1]	
Boat Type	**Depth**
Flat Bottomed (Wood or Canvas)	4 in.
Round Bottomed (Wood or Canvas)	6 in.
[1] After reference 4.	

Summary

Comparison of the boating criteria and hydraulic data for Cienega Creek shown above indicate that the stream could be boated by low draft canoes or kayaks much less than 10 percent of the time during unpredictable high flows, and that boating by larger commercial craft would be even more unlikely. Field data collected by the author indicates that low-draft recreational boating would be difficult due to overhanging vegetation, fences and other obstructions. No modern or historical accounts of any type of boating in Cienega Creek were obtained during the course of this study. A Level 4 will be conducted for Cienega Creek.

Limitations

This evaluation is based on readily available information that reflects the level of detail and funding authorized for the ANSAC Small Watercourses Navigability Study. The following limitations apply to the results presented above:

- The hydraulic rating sections may or may not apply to the entire study reach. However, the rating section results probably represent better than order-of-magnitude accuracy for estimates of width, depth, and velocity at any given point within the study reach.

- Hydrologic data for any stream varies with location within a reach, and with time in response to climatic conditions. The hydrologic information provided is best readily available data for the stream.

- Stream conditions were assumed to represent conditions as of the time of Arizona statehood. Unless stated otherwise, no data were identified during the Level 3 analysis that indicated substantive changes in stream morphology with respect to navigability criteria.

Photographs of Cienega Creek

Looking upstream from the Colossal Cave Road Bridge (downstream end of study reach).

Looking downstream from just downstream of Marsh Station Road.

Level 3 Analysis for Sonoita Creek
County: Santa Cruz
Hydrologic Unit: 15050301

Introduction

The following summarizes the Level 3 navigability analysis for Sonoita Creek. The purpose of the Level 3 analysis is to provide basic technical data regarding stream characteristics from which the ANSAC can make a recommendation of navigability or non-navigability.

"Sonoita" is a Spanish word meaning a small wetlands. Sonoita Creek was named for the wetlands that were once found along its river valley prior to settlement of the area by Anglo-Americans. Sonoita Creek is located in Santa Cruz County in southeastern Arizona.

Stream Geomorphology

The 265 square mile Sonoita Creek watershed is bounded by the Santa Rita Mountains to the north, the Canelo Hills to the east, the Patagonia Mountains to the south and the Santa Cruz River Valley to the west, and ranges from just over 9,400 feet at Mt. Wrightson to 3,400 feet at Rio Rico (Figure 4.3.2.1). The watershed extends from its confluence with the Santa Cruz River near the community of Rio Rico, to the headwaters located near the community of Sonoita (Figure 4.3.2.2). Vegetation within the watershed varies from Arizona Upland desert scrub in the lower elevations, to Oak-Woodland and Ponderosa Pine in the upper elevations of the Santa Rita Mountains. Vegetation along Sonoita Creek includes cottonwood-willow riparian forests at some locations, and Upper Sonoran desert and grassland dry wash species such as Palo Verde and mesquite, depending on local stream flow conditions. Table 4.3.2.1 provides a number of watershed characteristics for the Sonoita Creek as measured at the U.S. Geological Survey (USGS) stream gauge near Patagonia (#09481500), which is located a short distance upstream of Patagonia Lake (Figure 4.3.2.2).

The main valley of the Sonoita Creek ranges from 10 to 20 miles wide, which is cut by an inner valley less than one-half mile wide to a depth of approximately 100 feet (Bradbeer, 1978). The main channel of the Sonoita Creek is a dry sand bed channel approximately 10 to 20 feet wide in most places. The average slope of the channel is about 1.4 percent (0.014 ft./ft., Figure 4.3.2.3).

Figure 4.3.2.1
Sonoita Creek Location Map

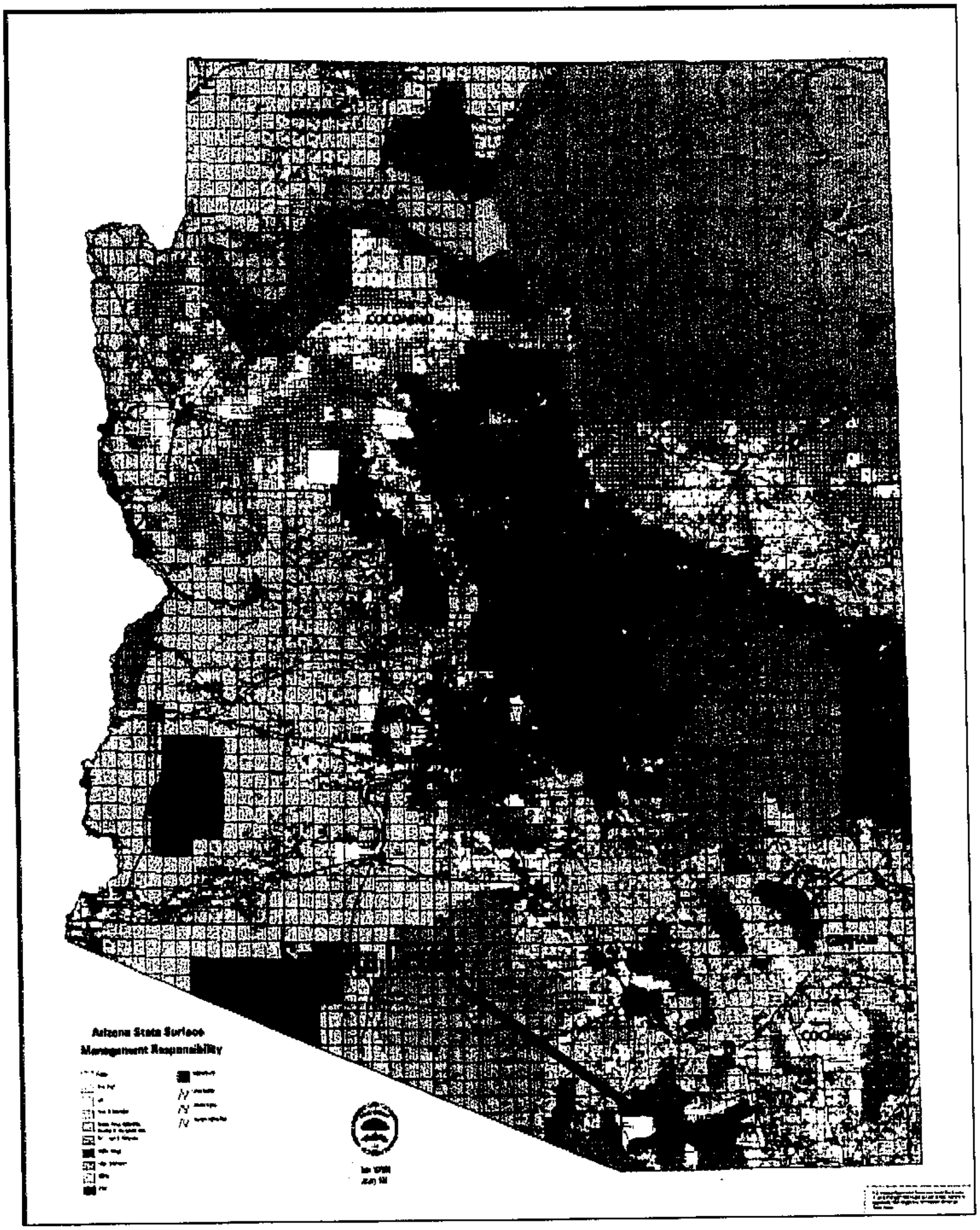
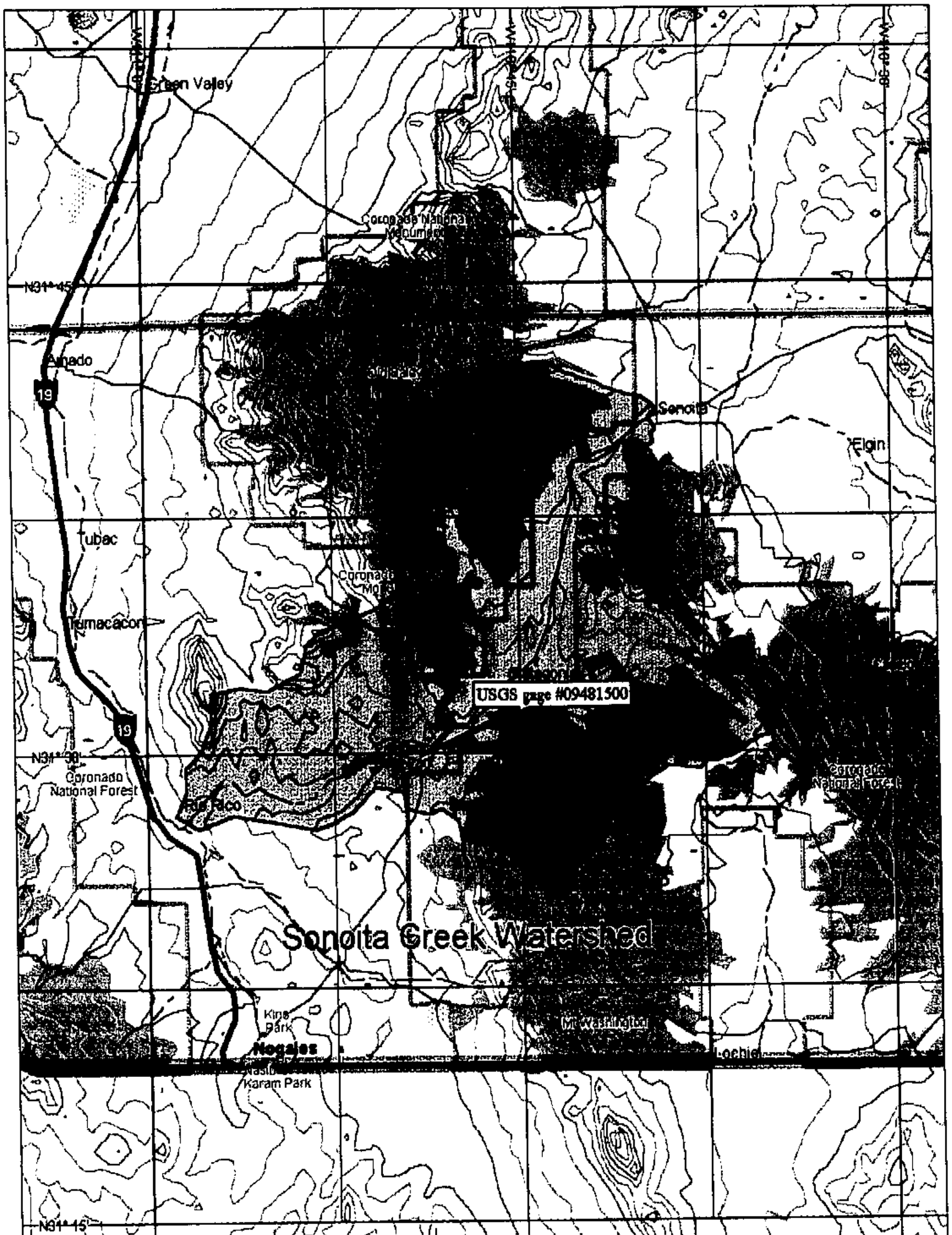


Figure 4.3.2.2
Sonoita Creek Watershed Location Map



3-D TopoQuads Copyright © 1999 DeLorme Yarmouth, ME 04096 1 mi Scale 1 : 300,000 Detail 8-7 Datum WGS84

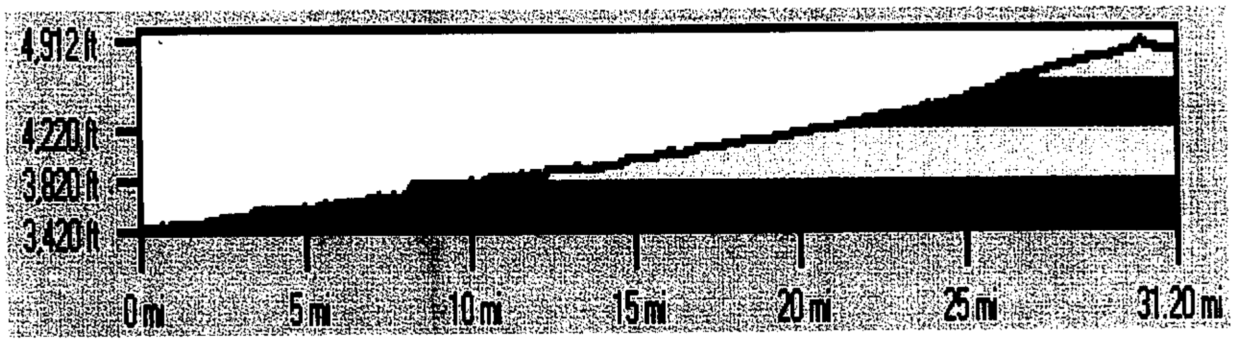


Figure 4.3.2.3
Longitudinal Profile of Sonoita Creek.

The channel generally has a wide, shallow cross section, except in the perennial reach near the Patagonia-Sonoita Creek Preserve, with a straight to slightly sinuous pattern. Low flows are typically braided, but seasonal floods fill the channel and flow in a single channel pattern. No evidence was identified in the historic record or from field investigation that the plan form or location of the stream varied significantly since the time of statehood.

For the purposes of this navigability study, Sonoita Creek was considered as a single reach of relatively uniform characteristics. Photographs of Sonoita Creek are provided at the end of this report.

Hydrology

The USGS stream gauge provided the only systematic record of flow in Sonoita Creek. Tables 4.3.2.2 to 4.3.2.4 and Figures 4.3.2.4 to 4.3.2.6 provide a summary of stream flow data and flood frequency predictions based on the USGS records (Pope et. al., 1998). Downstream of the USGS gauge, the natural hydrology of Sonoita Creek was altered by construction of a dam in 1968 at what is known today as Patagonia Lake. An agreement was made with downstream water users to provide for an annual release of water of at least 1,200 acre feet (1.7 cfs) by monthly releases of up to 200 acre feet per month (3.3 cfs), not including spillway flow during floods, to allow for a regular distribution of flow throughout the year (Bradbeer, 1978). In 1974, the 640-acre lake was purchased by the State of Arizona and turned over to the Arizona State Parks Board for management as a recreational facility. Patagonia Lake is located approximately seven miles west of the Town of Patagonia and approximately 1.7 miles downstream of the USGS gauge. The period of record for the USGS gage is 1931-1933 and 1936-1972.

Table 4.3.2.1 provides a summary of stream flow data and flood frequency predictions based on the USGS gauge data (USGS, 1998). Table 4.3.2.2 lists average monthly and average annual flow rates. Table 3 summarizes stream flow statistics and significant floods recorded at the USGS gauge. Table 4.3.2.4 shows the peak discharges for floods of various recurrence intervals. Figures 4.3.2.4 to 4.3.2.6 provide graphical depictions of discharge data for the USGS gauge.

Table 4.3.2.1
Sonoita Creek Navigability Study
Stream Characteristics Sonoita Creek near Patagonia (#09481500)

Watershed Characteristic	Value
Stream length	21.7 mi.
Main channel slope	76.7 ft./mi.
Mean basin elevation	4800 ft.
Mean annual precipitation	19.3 in.
Forested area	52 %
Drainage area	209 $mi.^2$
Period of record	1931-33, 1936-72

Table 4.3.2.2
Sonoita Creek Navigability Study
Mean Monthly Streamflow Data for Sonoita Creek near Patagonia (#09481500)

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Mean	7.5	9.9	5.5	4.1	2.5	1.6	13	25	9.2	3.9	4.0	10
Max	52	96	16	12	10	8.6	112	151	71	20	118	107
Min	1.1	0.99	0.87	0.49	0.06	0.00	0.06	1.5	0.05	0.03	0.32	0.99
Period of Record: 1931-1933, 1936-1972												

Table 4.3.2.3
Sonoita Creek Navigability Study
Streamflow Statistics for Sonoita Creek near Patagonia (#09481500)

Flow Characteristic	Flow Rate
Annual Mean Flow	8.1 (cfs)
Maximum Annual Mean	33 (cfs)
Minimum Annual Mean	1.9 (cfs)
Lowest Daily Mean (many dates)	0 (cfs)
Highest Daily Mean (Dec. 20, 1967)	1,780 (cfs)
Max. Instantaneous Peak Flow (Oct. 2, 1983)	16,000 (cfs)
Annual Mean Runoff	5,864 (acre-feet)
Flow value exceeded 10% of the time	11 (cfs)
Flow value exceeded 50% of the time	3.2 (cfs)
Flow value exceeded 90% of the time	0.45 (cfs)

Table 4.3.2.4 Sonoita Creek Navigability Study Peak Discharges for Sonoita Creek near Patagonia (#09481500)					
2-year	**5-year**	**10-year**	**25-year**	**50-year**	**100-year**
3,130	5,360	7,190	9,950	12,300	15,100

Figure 4.3.2.4
Flow Duration Curve for Sonoita Creek

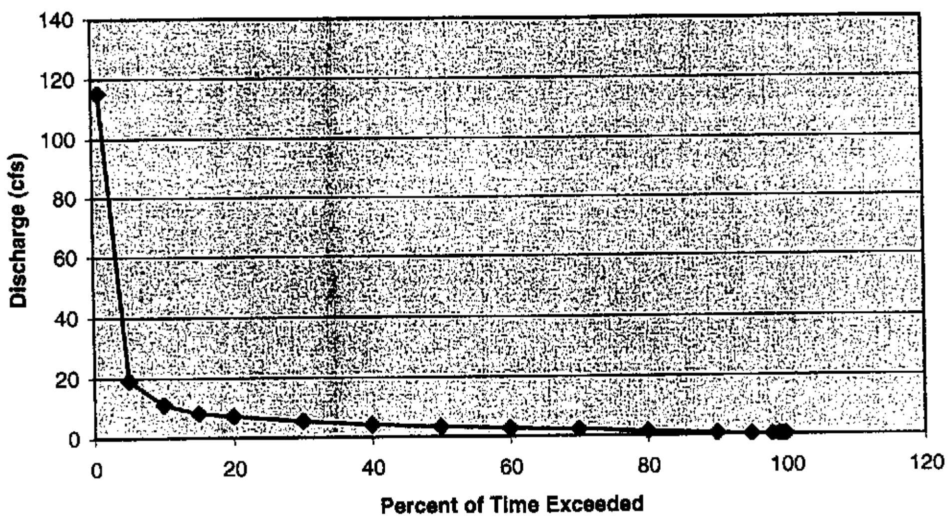


Figure 4.3.2.5
Monthly Average Flow for Sonoita Creek

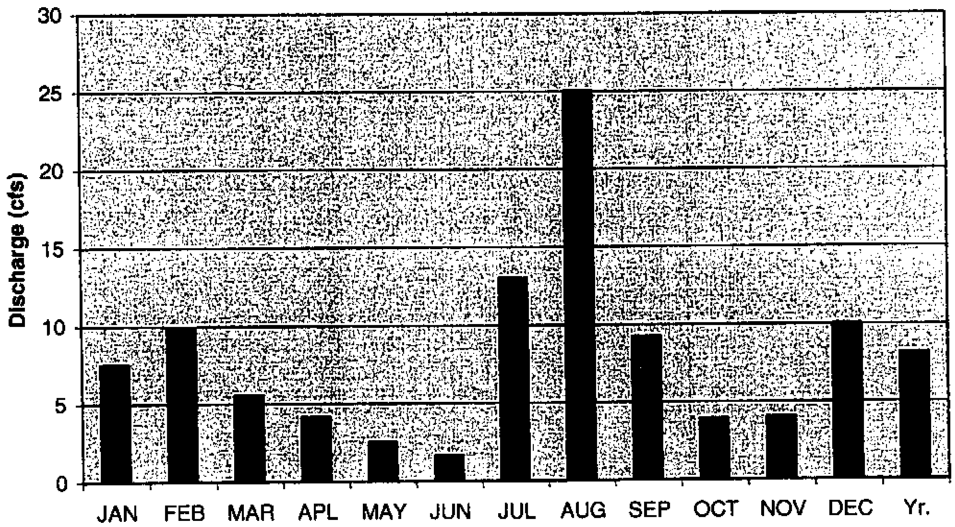
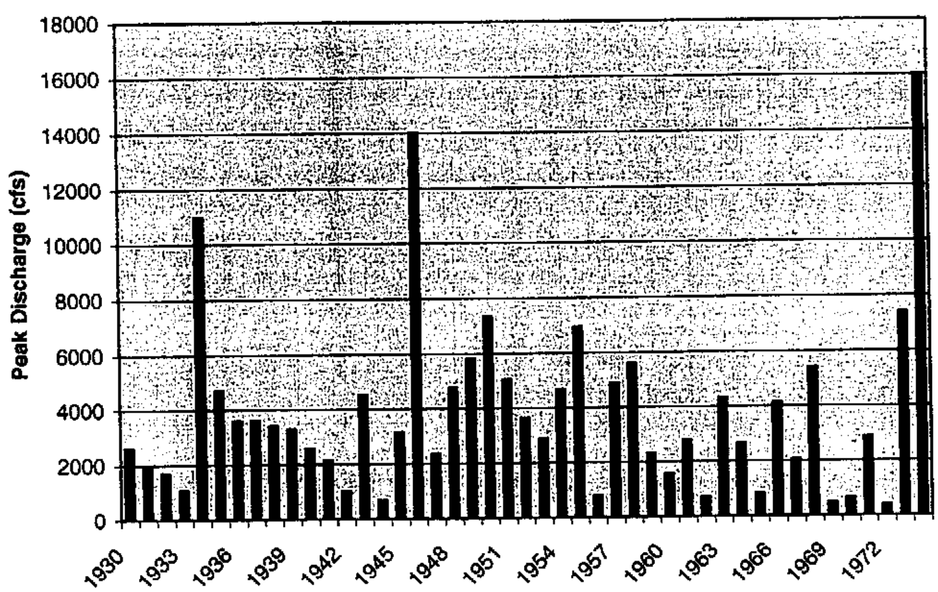


Figure 4.3.2.6
Annual Peak Discharges for Sonoita Creek



The USGS gage data indicate that the stream is perennial during most years. While the average monthly flow rates are all greater than zero, the minimum average monthly flow is zero for the month of June, indicating that the stream can dry up completely during the driest parts of some years. The highest average flows occur during the summer monsoon months of July and August, with a slight rise in average flow rates during the month of February. Field and anecdotal evidence suggests that most of Sonoita Creek flows less frequently than at the USGS gauge.

Downstream of the dam at Patagonia Lake, regulated releases average about 3.3 cfs, a rate equivalent to the median (50%) discharge at the USGS gauge. Storage behind the dam effectively moderates the natural flow rate, eliminating small flood peaks and seasonal high flows that originate upstream.

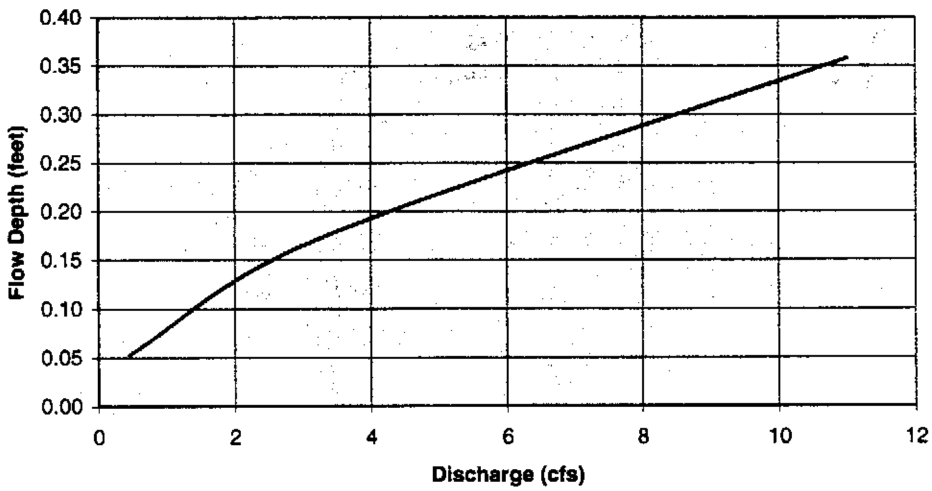
Hydraulics

Measured data for typical flow depths and widths for Sonoita Creek as of statehood were not available. Therefore, estimated hydraulic characteristics were developed based on observed stream conditions and historic stream flow records available from the USGS gauge. Table 4.3.2.5 summarizes of range of probable values for stream depth and width at various flow rates. Note that the hydraulic parameters shown below are based on flow data at the USGS gauge site, and probably represent no better than order-of-magnitude estimates of flow conditions at any specific location within the study reach. A rating curve for an assumed cross section developed from field observations is shown in Figure 4.3.2.7.

Table 4.3.2.5
Sonoita Creek Navigability Study
Estimated Range of Hydraulic Characteristics

Flow Duration	Discharge (cfs)	Flow Depth (ft)	Average Velocity (ft/s)	Flow Width (ft)
10 %	11	0.3 – 0.4	1.9 – 2.6	10 – 20
50 %	3.2	0.1 – 0.2	1.2 – 1.6	10 – 20
90 %	0.45	0.0 – 0.1	0.5 – 0.7	10 – 20
Average Annual	8.1	0.2 – 0.4	1.7 – 2.3	10 – 20
2-Year Flood	3,130	8 – 13	19 – 25	10 – 20

Figure 4.3.2.5
Sonoita Creek Depth-Discharge Rating Curve



Boating Criteria

The boating criteria cited below were reported in previous detailed navigability studies prepared for the Arizona State Land Department, and are based on the following references:

1. Cooperative Instream Flow Service Group, 1978. Methods of Assessing Instream Flows for Recreation. Instream Flow Information Paper: No. 6. FWS/OBS-78/34. June. Report prepared by U.S. Fish and Wildlife Service, U.S. Environmental Protection Agency, Heritage Conservation and Recreation Service, and Bureau of Reclamation.
2. Jason M. Cortell and Associates, Inc., 1977, Recreation and Instream Flow, Vol. 1: Flow Requirements, Analysis of Benefits, Legal & Institutional Constraints. Report submitted to U.S. Department of the Interior, Bureau of Outdoor Recreation #BOR D6429. July.
3. Walter B. Langbein, 1962. Hydraulics of River Channels as Related to Navigability. U.S. Geological Survey Water-Supply Paper 1539-W.
4. Jim Slingluff, 1987. Deposition of Jim Slingluff for No. C 569870, Maricopa County, et al and Arizona Center for Law in the Public Interest, et al., and Calmat Co. of Arizona, et al, v. State of Arizona, Arizona State Land Department, M. Jean Hassel, and Milo J. Hassel, et al. November 23, 1987.

The following tables summarize navigability criteria information from references 1 to 4. Note that these data reference recreational boating, not necessarily commercial boating.

Table 4.3.2.6 Minimum Required Stream Width and Depth for Recreation Craft[1]		
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

[1] After reference #1

Table 4.3.2.7 Minimum and Maximum Conditions for Recreational Water Boating[1]						
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

[1] After reference 2.

Table 4.3.2.8 Flow Requirements for Pre-1940 Canoe Boating[1]	
Boat Type	Depth
Flat Bottomed (Wood or Canvas)	4 in.
Round Bottomed (Wood or Canvas)	6 in.

[1] After reference 4.

Summary

Comparison of the boating criteria and hydraulic data for Sonoita Creek shown above indicate that the stream could be boated by low draft canoes or kayaks much less than 10 percent of the time, only during unpredictable high flows, and that boating by larger commercial craft would be even more unlikely. Field data collected by the authors indicates that low-draft recreational boating would be difficult due to overhanging vegetation, fences and other obstructions. No modern or historical accounts of any type of boating in

Sonoita Creek, except at Patagonia Lake were obtained during the course of this study. A Level 4 will be conducted for Sonoita Creek.

Limitations

This evaluation is based on readily available information that reflects the level of detail and funding authorized for the ANSAC Small Watercourses Navigability Study. The following limitations apply to the results presented above:

- The hydraulic rating sections may or may not apply to the entire study reach. However, the rating section results probably represent better than order-of-magnitude accuracy for estimates of width, depth, and velocity at any given point within the study reach.
- Hydrologic data for any stream varies with location within a reach, and with time in response to climatic conditions. The hydrologic information provided is best readily available data for the stream.
- Stream conditions were assumed to represent conditions as of the time of Arizona statehood. Unless stated otherwise, no data were identified during the Level 3 analysis that indicated substantive changes in stream morphology with respect to navigability criteria.

Photographs of Sonoita Creek

Photograph #1. Looking downstream from the Salero Road crossing approximately 3 miles west of Patagonia.

Photograph # 2 - Looking downstream from Rail X Ranch Estates access road located approximately 2 miles east of Patagonia.

4.4 LEVEL 4 ANALYSIS (DETAILED STUDY)

Cienega Creek and Sonoita Creek were studied at Level 4. Results of the detailed studies for Cienega Creek and Sonoita Creek are provided in Appendices C and D, respectively.

5.0 Conclusions and Recommendations

- The Level 1 analysis performed for the watercourses in Cochise County resulted in two data sets. Out of a total of 524 watercourses identified, there are 506 that were classified under RL1 and 18 that were classified under NRL1. The lists of both data sets are provided in Appendix A.

- The qualitative approach employed in the Level 2 analysis for the NRL1 data set resulted in initially sorting the 18 watercourses into *Category B* and *Category C*. No watercourse was classified under *Category A* in the first cut filter. In the second-cut filter and from the use of the criteria weights for watercourses in *Category B,* two watercourses ultimately survived the Level 2 analysis and 16 watercourses failed. The NRL2 watercourses for the Level 3 analysis included Cienega Creek and Sonoita Creek.

- Detailed studies were conducted for Cienega Creek and Sonoita Creek to further assess and evaluate the likelihood that the streams are navigated at the time of statehood.

6.0 References

Arizona Department of Water Resources (ADWR), Geospatial Data set: Dams, a digital file submitted to Stantec Consulting, Inc. dated March 12, 1999.

Arizona Game and Fish Department, Geospatial Data set: Perennial Waters of Arizona, a digital file submitted to Stantec Consulting, Inc. dated July 9, 1999.

Arizona State Land Department, Arizona Land Resources Information System (ALRIS), Geospatial Data set: Streams, a digital file submitted to Stantec Consulting, Inc. dated July 13, 1999.

Arizona State Land Department, Arizona Land Resources Information System (ALRIS), Geospatial Data set: County, a digital file submitted to Stantec Consulting, Inc. dated July 13, 1999.

Arizona State Land Department, Arizona Land Resources Information System (ALRIS), Geospatial Data set: HUCS, a digital file submitted to Stantec Consulting, Inc. dated July 13, 1999.

Arizona State Land Department, Arizona Land Resources Information System (ALRIS), Geospatial Data set: Springs, a digital file submitted to Stantec Consulting, Inc. dated July 13, 1999.

Arizona State Land Department, Arizona Land Resources Information System (ALRIS), Geospatial Data set: Lakes, a digital file submitted to Stantec Consulting, Inc. dated July 13, 1999.

Arizona State Land Department, Arizona Land Resources Information System (ALRIS), Geospatial Data set: AzTRS, a digital file submitted to Stantec Consulting, Inc. dated July 13, 1999.

Arizona State Parks (1995), Arizona rivers assessment technical summary, Report by Arizona State Parks and National Parks Service, Phoenix, Arizona.

Brown, D. E., Carmody, N. B., and Turner, R. M., (1981), Drainage map of Arizona showing perennial streams and some important wetland, Scale= 1:100000, Arizona Game and Fish Department, Phoenix, Arizona. Originally published in 1977, and updated in 1978 and 1981.

Silvey, W., Rinne, J. N., and Sorenson, R., 1984, RunWild, Wildlife/Habitat Relationships; Index to the Natural Drainage Systems of Arizona – A Computer Compatible Digital Identification of Perennial Lotic Waters. USDA Forest Service Southwestern Region Wildlife Unit Technical Report. 36 pages.

Stantec Consulting, Inc. (formerly SFC Engineering Company), (1996), Arizona Stream Navigability Study for the Santa Cruz River (from Gila River confluence to the headwaters), *Final Report*, submitted to Arizona State Land Department, Phoenix, Arizona. November 1996.

Stantec Consulting, Inc., (1999a), Small and Minor Watercourses Analysis, a proposal submitted to Arizona State Land Department, Phoenix, Arizona on June 1999.

Stantec Consulting, Inc., (1999b), Small and Minor Watercourses Pilot Study, Final Report, submitted to Arizona Navigable Stream Adjudication Commission (ANSAC), on October 1999.

Stantec Consulting, Inc., (1999c), Small and Minor Watercourses Analysis for La Paz County Arizona, Final Report, submitted to Arizona State Land Department, Phoenix, Arizona on December 31, 1999.

Stantec Consulting, Inc., (1999d), Small and Minor Watercourses Analysis for Mohave County Arizona, Final Report, submitted to Arizona State Land Department, Phoenix, Arizona on December 31, 1999.

Stantec Consulting, Inc., (1999d), Small and Minor Watercourses Analysis for Yuma County Arizona, Final Report, submitted to Arizona State Land Department, Phoenix, Arizona on December 31, 1999.

Stantec Consulting, Inc., (1998), Criteria for assessing characteristics of navigability for small watercourses in Arizona, Final Report, submitted to Arizona Navigable Streams Adjudication Commission (ANSAC), on September 1998.

Webb, Robert H., Spence S. Smith & V.Alexander S. McCord (1991): Historic Channel Change of Kanab Creek, Southern Utah and Northern Arizona, 1991. Monograph No.9 ed. Grand Canyon Natural History Association, Grand Canyon. 91 Pages.

Young, K. L., and Lopez, M., (1995), Fall Fish Count Summary, 1988-1994, Technical Report 81, Nongame and Endangered Wildlife Program, Arizona Game and Fish Department, Phoenix, Arizona, 119 pp., June 1995.

Appendix A – List of Watercourses

TABLE A-1A
RL1 Watercourses for Santa Cruz County

No. (1)	W_ID (2)	W_NAME (3)	SEGCOUNT (4)	W_COUNTIES (5)	W_MILES (6)	W_ADDRESS (7)	W_PER (8)	W_MBOAT (9)	W_HBOAT (10)	W_FISH (11)	W_DIMP (12)	W_SSTATUS (13)	HITS (14)
1	133	Balamote Wash 1	3	Pima/Santa Cruz	11.2927	T19.0S,R11.0E,S22	No	No	No	No	No	No	0
2	407	Cave Creek - Santa Cruz	3	Santa Cruz	5.8901	T20.0S,R16.0E,S07	No	No	No	No	No	No	0
3	657	Diablo Wash	1	Santa Cruz	5.1732	T20.0S,R13.0E,S18	No	No	No	No	No	No	0
4	797	Fraquita Wash	10	Pima/Santa Cruz	9.6541	T21.0S,R10.0E,S32	No	No	No	No	No	No	0
5	817	Gardner Canyon	7	Pima/Santa Cruz	20.0407	T19.0S,R17.0E,S10	No	No	No	No	No	No	0
6	37631	Harshaw Creek	11	Santa Cruz	14.3586	T22.0S,R16.0E,S05	No	No	No	No	No	No	0
7	37765	Josephine Canyon	6	Santa Cruz	18.7166	,,SLG	No	No	No	No	No	No	0
8	38443	Saucito Wash	1	Santa Cruz	4.1945	T20.0S,R11.0E,S07	No	No	No	No	No	No	0
9	38548	Sopori Wash	17	Pima/Santa Cruz	19.6681	T20.0S,R13.0E,S05	No	No	No	No	No	No	0
10	38729	Toros Wash	1	Santa Cruz	3.9785	T20.0S,R12.0E,S05	No	No	No	No	No	No	0
11	38738	Tres Bellotas Canyon	9	Santa Cruz	6.1966	T23.0S,R10.0E,S90	No	No	No	No	No	No	0
12	38756	Tubac Creek	2	Santa Cruz	4.4796	T21.0S,R13.0E,S12	No	No	No	No	No	No	0
13	38962	Yellow Jacket Wash	6	Pima/Santa Cruz	6.5086	T21.0S,R10.0E,S28	No	No	No	No	No	No	0
14	---	493 Unnamed watercourses	---	Santa Cruz	Varies	Varies	No	No	No	No	No	No	0

NOTES: The column headings are identified as follows:

W_ID:	Unique ID number given to the watercourse.
W_NAME:	Name of the watercourse.
SEGCOUNT:	Number of segments merged together to comprise the watercouse.
W_COUNTIES:	County(ies) where the watercourse is located.
W_MILES:	Length of the watercourse in miles.
W_ADDRESS:	Township, Range and Section of the mouth of the watercourse.
W_PER:	Stream classification- perennial or not.
W_MBOAT:	With modern boating or not.
W_HBOAT:	With historical boating or not.
W_FISH:	With fish or not.
W_DIMP:	Impacted by dam or not.
W_SSTATUS:	With special status designation or not.
HITS:	Number of affirmative hits based on the six attribute data.

TABLE A-1B
NRL1 Watercourses for Santa Cruz County

No. (1)	W_ID (2)	W_NAME (3)	SEGCOUNT (4)	W_COUNTIES (5)	W_MILES (6)	W_ADDRESS (7)	W_PER (8)	W_MBOAT (9)	W_HBOAT (10)	W_FISH (11)	W_SSTATUS (12)	W_DIMP (13)	HITS (14)
1	38546	Sonoita Creek	47	Santa Cruz	36.9206	,,SLG	Yes	No	No	Yes	Yes	Yes	4
2	108	Babocomari River - Santa Cruz	12	Santa Cruz	12.5730	,,SLG	Yes	No	No	Yes	Yes	No	3
3	470	Cienega Creek 1	50	Pima/Santa Cruz	45.2775	T17.0S,R17.0E,S01	Yes	No	No	Yes	Yes	No	3
4	36477	H82_0601	1	Santa Cruz	0.1130	T21.0S,R16.0E,S04	Yes	No	No	No	No	Yes	2
5	38107	O'Donnell Canyon	7	Santa Cruz	10.3189	T21.0S,R18.0E,S22	No	No	No	Yes	Yes	No	2
6	36134	Parker Canyon	1	Cochise/Santa Cruz	1.5568	T23.0S,R18.0E,S24	Yes	No	No	No	No	Yes	2
7	38647	Sycamore Canyon - Santa Cruz	11	Santa Cruz	9.8681	T23.0S,R11.0E,S90	Yes	No	No	No	Yes	No	2
8	38774	Turkey Creek - Cochise/Santa Cruz	8	Cochise/Santa Cruz	17.2469	,,SLG	Yes	No	No	Yes	No	No	2
9	41	Alum Gulch	4	Santa Cruz	5.7811	,,SLG	No	No	No	Yes	No	No	1
10	412	Cedar Creek 2	7	Pima/Santa Cruz	12.4395	T22.0S,R10.0E,S01	No	No	No	No	No	Yes	1
11	35996	H82_0013	4	Santa Cruz	0.7814	,,SLG	Yes	No	No	No	No	No	1
12	36135	H82_0234	2	Santa Cruz	4.1702	T23.0S,R18.0E,S26	No	No	No	No	No	Yes	1
13	36332	H82_0453	1	Santa Cruz	0.0966	T21.0S,R12.0E,S04	Yes	No	No	No	No	No	1
14	36364	H82_0485	4	Santa Cruz	3.1926	T23.0S,R13.0E,S18	No	No	No	No	No	Yes	1
15	38132	Oro Blanco Wash	8	Santa Cruz	7.0183	T22.0S,R10.0E,S24	No	No	No	No	No	Yes	1
16	36341	Peck Canyon Creek	7	Santa Cruz	10.0737	,,SLG	Yes	No	No	No	No	No	1
17	38269	Potrero Creek	9	Santa Cruz	12.7660	,,SLG	No	No	No	Yes	No	No	1
18	38329	Redrock Canyon	12	Santa Cruz	12.6608	T10.0S,R16.0E,S26	Yes	No	No	No	No	No	1

NOTES: The column headings are identified as follows:

W_ID: Unique ID number given to the watercourse.
W_NAME: Name of the watercourse.
SEGCOUNT: Number of segments merged together to comprise the watercouse.
W_COUNTIES: County(ies) where the watercourse is located.
W_MILES: Length of the watercourse in miles.
W_ADDRESS: Township, Range and Section of the mouth of the watercourse.
W_PER: Stream classification- perennial or not.
W_MBOAT: With modern boating or not.
W_HBOAT: With historical boating or not.
W_FISH: With fish or not.
W_DIMP: Impacted by dam or not.
W_SSTATUS: With special status designation or not.
HITS: Number of affirmative hits based on the six attribute data.

Table A-2A
RL2 Watercourses for Santa Cruz County

NO. (1)	W_ID (2)	W_NAME (3)	SEGCOUNT (4)	W_COUNTIES (5)	W_ADDRESS (6)	W_MILES (7)	L1_PER (8)	L2_PER (9)	L2_MBOAT (10)	L2_HBOAT (11)	L2_DIMP (12)	L2_FISH (13)	L2_SSTATUS (14)	NEW_RAT (15)
1	108	Babocomari River - Santa Cruz	12	Santa Cruz	,,SLG	12.573	No	No/Yes	No	No	No	Yes	Yes	8.38
2	38107	O'Donnell Canyon	7	Santa Cruz	T21.0S,R18.0E,S22	10.319	No	No/Yes	No	No	No	Yes	Yes	8.26
3	36134	Parker Canyon	1	Cochise/Santa Cruz	T23.0S,R18.0E,S24	1.557	No	No/Yes	No	No	Yes	No	No	7.50
4	38647	Sycamore Canyon - Santa Cruz	11	Santa Cruz	T23.0S,R11.0E,S90	9.868	Yes	Yes	No	No	No	No	No	7.00
5	412	Cedar Creek 2	7	Pima/Santa Cruz	T22.0S,R10.0E,S01	12.440	No	No	No	No	Yes	No	No	4.00
6	38132	Oro Blanco Wash	8	Santa Cruz	T22.0S,R10.0E,S24	7.018	No	No	No	No	Yes	No	No	4.00
7	35996	H82_0013	4	Santa Cruz	,,SLG	0.781	Yes	Yes/No	No	No	No	No	No	3.50
8	36332	H82_0453	1	Santa Cruz	T21.0S,R12.0E,S04	0.097	Yes	Yes/No	No	No	No	No	No	3.50
9	36341	Peck Canyon Creek	7	Santa Cruz	,,SLG	10.074	No	No/Yes	No	No	No	No	No	3.50
10	36477	H82_0601	1	Santa Cruz	T21.0S,R16.0E,S04	0.113	Yes	Yes/No	No	No	No	No	No	3.50
11	38329	Redrock Canyon	12	Santa Cruz	T10.0S,R16.0E,S26	12.661	No	No/Yes	No	No	No	No	No	3.50
12	41	Alum Gulch	4	Santa Cruz	,,SLG	5.781	No	No	No	No	No	Yes	No	3.00
13	38269	Potrero Creek	9	Santa Cruz	,,SLG	12.766	No	No	No	No	No	Yes	No	3.00
14	38774	Turkey Creek - Cochise/Sta. Cruz	8	Cochise/Santa Cruz	,,SLG	17.247	No	No	No	No	No	Yes	No	3.00
15	36135	H82_0234	2	Santa Cruz	T23.0S,R18.0E,S26	4.170	No	No	No	No	No	No	No	0.00
16	36364	H82_0485	4	Santa Cruz	T23.0S,R13.0E,S18	3.193	No	No	No	No	No	No	No	0.00

NOTES: The column headings are identified as follows:

W_ID: Unique ID number given to the watercourse. W_MBOAT:
W_NAME: Name of the watercourse. W_HBOAT:
SEGCOUNT: Number of segments merged together to comprise the watercouse. W_FISH:
W_COUNTIES: County(ies) where the watercourse is located. W_DIMP:
W_MILES: Length of the watercourse in miles. W_SSTATUS:
W_ADDRESS: Township, Range and Section of the mouth of the watercourse.
L1_PER: Level 1 stream classification - perennial or not.

L2_PER: Level 2 stream classification which includes Brown's perennial stream data.
L2_MBOAT: With or without modern boating account.
L2_HBOAT: With or without historical boating account.
L2_DIMP: Dam-impacted or not.
L2_FISH: With fish or not.
L2_SSTATUS: With special status designationo or not.
NEW_RAT Computed total rating of the watercourse based on the evaluated weights.

Table A-2B
NRL2 Watercourses for Santa Cruz County

NO. (1)	W_ID (2)	W_NAME (3)	SEGCOUNT (4)	W_COUNTIES (5)	W_ADDRESS (6)	W_MILES (7)	L1_PER (8)	L2_PER (9)	L2_MBOAT (10)	L2_HBOAT (11)	L2_DIMP (12)	L2_FISH (13)	L2_SSTATUS (14)	NEW_RAT (15)
1	38546	Sonoita Creek	47	Santa Cruz	,,SLG	36.9206	Yes	Yes	No	No	Yes	Yes	Yes	16.00
2	470	Cienega Creek 1	50	Pima/Santa Cruz	T17.0S,R17.0E,S01	45.2775	Yes	Yes	No	No	No	Yes	Yes	11.88

NOTES: The column headings are identified as follows:

W_ID: Unique ID number given to the watercourse.
W_NAME: Name of the watercourse.
SEGCOUNT: Number of segments merged together to comprise the watercouse.
W_COUNTIES: County(ies) where the watercourse is located.
W_MILES: Length of the watercourse in miles.
W_ADDRESS: Township, Range and Section of the mouth of the watercourse.
L1_PER: Level 1 stream classification - perennial or not.
W_MBOAT:
W_HBOAT:
W_FISH:
W_DIMP:
W_SSTATUS:
L2_PER: Level 2 stream classification which includes Brown's perennial stream data.
L2_MBOAT: With or without modern boating account.
L2_HBOAT: With or without historical boating account.
L2_DIMP: Dam-impacted or not.
L2_FISH: With fish or not.
L2_SSTATUS: With special status designationo or not.
NEW_RAT Computed total rating of the watercourse based on the evaluated weights.

Table A-3
List of Small and Minor Watercourses for Santa Cruz County

Alum Gulch
Babocomari River - Santa Cruz
Batamote Wash 1
Cave Creek - Santa Cruz
Cedar Creek 2
Cienega Creek 1
Diablo Wash
Fraquita Wash
Gardner Canyon
Harshaw Creek
Josephine Canyon
O'Donnell Canyon
Oro Blanco Wash
Parker Canyon
Peck Canyon Creek
Potrero Creek
Redrock Canyon
Saucito Wash
Sonoita Creek
Sopori Wash
Sycamore Canyon - Santa Cruz
Toros Wash
Tres Bellotas Canyon
Tubac Creek
Turkey Creek – Cochise/Santa Cruz
Yellow Jacket Wash
498 Unnamed Watercourses

Appendix B - Criteria Weight Evaluation

Figure B-1

Criteria Scoring Matrix

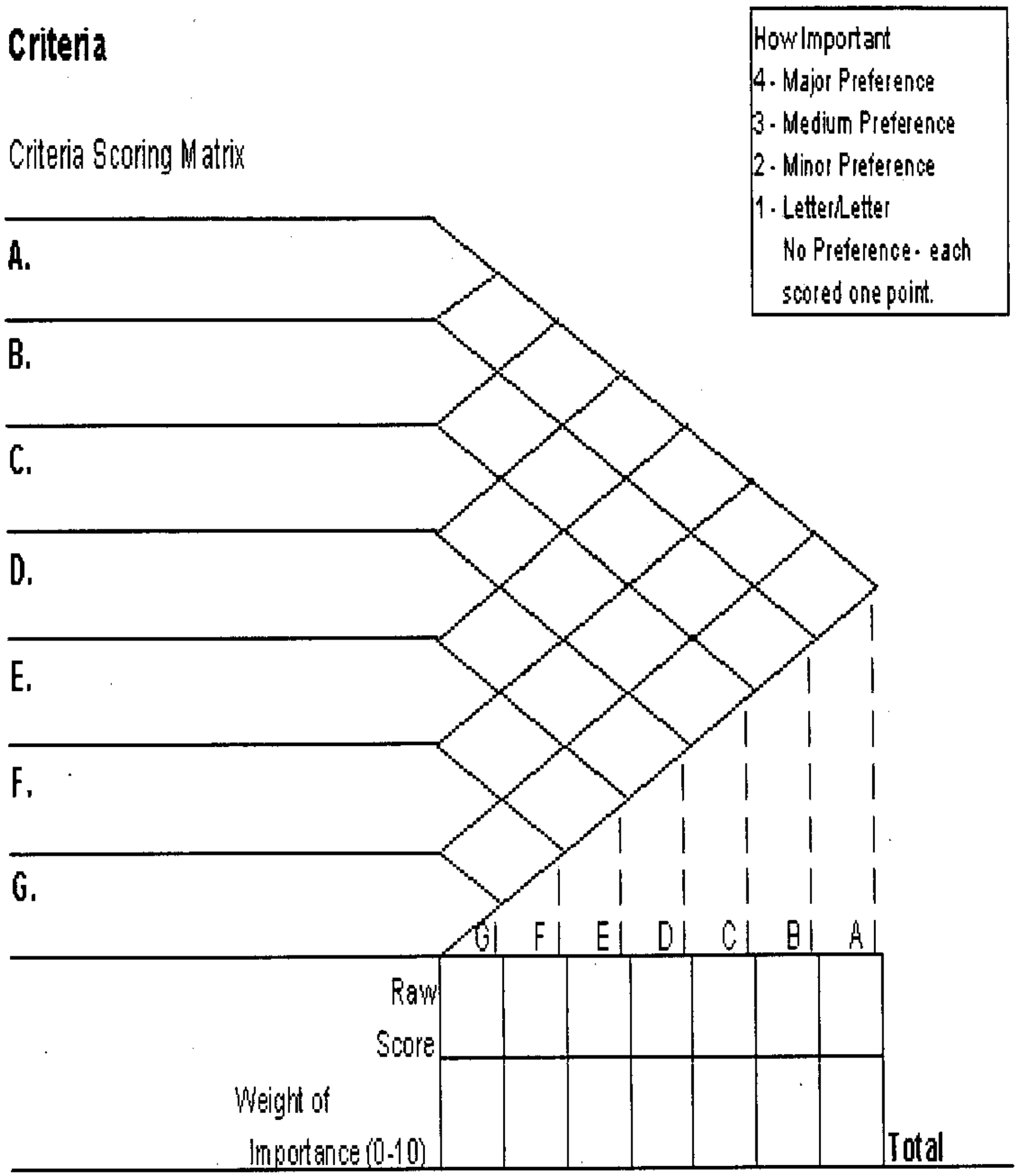


Table B-1
Evaluation of Numerical Weights for the Six Criteria

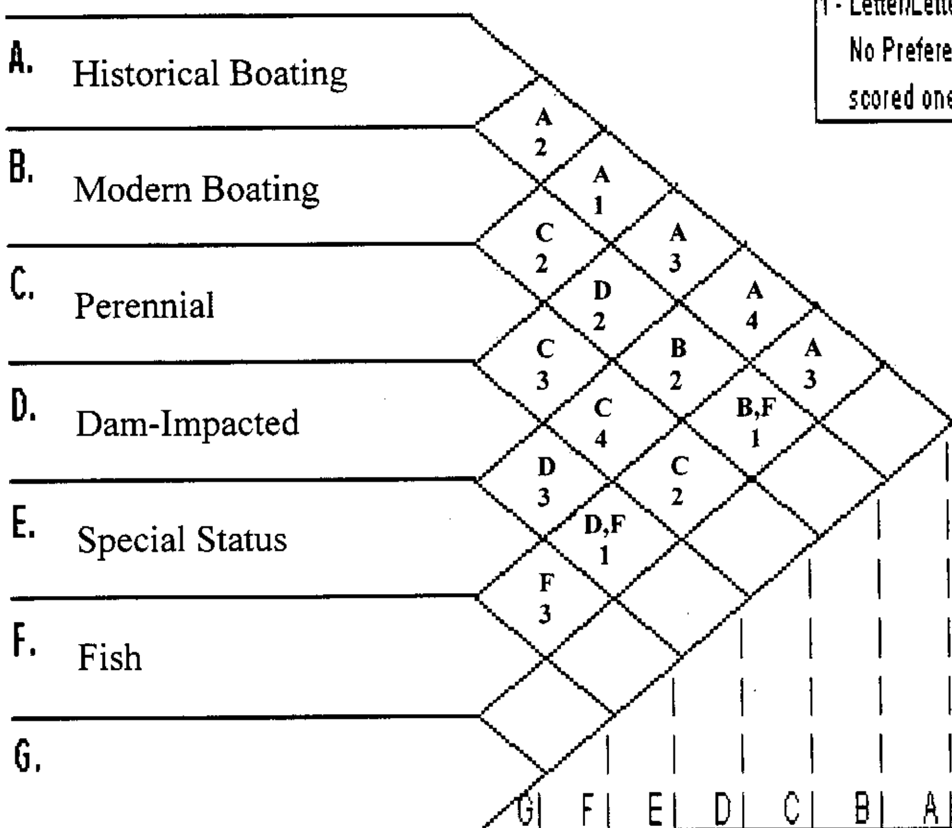
Item No.	Description of Criterion	Participant No.							Average Weight	Recommended Weight
		1	2	3	4	5	6	7		
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
1	Historical Boating	9	10	10	10	10	10	10	9.9	10
2	Modern Boating	3	7	10	9	7	10	7	7.6	8
3	Perennial	8	5	8	6	6	7	6	6.6	7
4	Dam-Impacted	7	2	4	2	4	5	3	3.9	4
5	Special Status	2	3	2	2	2	2	2	2.1	2
6	Fish	4	3	6	3	3	3	5	3.9	4

Participant No. 1

Criteria

Criteria Scoring Matrix

How Important
4 - Major Preference
3 - Medium Preference
2 - Minor Preference
1 - Letter/Letter
No Preference - each scored one point.



	G	F	E	D	C	B	A	
Raw Score		4	0	6	11	3	13	
Weight of Importance (0-10)		4	2	7	8	3	9	Total

Participant No. 2

Criteria

Criteria Scoring Matrix

How Important
4 - Major Preference
3 - Medium Preference
2 - Minor Preference
1 - Letter/Letter
No Preference - each scored one point.

A. Historical Boating

B. Modern Boating

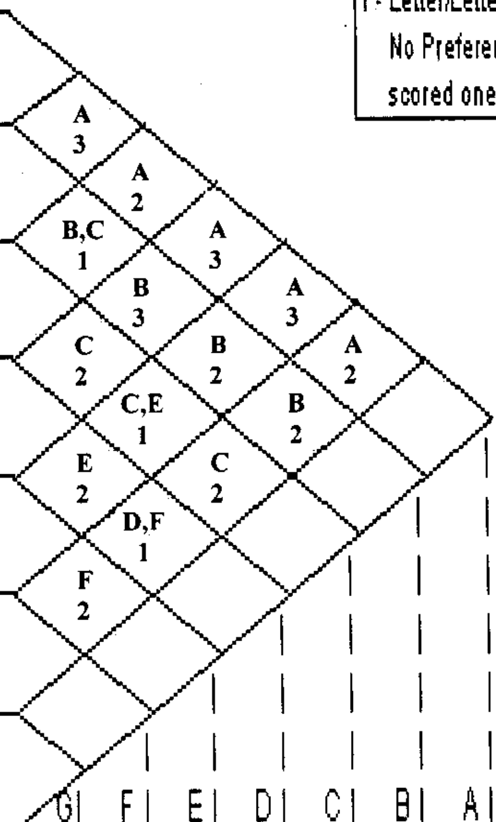
C. Perennial

D. Dam-Impacted

E. Special Status

F. Fish

G.



	G	F	E	D	C	B	A	Total
Raw Score		3	3	1	6	8	13	
Weight of Importance (0-10)		3	3	2	5	7	10	

Participant No. 3

Criteria

Criteria Scoring Matrix

How Important
4 - Major Preference
3 - Medium Preference
2 - Minor Preference
1 - Letter/Letter No Preference - each scored one point.

A. Historical Boating

B. Modern Boating

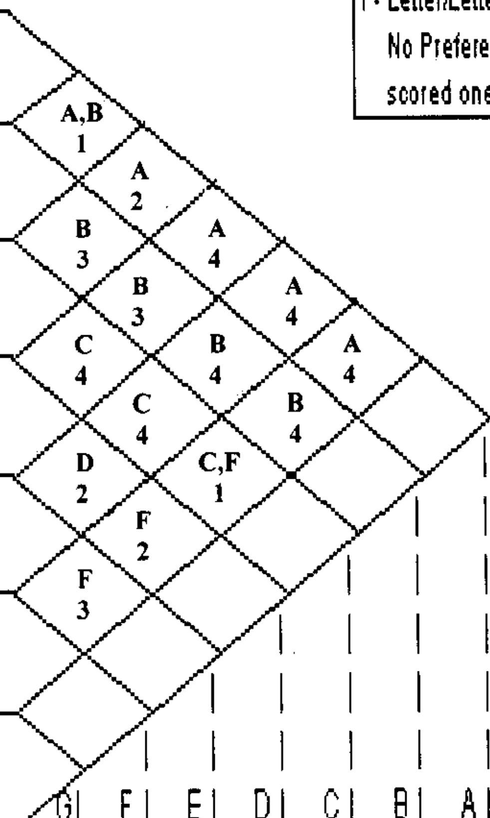
C. Perennial

D. Dam-Impacted

E. Special Status

F. Fish

G.



	G	F	E	D	C	B	A
Raw Score		6	0	2	9	15	15
Weight of Importance (0-10)		6	2	4	8	10	10

Total

Participant No. 4

Criteria

Criteria Scoring Matrix

How Important
4 - Major Preference
3 - Medium Preference
2 - Minor Preference
1 - Letter/Letter
No Preference - each scored one point.

A. Historical Boating

B. Modern Boating

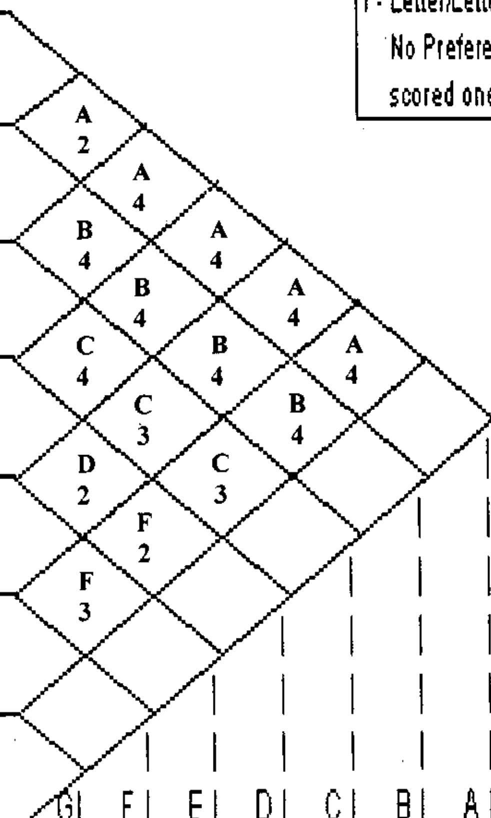
C. Perennial

D. Dam-Impacted

E. Special Status

F. Fish

G.



	G	F	E	D	C	B	A	
Raw Score		**5**	**0**	**2**	**10**	**16**	**18**	
Weight of Importance (0-10)		**3**	**2**	**2**	**6**	**9**	**10**	Total

Participant No. 5

Criteria

Criteria Scoring Matrix

How Important
4 - Major Preference
3 - Medium Preference
2 - Minor Preference
1 - Letter/Letter
No Preference - each scored one point.

A. Historical Boating

B. Modern Boating

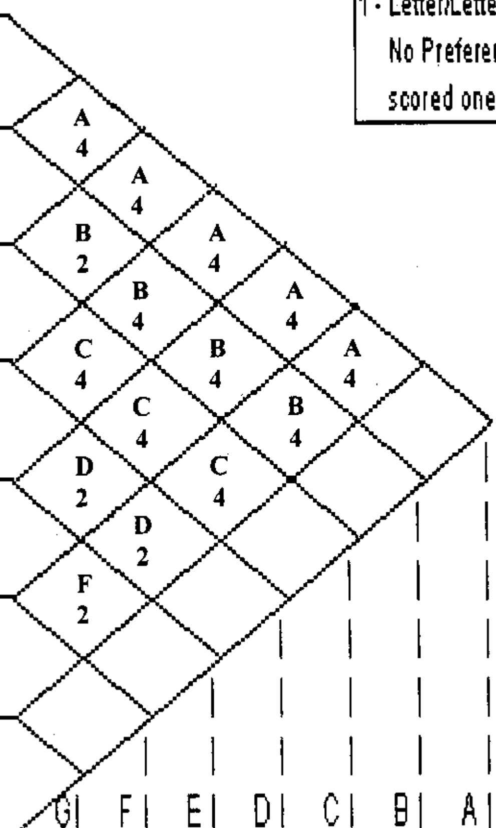
C. Perennial

D. Dam-Impacted

E. Special Status

F. Fish

G.



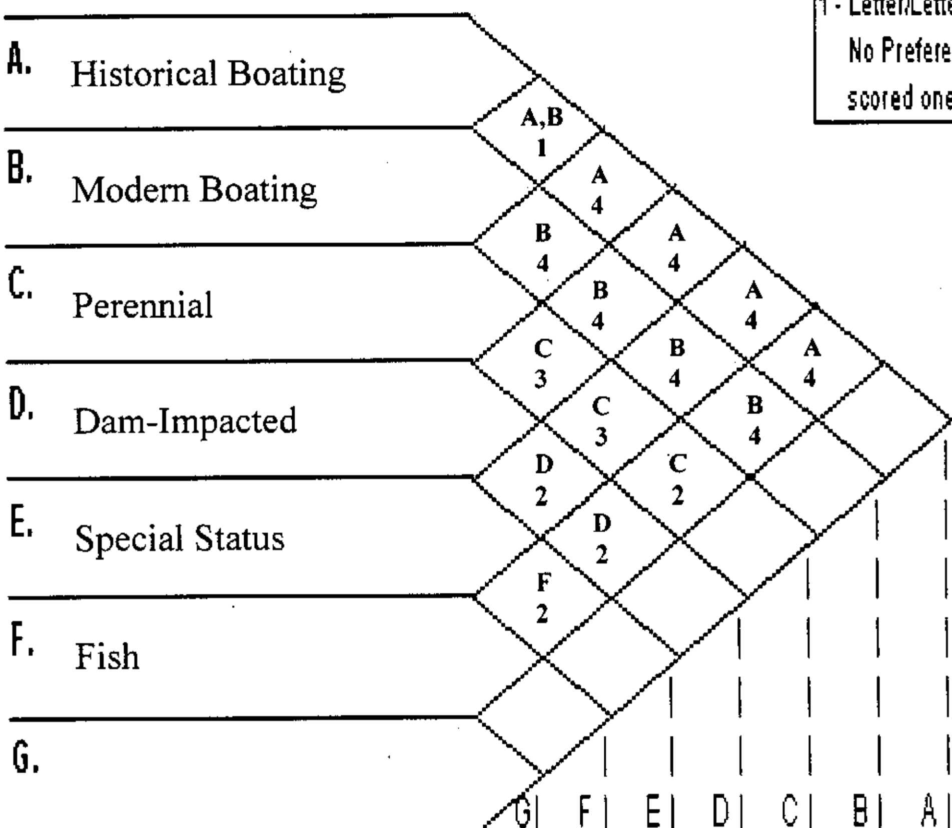
	G	F	E	D	C	B	A	
Raw Score		2	0	4	12	14	20	
Weight of Importance (0-10)		3	2	4	6	7	10	Total

Participant No. 6

Criteria

How Important
4 - Major Preference
3 - Medium Preference
2 - Minor Preference
1 - Letter/Letter
No Preference - each scored one point.

Criteria Scoring Matrix



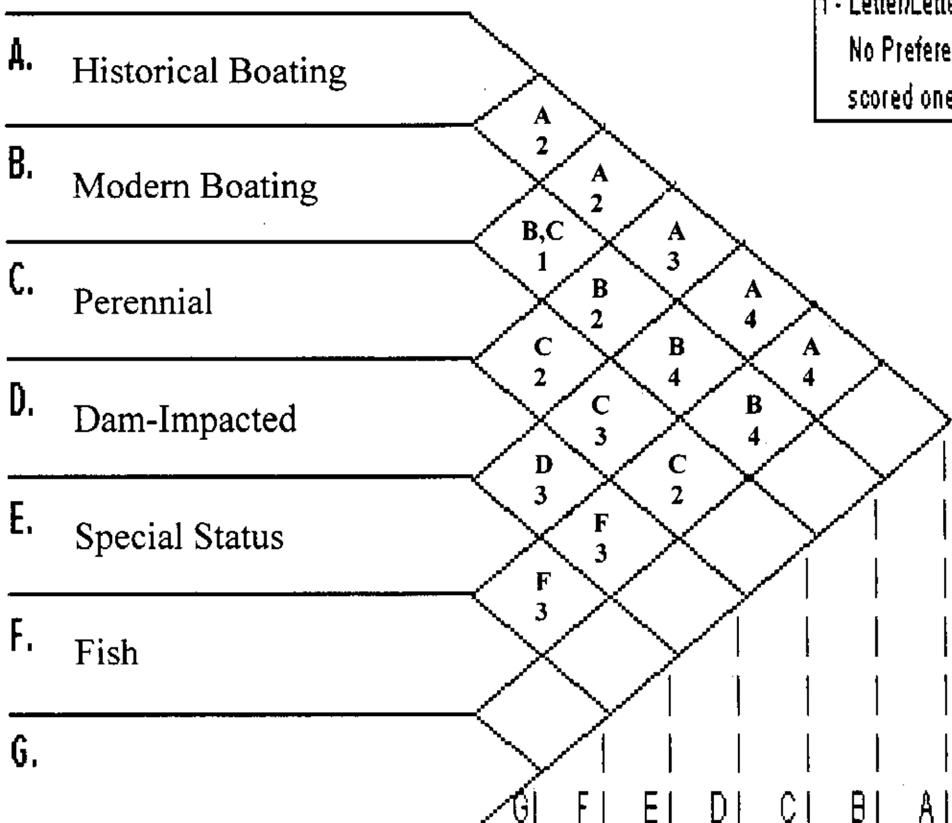
	G	F	E	D	C	B	A	
Raw Score		2	0	4	8	17	17	
Weight of Importance (0-10)		3	2	5	7	10	10	Total

Participant No. 7

Criteria

How Important
4 - Major Preference
3 - Medium Preference
2 - Minor Preference
1 - Letter/Letter
No Preference - each scored one point.

Criteria Scoring Matrix



	G	F	E	D	C	B	A	
Raw Score		6	0	3	8	11	15	
Weight of Importance (0-10)		5	2	3	6	7	10	Total

Appendix C
Stream Navigability Investigation for Cienega Creek

Stream Navigability Investigation

For

Cienega Creek

From: the Headwaters
To: Pantano Wash

Prepared for:

Arizona State Land Department
1616 West Adams Street
Phoenix, Arizona 85007
(602) 542-4621

June 2000

Prepared by:

JE FULLER
HYDROLOGY & GEOMORPHOLOGY, INC.
5235 S. Kyrene Road, Suite 205
Tempe, Arizona 85283

In Association With:

Stantec Consulting
7776 Pointe
Parkway
Suite 290
Phoenix, AZ 85044

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PREFACE

This report was prepared under contract to the Arizona State Land Department (ASLD). This report summarizes information gathered relating to the navigability of Cienega Creek in southeastern Arizona. Information presented in this report is intended to provide data for the Arizona Navigable Stream Adjudication Commission (ANSAC) from which ANSAC can make a recommendation to the Arizona Legislature regarding the navigability of the stream. This report does not make a recommendation or draw any conclusions regarding title navigability.

The report consists of the following parts:

- Historical information from periods prior to and including the time of statehood are discussed with respect to river uses, modes of transportation, and river conditions.
- Hydrologic and geomorphic information are presented to document both past and present stream conditions as they relate to navigability.
  - Land ownership information is presented in GIS format to identify the location of public vs. private land boundaries.

This study was performed by JE Fuller/ Hydrology & Geomorphology, Inc. (JEF), and Stantec Consulting, Inc. (Stantec). The study was completed under a Continuing Services Addenda to Stantec's On-call Contract No. 08 for the ASLD on behalf of ANSAC. Project staff included: V. Ottosawa-Chatupron/ASLD, Project Manager; J. Fuller/JEF, Project Manager; J. Wallace/JEF, Project Engineer; and T. Lehman/JEF, GIS Task Leader. Data summarized in this study were obtained from numerous agencies, libraries, and collections named within the report. Use of this document is governed by ASLD and ANSAC.

EXECUTIVE SUMMARY

JE Fuller/ Hydrology & Geomorphology, Inc. (JEF) was retained by the Arizona State Land Department (ASLD) to prepare a report summarizing information related to the navigability of Cienega Creek. The study reach extends from the headwaters of Cienega Creek near Sonoita, Arizona, to a point near Vail, Arizona where the stream name changes to Pantano Wash (Figure 1). The location of the point where the name change occurs varies on some local and historical maps. For purposes of this report, the downstream limit of Cienega Creek was conservatively defined at the Colossal Cave Road Bridge. Table ES-1 below shows the latitude and longitude of the Cienega Creek study limits.

Table ES-1. Cienega Creek Navigability Study Reach Limits		
Location along Cienega Creek	**Latitude**	**Longitude**
Colossal Cave Road crossing	32°03.0'N	110°41.9'W
Headwaters divide	31°35.2'N	110°38.8'W

The basic approach to this study was to develop a database of information to be used by ANSAC in making recommendations concerning 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:

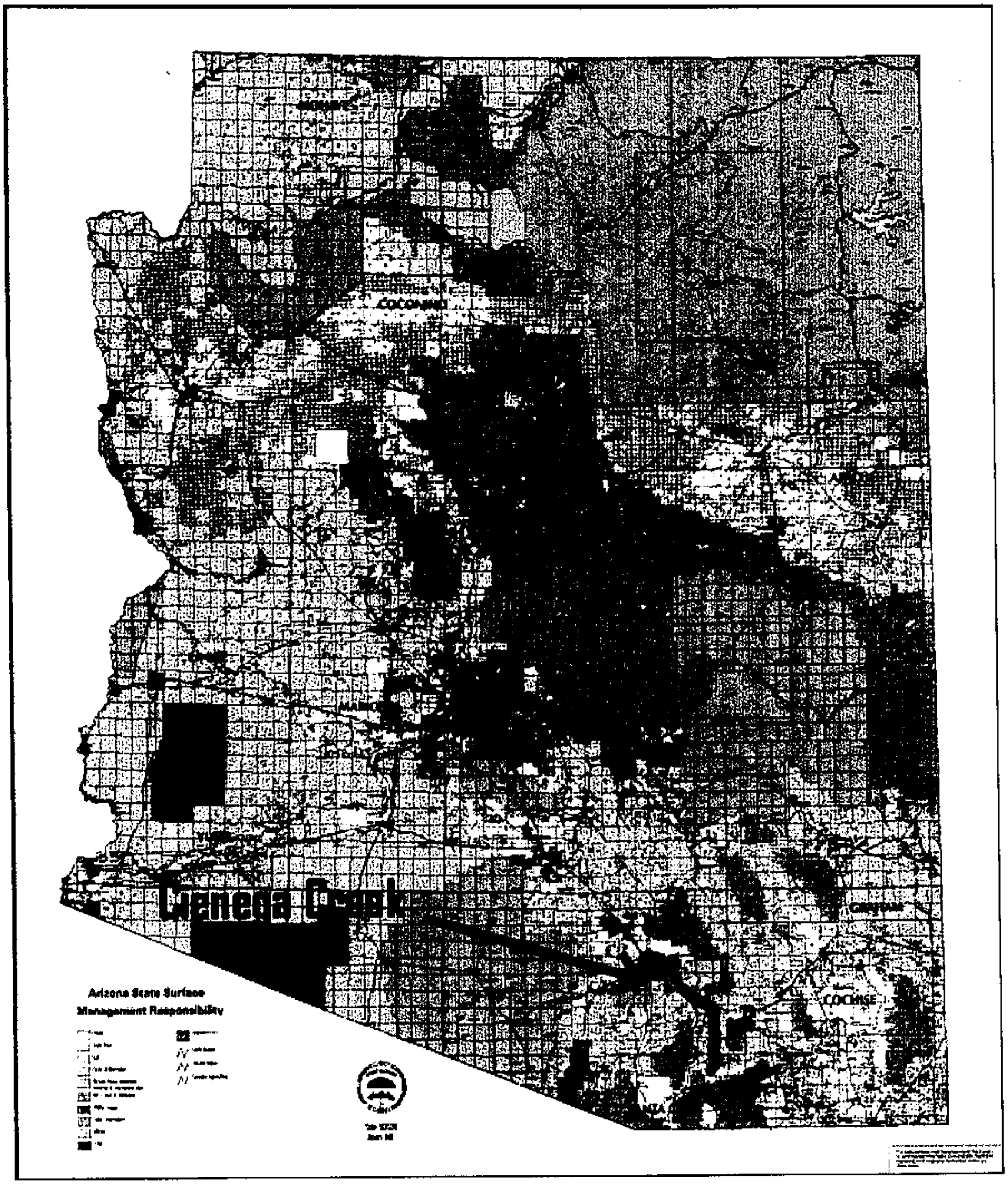
- Historical Uses of the Creek. Data describing actual uses of the stream as of the time of statehood were collected to help answer the question, "Was the stream used for navigation?"

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

Specific tasks for the study included agency contact, a literature search, summary of data collected from agencies and the literature, and preparation of a final report. The objectives of the agency contact task were to inform community officials of the study, to obtain information on historical and potential stream uses, and to obtain access to data collected by agency personnel for the stream. For the latter task, public officials from agencies having jurisdiction along the stream segments were contacted. The objective of the literature search was to obtain published and unpublished documentation of historical stream uses and stream conditions. Information collected from agency contacts was supplemented by published information from public and private collections.

The literature search focused on three subject areas: (1) history, (2) hydrology and geomorphology and (3) land ownership. Historical data provide information on actual uses of the stream as of the time of statehood, but also provide information on whether stream conditions would have supported navigation. This document summarizes

Figure ES-1: Cienega Creek Location Map



uses of the stream and the adjacent river valley in historic times, with special emphasis on the establishment, growth, and development of towns, irrigation systems, and commercial activities where applicable.

Hydrologic/hydraulic data are the primary source of information regarding susceptibility to navigation. These data include estimates of flow depth, width, velocity, and average flow conditions as of the time of statehood, based on the available modern records for natural stream conditions as of the time of statehood, as well as for existing stream conditions. Existing state land ownership data were compiled into a GIS database that identified the location of public vs. private land along the stream. The results of the data collection are summarized in the following paragraphs.

History

The Cienega Valley has a history of human occupation dating to at least 1000 B.C. Exploration of the study area by the Spanish began in the 1600's. The California Gold Rush of 1849 brought the first influx of American travelers and settlers from the east. The first Anglo-American establishment in the vicinity of the Cienega Valley was at Fort Buchanan, which was established in 1857 on the Sonoita Creek between the Towns of Sonoita and Patagonia. Construction of the Southern Pacific and New Mexico and Arizona railroad lines through the north end of the Cienega Valley in the 1870's and 1880's further fueled settlement of the area. Between 1876 and 1926 the Empire Ranch was the primary ranching establishment in the area with range holdings that spanned nearly the entire Cienega Valley. In 1903, the date nearest to the time of statehood for which information in the record could be found regarding number of cattle, the Empire Ranch had 12,000 head of cattle grazing in the Cienega Valley. The Empire Ranch was also supported in part by silver mining and milling operations at the Total Wreck Mine located in the Empire Mountains. The milling operations at the mine depended in part on water pumped from Cienega Creek through a two-mile long pipeline. Transportation in the Cienega Valley was generally by foot, horse, wagon or railroad. In 1911 a dam was constructed on Cienega Creek near Vail to force groundwater to the surface for irrigation diversions. No evidence of boating on Cienega Creek was found in the historical record.

Hydrology & Geomorphology

Cienega Creek drains a 457 square mile watershed that extends to the Santa Rita, Whetstone and Empire Mountains. The stream has an average slope of about 0.9 percent (0.09 ft./ft.), and consists of a sand and gravel-bedded channel and low banks lined by riparian vegetation or grassland. The main channel is straight to slightly sinuous, and consists of single and braided channel reaches. No evidence was identified in the record to suggest that the location or alignment of the stream has varied significantly over time.

Historical and modern hydrologic records indicate that Cienega Creek is an interrupted stream, with perennial, intermittent, and ephemeral reaches. That is, some reaches contain year-round flow, but others flow only seasonally or after significant rainstorms. The mean annual flow at the U.S. Geological Survey (USGS) gauging station near Vail, Arizona is 6.5 cfs, which flows at an average depth of less than ½ foot, and a width of 6 to 20 feet. According to the USGS gauge records, 90 percent of the time the stream flow is less than 5 cfs. The USGS gauge is located near a dam which forces groundwater to the surface, increasing the surface flow to rates higher than the natural surface flow rate. Many parts of the stream are normally dry.

Boating

Comparison of estimated flow depths and widths for typical flow rates with federal boating criteria indicates that acceptable boating conditions are rare, and occur only during unpredictable flood conditions. There is no evidence in the record to suggest that Cienega Creek was used for commercial or recreational boating of any kind in the past. No evidence was identified for this study to suggest that flow conditions existed at the time of statehood that would have made the stream susceptible to boating of any kind except possibly during infrequent flood events.

Land Ownership

A Geographic Information System (GIS) mapping product was developed depicting the spatial relationship between the studied stream and land ownership. Mapping of the study area was performed utilizing ESRI ArcView 3.2 GIS software. The base layers for the GIS were obtained from the Arizona Land Resources Information System (ALRIS) maintained by the Arizona State Land Department (ASLD) as modified by Stantec Consulting Inc. for the ANSAC Small Watercourse and Minor Watercourse Pilot Study. In addition, floodplain data from the Federal Emergency Management Agency (FEMA) National Flood Insurance Program (NFIP) Q3 Flood Data were processed for presentation with the Stantec data. Finally, the U.S. Geological Survey (USGS) 100,000 series digital raster graphic (DRG) maps were used as supplemental background for these maps.

Navigability Criteria

A.R.S. Section 37-1128 mandates a presumption of non-navigability if certain criteria apply to the stream reach as of February 14, 1912. Data for Cienega Creek, developed as a part of this study are summarized below for each of the criteria established by A.R.S. Section 37-1128 (each numbered item lists the criteria in italics followed by the associated finding of the study):

1. *The stream flowed only in direct response to precipitation and was dry at all other times.* Some reaches of Cienega Creek are perennial or intermittent, flowing year-round in response to discharge of springs, interception of groundwater, and sustained runoff. Other reaches are normally dry and flow only in direct response to precipitation.

2. *No sustained trade and travel occurred both upstream and downstream in the watercourse.* No evidence was found to indicate that sustained trade or travel occurred in boats in either the upstream or downstream direction on Cienega Creek.

3. *No profitable commercial enterprise was conducted by using the watercourse for trade and travel.* No evidence was found to indicate that commercial enterprise of any kind was conducted using the watercourse for trade or travel in boats. The creek alignment was used to drive cattle from the Empire Ranch.

4. *Vessels customarily used for commerce on navigable watercourses in 1912, such as keelboats, steamboats or powered barges, were not used on the watercourse.* There is no evidence to suggest that any types of vessels were ever used on Cienega Creek.

5. *Diversions were made from the watercourse to irrigate and reclaim land by persons who made entries under the Desert Land Act of 1877.* No evidence that entries under the Desert Land Act of 1877 were made for diversion of flow from Cienega Creek. The natural and subsurface flow of Cienega Creek was diverted for irrigation near the community of Vail and mining use on the Empire Ranch during the period around statehood.

6. *Any boating or fishing was for recreational and not commercial purposes.* No evidence was found of boating or commercial fishing on Cienega Creek as of the time of statehood. Fish recorded in Cienega Creek include minnows and other non-sport or commercial species.

7. *Any flotation of logs or other material that occurred or was possible on the watercourse was not and could not have been regularly conducted for commercial purposes.* No record of use of Cienega Creek for flotation of logs or other material was found in historical documents.

8. *There were bridges, fords, dikes, manmade water conveyance systems or other structures constructed in or across the watercourse that would have been inconsistent with or impediments to navigation.* At least one diversion structure and one diversion dam were recorded in the historical documents collected for this study. It is likely that there were numerous fords or other crossings existing along the 44-mile study reach. Some of these structures may have been impediments to some types of navigation.

9. *Transportation in proximity to the watercourse was customarily accomplished by methods other than by boat.* Based on the evidence collected, transportation in proximity to Cienega Creek was customarily accomplished by foot, horse, wagon, or railroad as of the time of statehood.

10. *The United States did not regulate the watercourse under the Rivers and Harbors Act of 1899.* No evidence was found in the research to indicate that Cienega Creek was regulated under this code as of the time of statehood.

INTRODUCTION

Information presented in this report is intended to provide data for the Arizona Navigable Stream Adjudication Commission (ANSAC) from which ANSAC can make a recommendation to the Arizona Legislature regarding the navigability of Cienega Creek. This report does not make a recommendation or draw any conclusions regarding title navigability. The report consists of the following parts:

- History
- Hydrology & Geomorphology
  - Land Ownership

"Cienega" is a Spanish word meaning a marsh or swamp. Literally, the word means "hundred (cien) waters (agua)" and carries the connotation of a rich combination of flowing water, stagnant water, stream flow, springs, and shallow groundwater. Cienega Creek was named for the cienegas that were once found along its river valley prior to settlement of the area by Anglo-Americans.

Cienega Creek is located in Pima and Santa Cruz Counties in southeastern Arizona. The Cienega Valley watershed is bounded by the Rincon Mountains to the north, the Whetstone Mountains to the east, the Canelo Hills to the south, and the Santa Rita Mountains to the west (Figure 1).

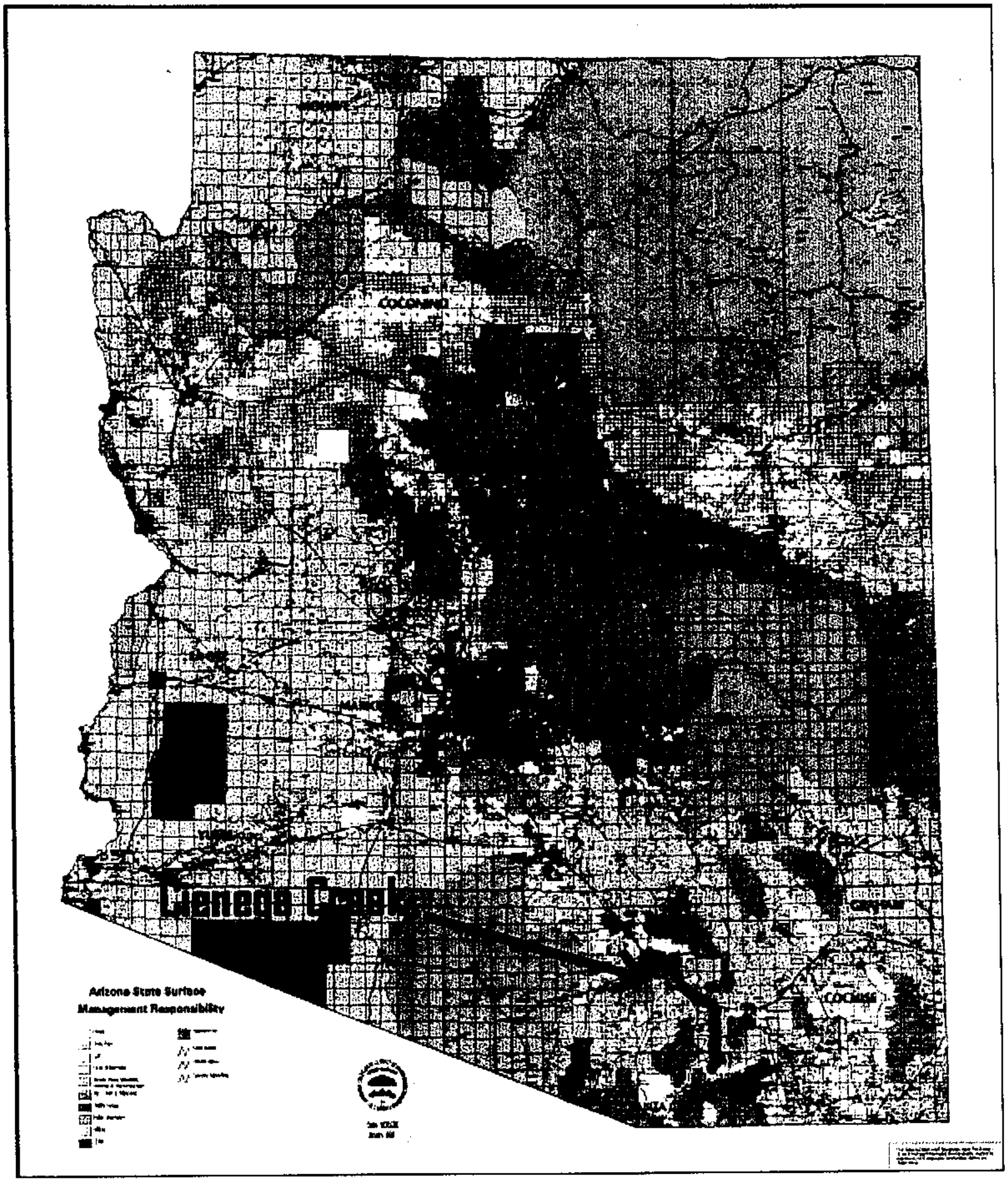
HISTORY

Early Explorers and Settlers

The Cienega Valley has a history of human occupation dating to at least 1000 B.C., which was continued by the Hohokam culture between 1 and 1400 A.D (Eddy & Cooley, 1983). Exploration of the area by the Spanish began in the 1600's. In 1699, Father Eusebio Francisco Kino, a Jesuit missionary explorer, delivered 150 head of cattle to the rancheria Sonoita located near the headwaters of Cienega Creek (Dowell, 1978). However, cattle grazing was not generally successful in the region until the early 1780's at which time the Spanish crown granted large land holdings to cattlemen in the form of land grants generally known as "floats." Between 1831 and 1850 Apache raids drove many of these cattle raisers of their ranches.

The California Gold Rush of 1849 brought an influx of Anglo-American travelers and settlers from the east. The first Anglo-American settlement in the vicinity of the Cienega Valley was at Fort Buchanan, established on nearby Sonoita Creek in 1857 to protect mining activity near Tubac. New ranching operations sprang up in the Cienega Valley to supply beef to the fort and the newly created Chiricahua Apaches Reservation east of the Dragoon Mountains. Construction of the Southern Pacific and the New Mexico and Arizona railroad lines in the 1870's and 1880's further fueled settlement of the Cienega Valley.

Figure 1: Cienega Creek Location Map



The modern history of the Cienega Valley is largely the history of the Empire Ranch. In 1876, Walter Vail and Herbert Hislop purchased a 160-acre tract known as the Empire Ranch in the Cienega Valley. The original 160-acre tract was located on a tributary to Cienega Creek known as Empire Gulch, which contained a perennial spring that provided a reliable water source for the ranch. Vail, Hislop and a third partner named John N. Harvey, who joined the ranch shortly after the original purchase, continually expanded the ranch by purchasing adjoining or nearby ranches or grazing rights, including the cattle associated with them. Hislop left the ranch in 1878 but was replaced by Vail's older brother Edward in 1879. Following closure of Fort Buchanan and Camp Crittenden, and relocation of the Chiricahua Apaches, the demand for beef created by the mining boom in Tombstone helped provide a ready market. From 1879 to 1903, the Empire Ranch herd grew from 2,200 to over 12,000 cattle grazing the Cienega Valley (Dowell, 1978). When Walter Vail died in 1906, the ranch covered almost 1 million acres (BLM). Figure 2 provides an overview of the Empire Ranch location within the Cienega Valley and surrounding area.

The owners of the Empire Ranch supported their ranching operations in part through the development of a mining operation called the Total Wreck Mine[1]. The Total Wreck Mine was located along the west edge of the Cienega Valley on the east flank of the Empire Mountains (Figure 2). In 1881 the Vail brothers secured control of the mine and incorporated it as the Total Wreck Mining and Milling Company. Within two years its silver production rivaled that of the most prosperous mines in the territory (Dowell, 1978). In 1882 the Vail's purchased the Meadow Valley Ranch, located near the mine, from rancher Don Sanford. The purchase extended the range of the Empire Ranch five miles farther north along the Cienega Ranch but also provided a source of water for use in milling operations at the mine. For this purpose, the Vail's installed a 40-horsepower pump on Cienega Creek and pumped water two miles to the mine through a six-inch iron pipeline. In 1884 a depression in silver prices crippled the mining operation and the Vail's closed it three years later when ore yields fell too low for profit. In 1890 postal service was discontinued to the settlement that had grown up around the mine.

In 1988 the Bureau of Land Management acquired the ranch lands in the Cienega Valley, and formed the 45,000-acre Empire-Cienega Resource Conservation Area (RCA; Figure 3). Ranching continues in the RCA under a grazing permit held by John and Mac Donaldson of Sonoita. The Cienega Valley is currently proposed for inclusion as part of the Las Cienegas National Conservation Area (NCA; Figure 4) under the Las Cienegas NCA Establishment Act being supported by U.S. Representative John Kolbe.

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[1] So named because one of the original co-claimants, one John T. Dillon, remarked to Vail and Harvey that "the mineral formation is almost a total wreck" (Barnes, 1988).

Figure 2: Empire Ranch Holdings (1876-1926) in Cienega Valley
(from Dowell, 1978)

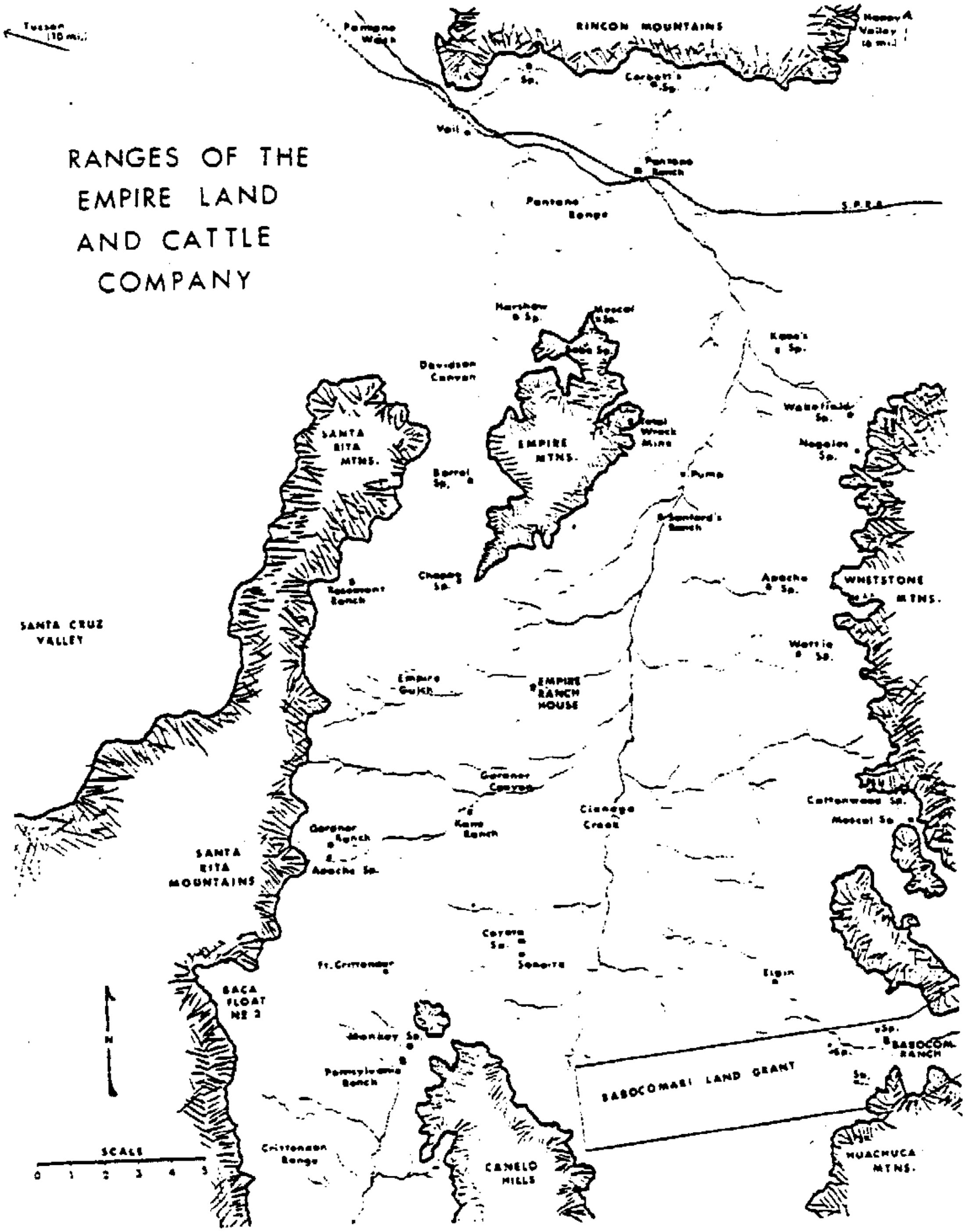


Figure 3: Location Map of Empire-Cienega RCA

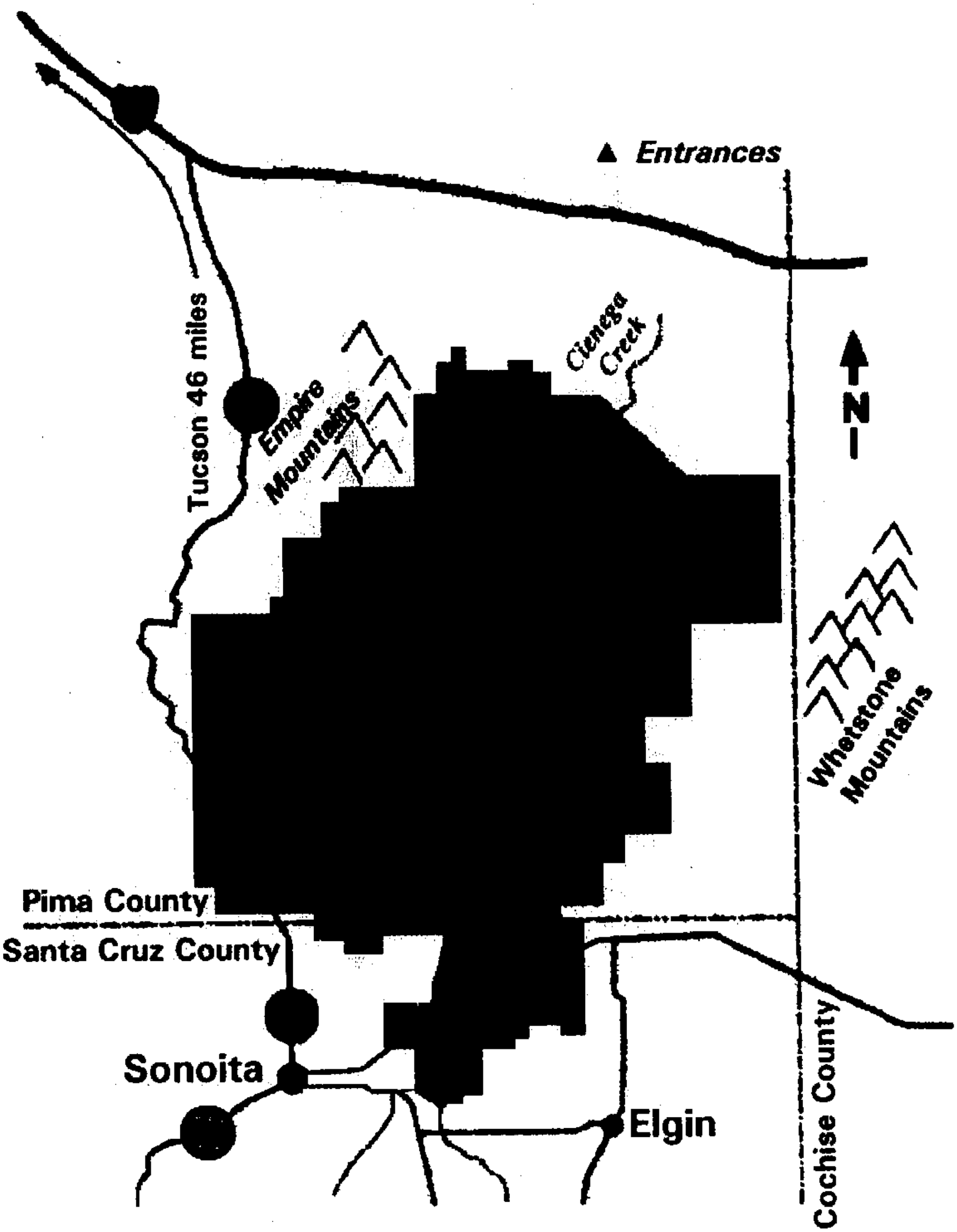
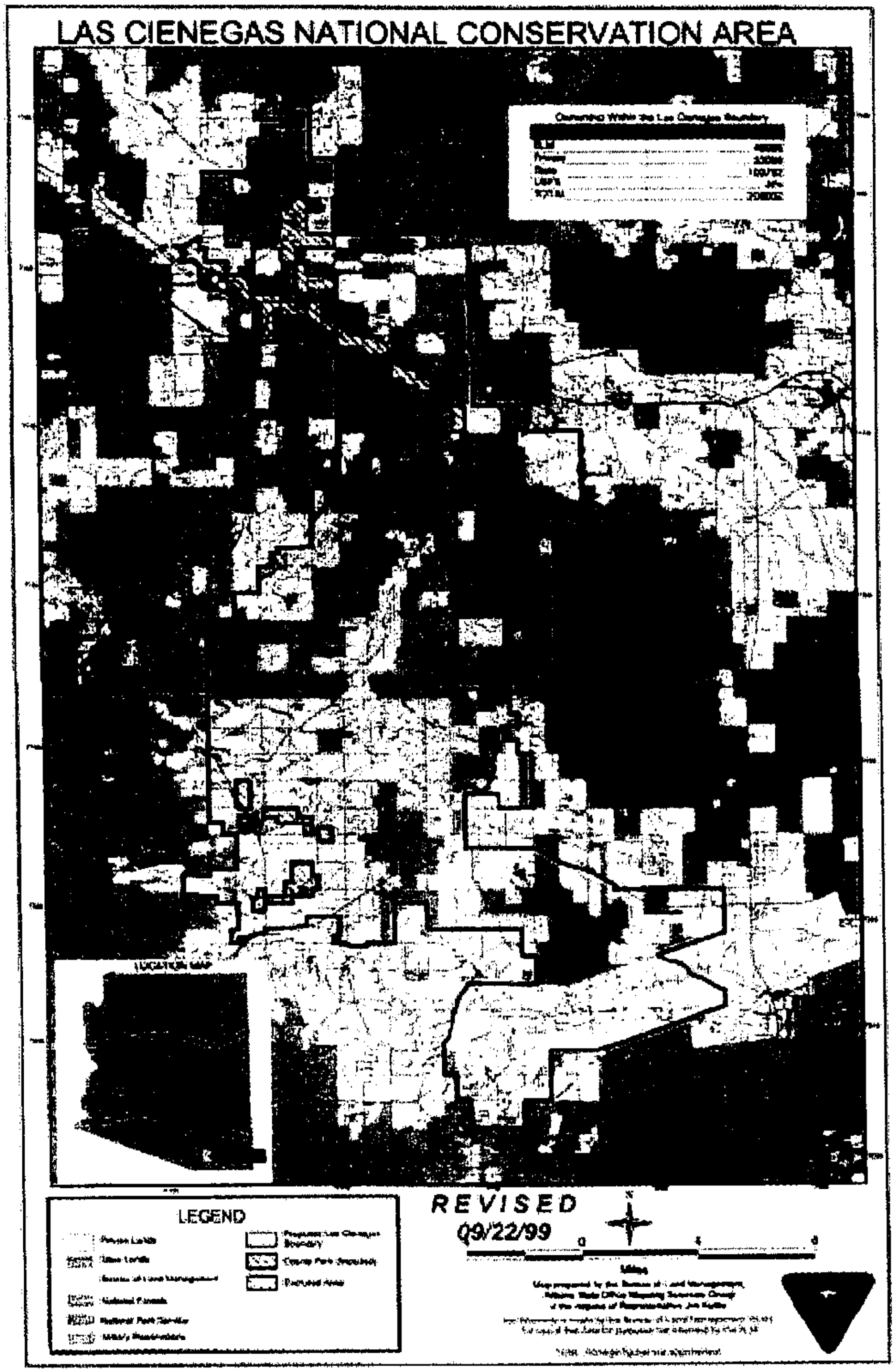


Figure 4: Proposed Las Cienegas National Conservation Area



Wildlife and Habitat

According to the records of early explorers and settlers, Cienega Creek prior to 1900 (Eddy & Cooley, 1983) was a sluggish stream flowing through dense cienegas or bogs choked with tall grass. These ponds provided permanent and temporary homes for aquatic animal species such as beaver and waterfowl. The stream currently supports numerous mammal, amphibian, reptile, bird and native fish species, including the Gila topminnow, Gila chub and longfin dace (BLM, 2000) within the interrupted perennial reaches. The adjacent grama, sacaton, and salt grasslands probably supported wild grazing animals throughout the previous century (Eddy & Cooley, 1983), prior to being converted to cattle grazing lands in the late 1800's. The uplands in the region were covered with a scattered growth of mesquite, palo verde, and prickly pear cactus (Dowell, 1978).

Today, the vegetation of the Cienega Valley is characterized as typical of the upper Sonoran life zone. The sacaton flats present during the first half of the 20th century, were invaded and dominated by moderately dense mesquite woods, with clusters of live oak along the upper drainages, yucca and agave along the divide between the Cienega Creek and Davidson Canyon drainages. Cottonwoods and willow and scattered populations of velvet ash occur along Cienega Creek while oaks and juniper woodlands thrive on the rolling hillsides of the valley.

Wildlife observed in the mid 20th century includes javalina, mule dear, antelope, coyote, badger, rabbits, gophers and various other rodents (Eddy, 1958). The stream itself currently supports numerous mammal, amphibian, reptile, bird and native fish species, including the Gila topminnow, Gila chub and longfin dace (BLM, 2000) within the interrupted perennial reaches.

Transportation

Transportation through the Cienega Valley as of the time of statehood was by foot, horseback, horse-drawn wagon or railroad. Cattle drives were often run along Cienega Creek, but all travel was by foot, horse, or wagon. The Southern Pacific Railroad started service across the north end of the valley in 1877. The New Mexico & Arizona line was built between Nogales and Benson through the south end of the valley and along Sonoita Creek in 1881-1882 to connect the Southern Pacific Railroad with the Sonoran Railway in Mexico (Walker & Bufkin, 1979). No record of commercial, recreational, or any other type of boating on Cienega Creek was identified during the course of this study.

Other Uses of Cienega Creek

In 1911 a dam was constructed on Cienega Creek at a location approximately 60 feet downstream from the current location of the USGS gauge near Vail (#09484600). The purpose of the dam was to force shallow groundwater to the surface for diversion into an irrigation ditch for a nearby ranch. The dam was built on a radius spanning a width of approximately 67 feet and extending to bedrock at a depth of approximately 45 feet below the stream surface. A magazine article by Mr. George E.P. Smith, who supervised construction of the dam, states that, after construction of the dam, the surface flow upstream of the dam was approximately 0.6 cfs while the surface flow downstream of the dam was increased to approximately 1.5 cfs (670 gal./min.), resulting in a nearly 1.0 cfs increase in flow as a result of the dam (Figure 5).

Figure 5: 1911 Photograph of Sub-Surface Dam on Cienega Creek

No other uses of the stream apart from the dam construction, use of the stream flow for cattle grazing, and diversions to the Total Wreck Mine, were documented in the literature collected for this study.

Summary

The Cienega Valley history of human occupation dates back to 1000 B.C. and extends to the present. Spanish exploration of the area began in the 1600's, but it was after the California Gold Rush of 1849 that first influx of Anglo-American settlers reached the area. Between 1876 and 1926 the Empire Ranch was the primary settlement in the area with land holdings that spanned the entire Cienega Valley. In 1903, the Empire Ranch had 12,000 head of cattle grazing in the Cienega Valley. The Empire Ranch also operated the Total Wreck Mine, which depended in part on water pumped from Cienega Creek. Transportation in the area was by foot, horse, wagon or rail. There is no record in the literature of boating or other use of Cienega Creek to run passenger craft or typical commercial craft such as keelboats, steamboats or powered barges.

HYDROLOGY

Geographic and Hydrologic Setting

The Cienega Creek watershed is located in southeastern Arizona and extends from a point near Vail, Arizona where the stream changes name to Pantano Wash, south to the headwaters located in the Canelo Hills of Santa Cruz County, Arizona (Figure 6). The Cienega Creek watershed is bounded by the Rincon Mountains to the north, the Whetstone Mountains to the east, the Canelo Hills to the south, and the Santa Rita Mountains to the west. The watershed consists primarily of the grasslands of the Cienega Valley. The vegetation of the Cienega Creek watershed includes ponderosa pine in the upper elevations of the Santa Rita Mountains while the lower elevations include oak, juniper, agave and extensive grasslands. Elevations within the basin range from 3,200 at the Colossal Cave Road crossing to over 9,400 feet on Mt. Wrightson in the Santa Rita Mountains. The table below provides a number of watershed characteristics for Cienega Creek as measured at USGS stream gauge (Figure 6)[2].

Table 1. Cienega Creek Navigability Study
Stream Characteristics

Watershed Characteristic	Pantano Wash near Vail	Cienega Creek near Pantano
Stream length	43.5 mi.	31.2 mi.
Main channel slope	46.3 ft./mi.	59.8 ft./mi.
Mean basin elevation	4500 ft. msl	4890 ft. msl
Mean annual precipitation	15.4 in.	16.6 in.
Forested area	15 %	13 %
Drainage area	457 mi.^{2}	289 mi.^{2}

Data Sources

Hydrologic for Cienega Creek are available from USGS gauge near Vail (#09484600) and Pantano (#09484560), which are located upstream of the Colossal Cave Road and at the Interstate-10 crossing, respectively. Additional hydrologic data were collected during the field investigation, and from records and anecdotal information available in the literature. The USGS gauge near Vail (#09484600) is located approximately 60 feet upstream from the sub-surface dam described in the "History" chapter. The USGS report that base runoff past the gauge consists of "downvalley underflow that is brought to the surface by the concrete dam…" (Pope et. al, 1998).

Statehood Hydrology

No hydrologic records from the year of statehood (February 14, 1912) were found during the course of this study. Hydrologic data from the time of statehood are limited to historical accounts, anecdotal data, and secondary reports such as the survey notes of the Government Land Office (GLO) surveyors. GLO survey data on file at the Bureau of

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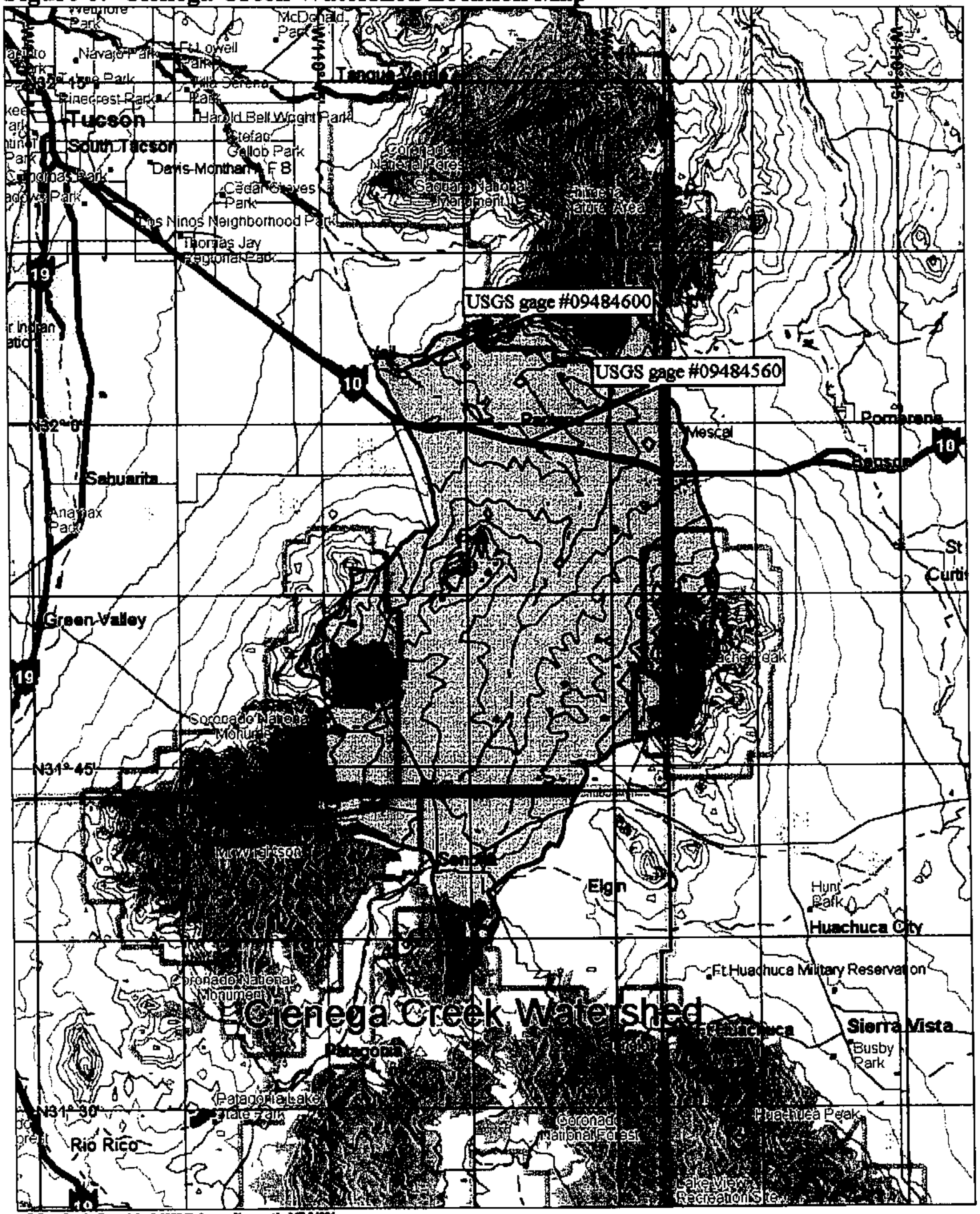
2 The USGS refers to this gauge as the Pantano Wash Near Vail. However the gauge location corresponds roughly to the downstream limit of the Cienega Creek as defined in this report.

Figure 6: Cienega Creek Watershed Location Map



 2 mi Scale: 1 : 400,000 Detail: 8-2 Datum: WGS84

Land Management Records office in Phoenix included notes from ten separate surveys that covered the Cienega Creek study reach. The earliest survey was dated October-November 1873, and the latest was performed in December 1912 (White, 1874a; White, 1874b; White, 1874c; White, 1874d; White, 1874e; Roskruge, 1881; Wolfley, 1884; Contzen, 1902; Jacobs & Curry, 1911; Hesse, 1912). Unfortunately, no surveys were performed in February 1912, and although the Hesse survey dates to 1912, it does not mention stream conditions.

Cienega Creek crosses a total of 52 Township and Range section line boundaries. The GLO survey notes made mention of Cienega Creek on 27 of these 52 section line traverses. The October 1874 survey notes specifically state that Cienega Creek was dry at the following section lines in Township 20 South, Range 17 East (White, 1874b):

- Section 15/22
- Section 10/15
- Section 3/10

Running water is mentioned twice in the survey notes for Cienega Creek. Notes from the November-December 1874 survey record a "stream of water" crossing the boundary of sections 19 and 30 in Township 16 South Range 17 East, between what is now Pantano Road and Interstate-10 (White, 1874d). The September 1908 GLO survey records make only brief mention of "running water" at the boundary of sections 30 and 31 in Township 17 South Range 18 East, approximately 5 miles south of the present day Interstate-10 crossing (Jacobs & Curry, 1911). An earlier 1874 GLO survey made reference to two section line crossings located between the current day Marsh Station Road and I-10 crossings as a "swampy place." This is consistent with early historical accounts of Cienega Creek that state that the stream once had a more marshy character than it does today (White, 1874d).

Most information available is anecdotal in nature, coming from accounts of conditions that existed at that time based on incidental references. Those accounts indicate that as of the time of statehood Cienega Creek had some perennial and some intermittent reaches, depending on depth to groundwater, subsurface geology, and proximity to water sources such as springs (Eddy and Cooley, 1983).

Post-Statehood Hydrology

The USGS stream gauges provide the only systematic record of stream flow on Cienega Creek. Tables 2 to 5 provide summaries of streamflow data and flood frequency predictions based on the USGS gauge records (Pope et. al., 1998). The locations of the two gauges within the study area are shown on Figure 6. Figures 7 and 8 provide graphical depictions of annual peak and mean discharge values for the two gauges. The Cienega Creek near Pantano gauge provides only peak discharge data (i.e., no daily discharge data available).

Table 2. Cienega Creek Navigability Study Mean Monthly Streamflow Data for Pantano Wash at Vail (#09484600)												
Month	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**
Mean	8.4	4.7	3.4	2.1	1.3	1.2	12	20	12	1.9	1.2	6.4
Max	111	36	18	5.2	2.0	3.6	50	93	105	6.7	3.0	50
Min	0.10	0.10	0.12	0.32	0.19	0.07	0.66	0.52	0.16	0.10	0.10	0.10
Period of Record: 1959-1974, 1975-1989 and 1989-1998												

Table 3. Cienega Creek Navigability Study Streamflow Statistics for Pantano Wash at Vail (#09484600)	
Flow Characteristic	**Flow Rate**
Annual Mean Flow	6.2 (cfs)
Maximum Annual Mean	13 (cfs)
Minimum Annual Mean	1.8 (cfs)
Lowest Daily Mean (numerous occurrences)	0 (cfs)
Highest Daily Mean (Sep. 10, 1964)	2,230 (cfs)
Max. Instantaneous Peak Flow (Aug. 11, 1958)	38,000 (cfs)
Annual Mean Runoff	4,489 (acre-feet)
Flow value exceeded 10% of the time	4.7 (cfs)
Flow value exceeded 50% of the time	1.4 (cfs)
Flow value exceeded 90% of the time	0.43 (cfs)

Table 4. Cienega Creek Navigability Study Peak Discharges for Pantano Wash at Vail (#09484600)					
2-year	**5-year**	**10-year**	**25-year**	**50-year**	**100-year**
2,600	6,450	10,400	17,200	23,900	32,100

Table 5. Cienega Creek Navigability Study Peak Discharges for Cienega Creek near Pantano (#09484560)					
2-year	**5-year**	**10-year**	**25-year**	**50-year**	**100-year**
1,880	4,020	6,150	9,930	13,700	18,500

The USGS gauge data summarized in Tables 2 to 5 and Figures 7 to 8 indicate that Cienega Creek is a perennial stream at the gauge near Vail. The highest seasonal flow rates occur during the summer monsoon in July through September. A slight rise in flow rate also occurs during the winter months of December, January and February probably due as much to decreased evapotranspiration as to seasonal rainfall or snowmelt. The average annual flow rate is 6.2 cfs at Vail, although that station is impacted by a small dam upstream which forces groundwater to the surface and increases the low flow rate. However, since the dam was built in 1911, this forced flow condition is representative of conditions as of the time of statehood. The 50% flow duration, or median flow rate, is 1.4 cfs. Comparison of the 50% flow duration and the average annual flow rate indicates that the average annual flow rate is skewed upward by floods. That is, much of the annual flow volume is provided by floods rather than low flows, a condition similar to many ephemeral streams in Arizona. The minimum monthly flow is 0.1 cfs, indicating

Figure 7: Annual Peak and Mean Discharge Data for Cienega Creek at Vail

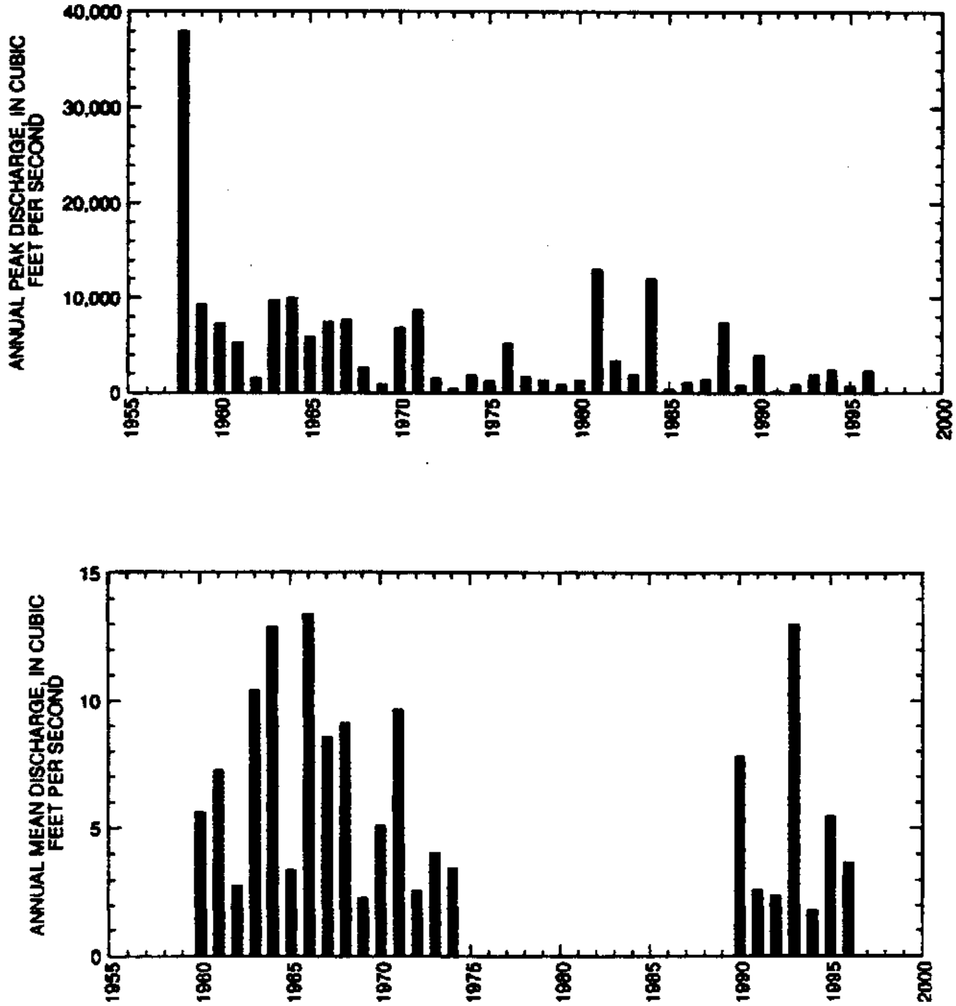
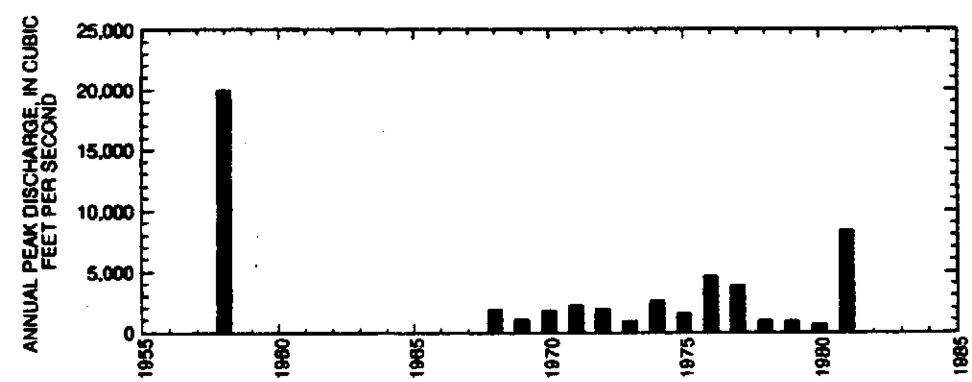


Figure 8: Annual Peak Discharge Data for Cienega Creek at Interstate-10



that at the USGS gauge at Vail, Cienega Creek is perennial, even though flow is not substantial.

A comparison of the magnitudes and dates of floods recorded at the Vail (#09484600) and Pantano (#09484560) gauges indicates that the flows vary significantly between the two stations. Therefore, although the stream flow data reported for the Vail gauge are the best available information, the flow rates may not be any better than order of magnitude estimates of flow at other reaches of Cienega Creek.

Floods

Historic information on the occurrence of floods along Cienega Creek was very limited. However, one account indicates that over 100 head of cattle on the Empire Ranch were lost to flooding along Cienega Creek in July 1887 (Dowell, 1978). The largest flood of record on the two U.S.G.S. stream gauges occurred on August 11, 1958 when a flow of 38,000 cfs occurred at the Vail gauge (USGS gauge No. 09484600). This same event resulted in a discharge measurement of 20,000 cfs at the Interstate-10 location (USGS gauge no. 09484560). Even small floods, such as the 2-year storm, are significantly larger than average flow conditions, and result in drastic increases in depth and velocity making navigation during floods difficult.

Climatic Variation

Research from previous navigability studies (CH2M Hill, 1993) indicates that Arizona's climate at statehood was not drastically different from existing or pre-statehood conditions. However, the period around the year 1912 was probably subject to higher than average stream flow, indicating that streams may have been more likely to have been navigable at statehood, than during other, less "wet" periods of Arizona history.[3] 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.

Geomorphology

Cienega Creek drains a 457 square mile watershed that extends to the Santa Rita, Whetstone and Empire Mountains. The stream has an average slope of about 0.9 percent (0.09 ft./ft.), and consists of a sand and gravel-bedded channel and low banks lined by riparian vegetation or grassland. The main channel is straight to slightly sinuous, and consists of single and braided channel reaches. No evidence was identified in the record to suggest that the location or alignment of the stream has varied significantly over time.

Downstream of I-10, Cienega Creek flows within a well-defined canyon, while upstream of I-10 the stream is shallower with a less well-defined transition to the surrounding grasslands. Historical data suggest that Cienega Creek experienced arroyo cutting during the late 1800's and early 1900's (Eddy and Cooley, 1983). Eddy (1958) notes that a local

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[3] Human impacts such as irrigation diversions, etc., have tended to lessen average stream discharge rates obscuring climatic effects on some Arizona streams.

rancher, E. Hilton, claimed that as a boy it was possible to drive across the valley floor in a buggy without obstructions. Estimates of Mr. Hilton's age would place the year of his recollection prior to 1890. In the same reference, another area rancher Harry Barnett claims that in 1905 Cienega Creek "was not a third as deep as it is today." Eddy goes on to note that the result of arroyo cutting was "a general lowering of the water table, a desiccation of soil moisture, and the prohibition of floodplain and dry farming." Harry Barnett had also observed a general replacement of grasslands by mesquite woods along the drainages within the last fifty years and a drying up of several cienegas, which formerly existed on Cienega Creek (Eddy, 1958). Based on recent field investigation, arroyo cutting appears to be continuing today in the upper reaches of Cienega Creek in Santa Cruz County.

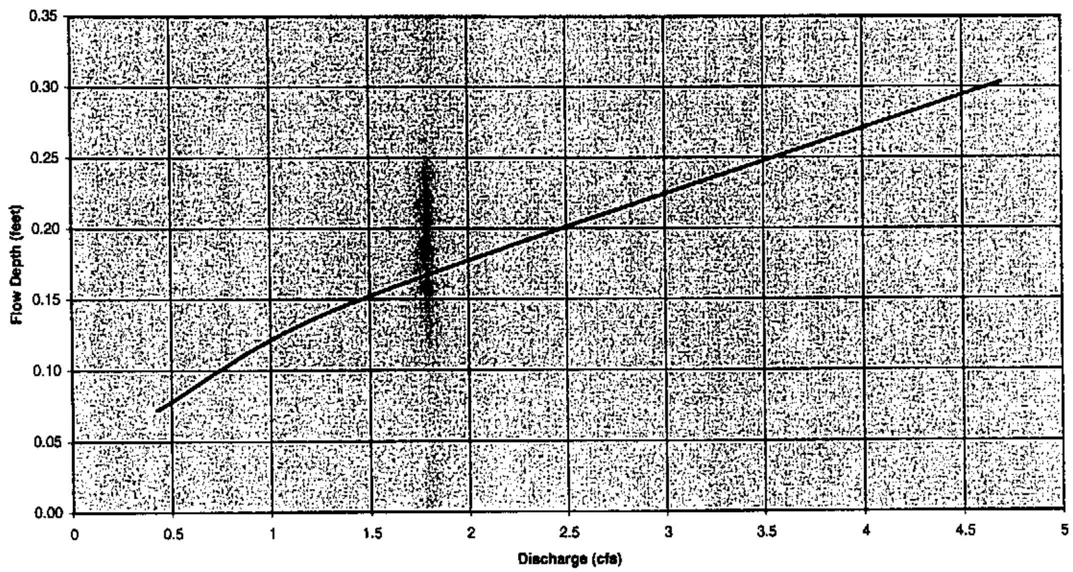
Hydraulic Characteristics

Measured data for hydraulic flow characteristics at the time of statehood were not available. However, estimated hydraulic characteristics were developed based on observed stream conditions and historic streamflow data available from the USGS stream gauge at Vail (#09484600). Table 6 provides a summary of the resulting range of values for estimated stream depth, width, and velocity. It should be noted that the hydraulic parameters shown below are not specific to any one location along the stream and assume that the streamflow characteristics for the referenced gauge would be relevant at all locations within the study area. Because the stream channel is somewhat confined at the gauge, the flow depths may be slightly higher than will occur elsewhere in the study area. A rating curve for an assumed cross section developed from field observations is shown in Figure 9.

Table 6. Cienega Creek Navigability Study
Estimated Range of Hydraulic Characteristics

Flow Duration	Discharge (cfs)	Flow Depth (ft)	Average Velocity (ft/s)	Flow Width (ft)
10 %	4.7	0.2 – 0.4	1.2 – 1.9	6 – 20
50 %	1.4	0.1 – 0.2	0.7 – 1.2	6 – 20
90 %	0.43	0.0 – 0.1	0.5 – 0.7	6 – 20
Average Annual	6.2	0.2 – 0.5	1.3 – 2.1	6 – 20
2-Year Flood	2,600	9 – 18	15 – 24	6 – 20

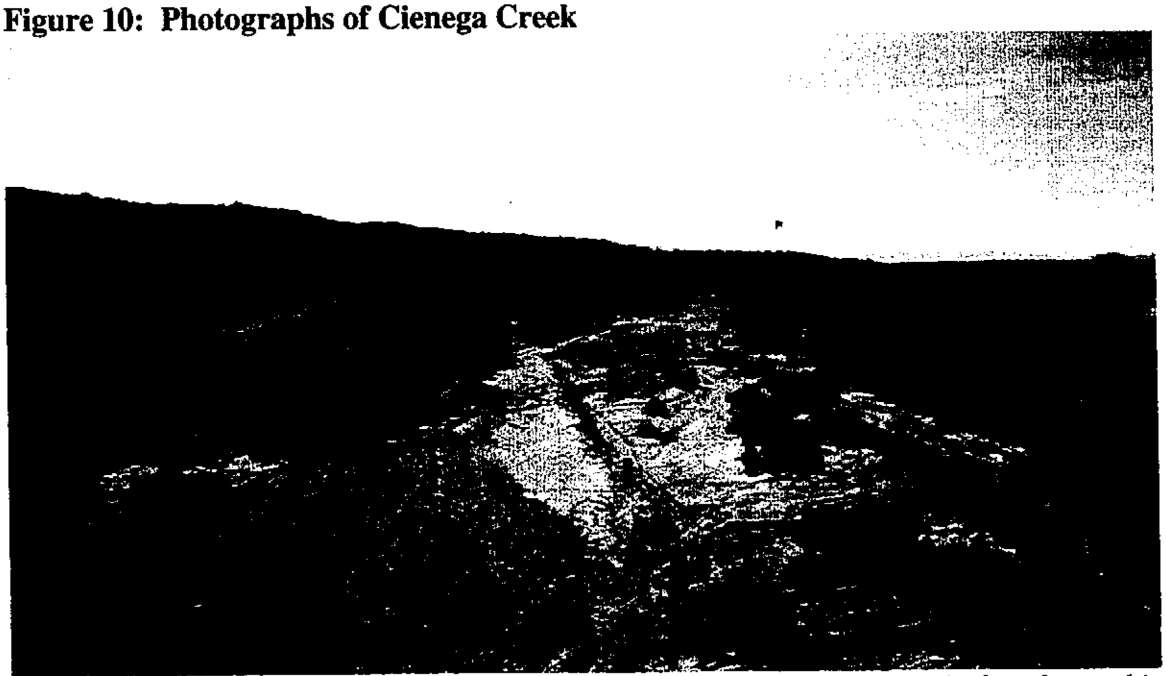
Figure 9. Cienega Creek Depth-Discharge Rating Curve



Field Investigation

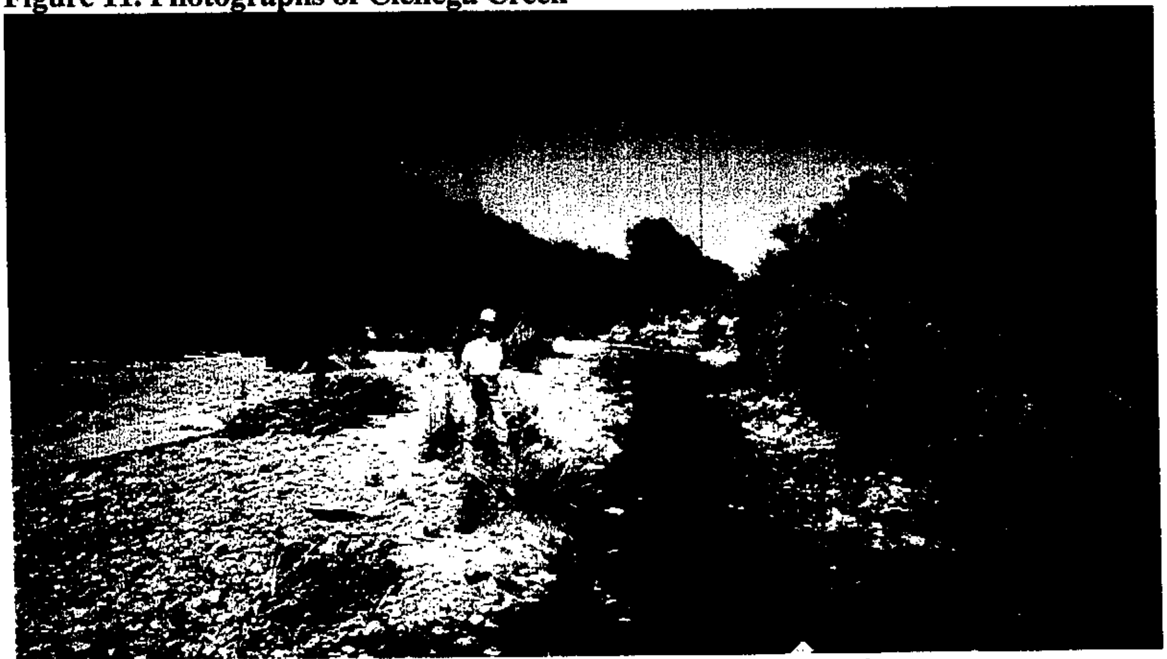
As a part of this study, a field investigation was conducted on April 25, 2000 to observe and document the condition of the stream at various locations within the study area. Some of the photographs taken at various locations along Cienega Creek are shown in Figures 10 to 15. The field photographs support the historical descriptions of stream flow conditions, and confirm the variability of flow conditions within the study area.

Figure 10: Photographs of Cienega Creek



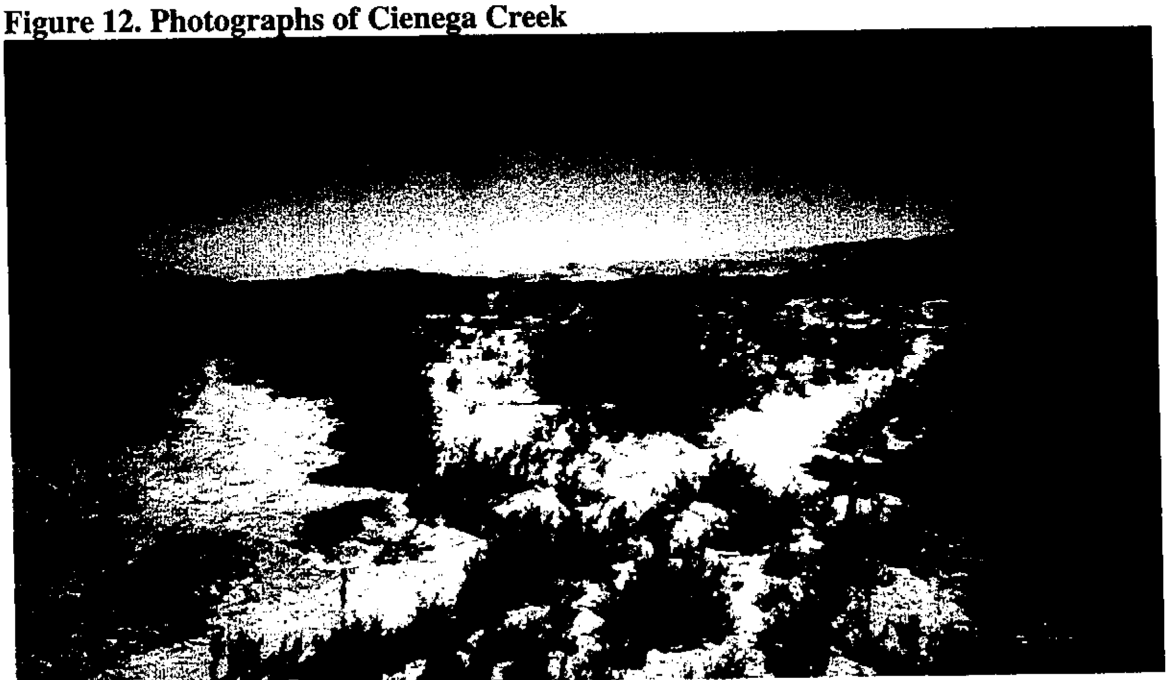
Looking upstream from the Colossal Cave Road Bridge (downstream end of study reach)

Figure 11. Photographs of Cienega Creek



Looking downstream from just downstream of Marsh Station Road.

Figure 12. Photographs of Cienega Creek

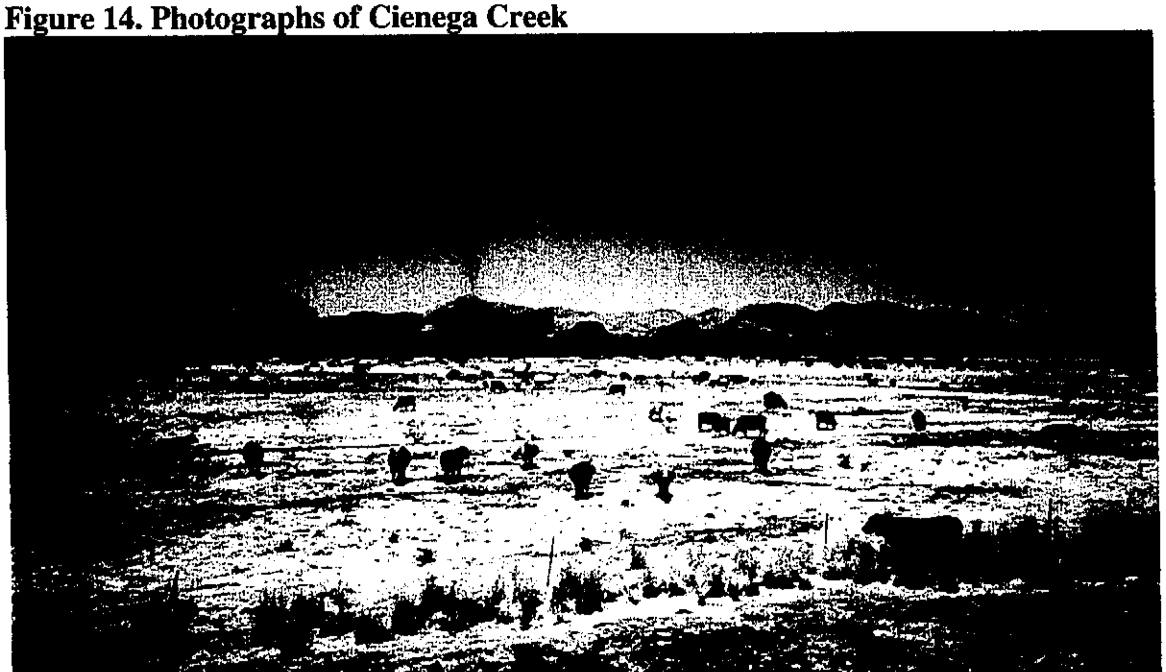


Looking downstream from Interstate-10

Figure 13. Photographs of Cienega Creek

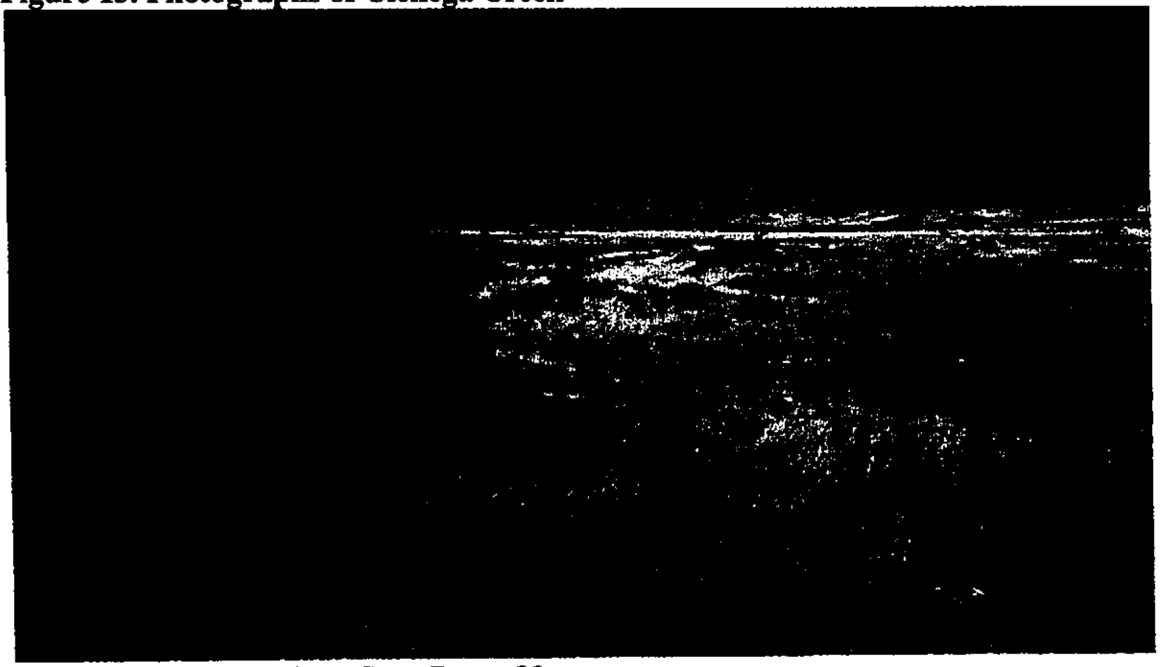
Looking downstream from near Cienega Ranch (Lat. 31° 49.3', Long. 110° 35.3')

Figure 14. Photographs of Cienega Creek



Looking west toward Cienega Creek (background) and floodplain (foreground)

Figure 15. Photographs of Cienega Creek



Looking downstream from State Route 82.

Susceptibility to Navigation

Some federal agencies have formally described stream conditions that 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 7 and 8, were developed primarily for recreational boating, not necessarily for commercial boating. Minimum and maximum stream conditions required are summarized in the tables below.

Table 7. 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. 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.	5 fps	-	-	10 fps
Source: Cortell and Associates, 1977						

Most Arizona boaters surveyed, as a part of previous navigability studies did not agree with the minimum velocity and width criteria given in Table 8. 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 are probably intended to indicate what stream conditions are most typically considered "fun."

As an aid in evaluating the susceptibility of the study stream reaches to navigation, the depth-velocity-width data for specific discharges provided in the previous sub-sections of this section can be compared with the required conditions for boating shown in the tables above. For the Cienega Creek gauge location, such a comparison indicates that none of the flows shown in Table 6 would provide conditions for an acceptable experience even by canoe, kayak or tube, much less by larger commercial craft, except during small floods. Higher flow rates may occur during flash floods, but last only for short periods and would be likely to be dangerous for boating. Note that the gauge station used for the streamflow data in this assessment was located downstream of a structure built to force groundwater to the surface. Thus the streamflow quantities used in this assessment are most likely higher than flows that would occur elsewhere within the study reach.

Boating

No references to commercial, recreational, or any other type of boating on Cienega Creek were identified during this study. No commercial recreational outfitters advertise any operations or excursions on Cienega Creek.

Summary

Cienega Creek has perennial, intermittent and ephemeral reaches that reflect the variety of water supply, subsurface geology, and water use within the river valley. There is no evidence in the record to suggest that the location or alignment of the stream has varied significantly over time, although the stream may have included more wetlands and cienegas prior to the 1900's. Comparison of estimated flow characteristics for Cienega Creek with federal boating criteria indicates that acceptable boating conditions do not exist for typical flow conditions. There is no evidence in the record to suggest that Cienega Creek was used for commercial or recreational boating of any kind in the past. There was no evidence identified for this study that suggests that flow conditions as of the time of statehood would have made the stream susceptible to boating of any kind except possibly during infrequent flood events.

LAND OWNERSHIP

A Geographic Information System (GIS) mapping product was developed depicting the spatial relationship between the studied stream and land ownership. Mapping of the study area was performed utilizing ESRI ArcView 3.2 GIS software. The base layers for the GIS were obtained from the Arizona Land Resources Information

System (ALRIS) maintained by the Arizona State Land Department (ASLD) as modified by Stantec Consulting Inc. for the ANSAC Small Watercourse and Minor Watercourse Pilot Study. In addition, floodplain data from the Federal Emergency Management Agency (FEMA) National Flood Insurance Program (NFIP) Q3 Flood Data were processed for presentation with the Stantec data. Finally, the U.S. Geological Survey (USGS) 100,000 series digital raster graphic (DRG) maps were used as supplemental background for these maps. Land use maps are provided in Appendix C-2.

Table 9. Cienega Creek Navigability Study
Base and Reference Layers from ALRIS

Name	Contents
STREAMS	Hydrography consisting of linear features, i.e., streams
SPRINGS	This data set consists of spring locations in Arizona
TRANS123	Statewide transportation data. Linear data representing roads and streets, classes 1, 2, and 3 from the ALRIS database.
LAND	This data set contains a group of integrated data layers. These layers consist of Public Land Survey system data (Township, Ranges and Section), land ownership and county boundaries.
AZTRS	This statewide coverage consists of the Township, Range and Section grid lines. This dataset was created by processing the LAND coverage. See the LAND documentation.
HUC	Hydrologic Unit Code areas (drainage basins) in Arizona.
Projection	NAD 27, UTM Zone 12

Ownership Categories

Private
State of Arizona (State Trust)
U.S. Forest Service (Coronado National Forest)
Bureau of Land Management (BLM)
Parks and Recreation

FEMA Floodplains

NFIP Q3 data for Pima County. ARC/INFO coverages from FEMA converted to ArcView shapefiles and projected to fit with the Stantec data by JEF.

USGS Digital Raster Graphics (DRG)

100,000 scale series DRGs used as additional background map. Includes topography and numerous place names for helpful reference and orientation.

CONTACTS

Agency/Affiliation	Name	Address	Phone
Arizona Historical Society	Ms. Susan Sheehan	949 E. 2nd Street Tucson, AZ 85719	520-628-5774
BLM Tucson Field Office	Ms. Karen Simms	12661 E. Broadway Tucson, AZ 85748	520-722-4289
Pima County Flood Control District	Ms. Julia Fonseca	201 N. Stone, 4th Flr Tucson, AZ 85701	520-740-6350
U.S. Geological Survey	Mr. Greg Pope	520 N. Park Ave. Suite 221 Tucson, AZ 85719	520-670-6671
BLM Public Records Section	Mr. Jim Hutchison	3707 N. 7th Street Phoenix, AZ 85014	602-650-0511

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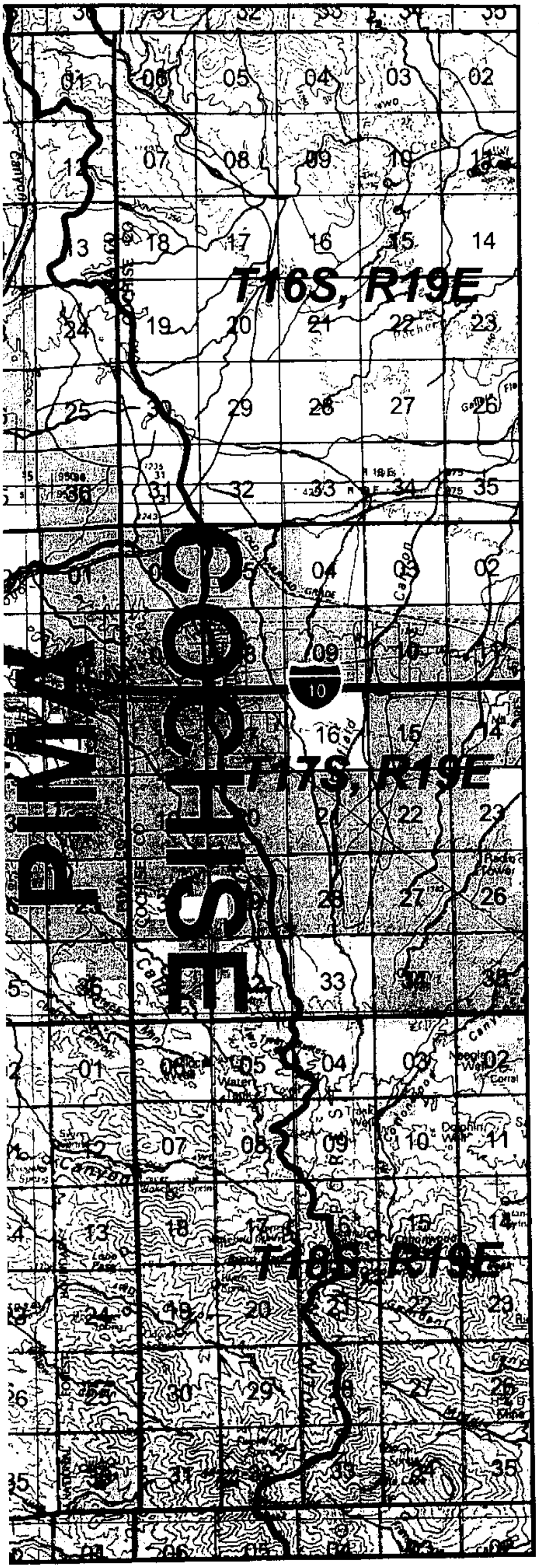
APPENDIX C-1

LAND OWNERSHIP MAPS



LEGEND

- Cienega Creek
- County Line
- FEMA Floodplains
- USGS HUCS
- Section Lines
- Perennial streams
- Streams
- Springs

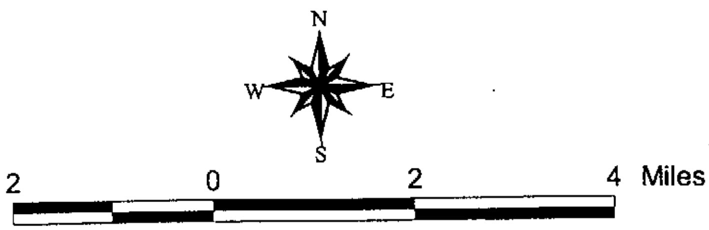
Land Ownership

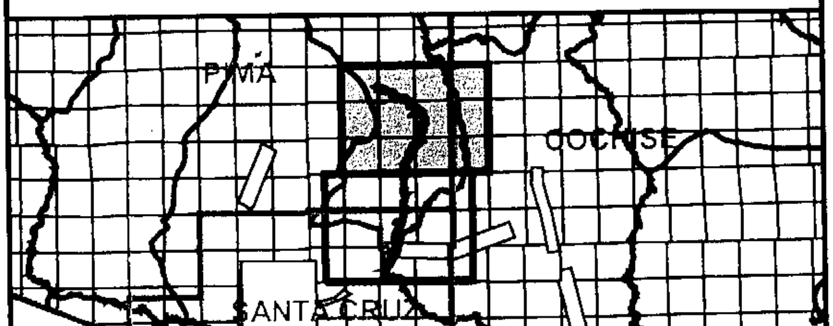
- BLM
- CORONADO N.F.
- PRIVATE
- STATE TRUST
- PARKS & RECREATION
- FT. HUACHUCA

Transportation

- Interstate
- State Hwy
- Improved Road

Background map is the USGS 100,000 series DRG.



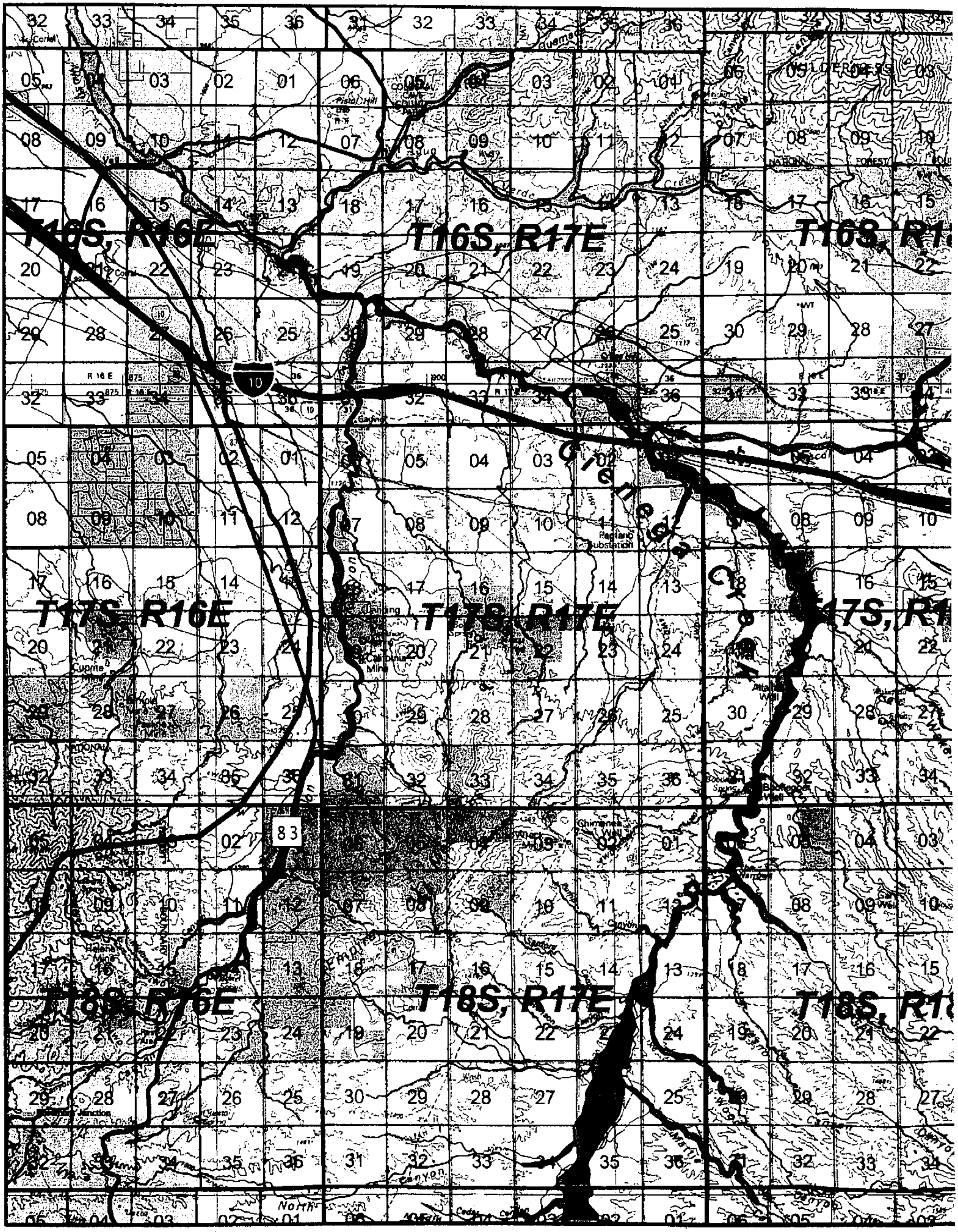


Index of Sheets and Vicinity Map

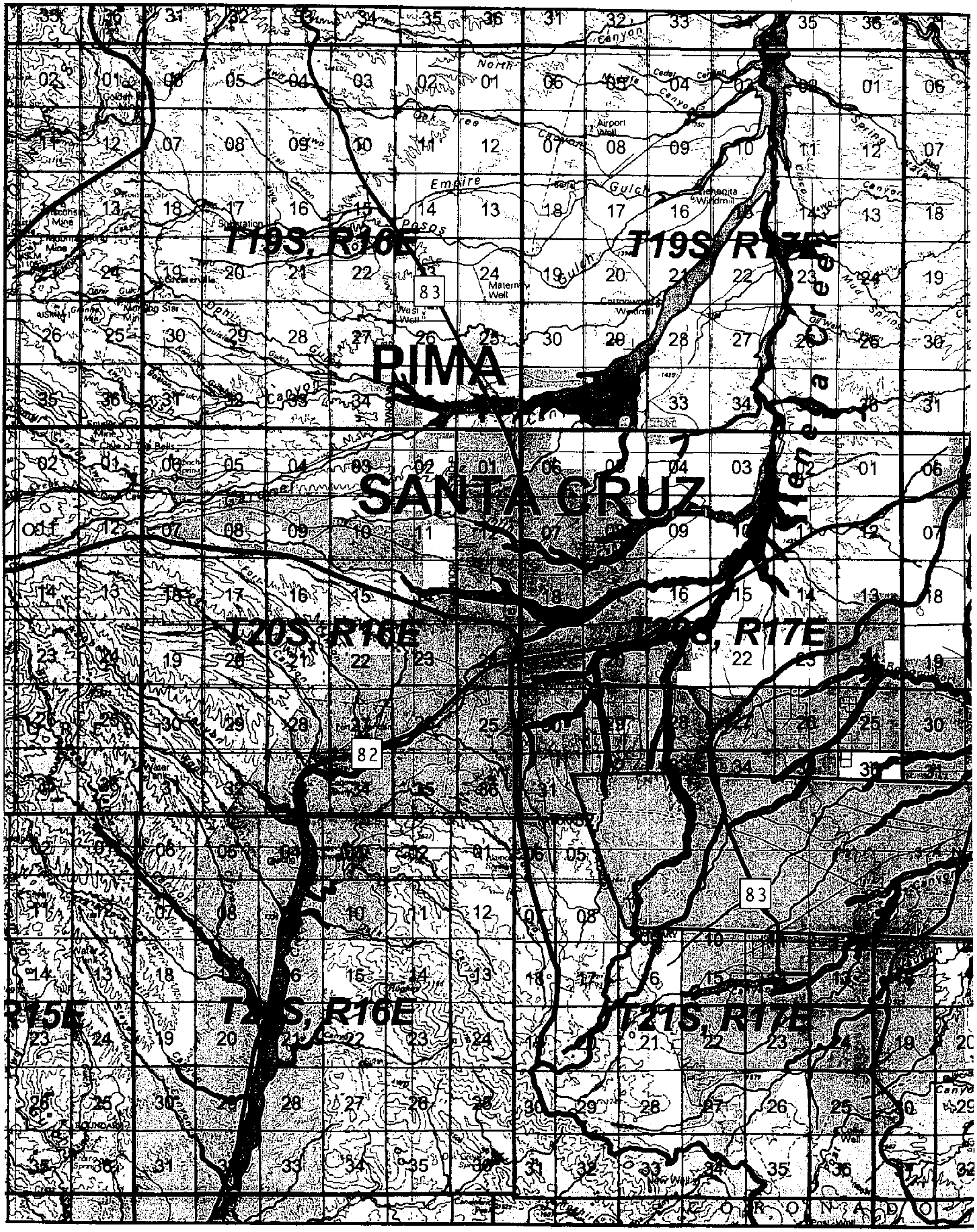
CIENEGA CREEK NAVIGABILITY STUDY
Land Ownership Map

Prepared for: Arizona State Land Department
By: JE FULLER HYDROLOGY & GEOMORPHOLOGY, INC.

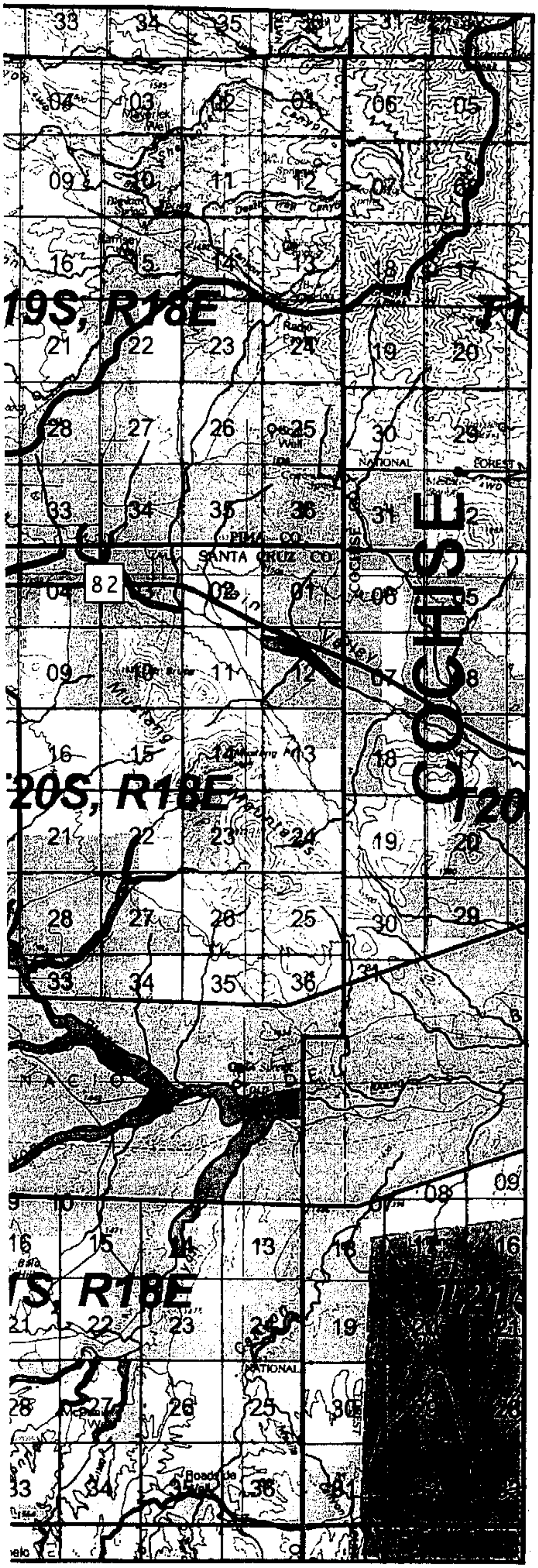
June 2000 Sheet 1 of 2



T16S, R16E
T16S, R17E
T17S, R16E
T17S, R17E
T18S, R16E
T18S, R17E
10
83
Cienega Creek



T19S, R16E
T19S, R17E
PIMA
SANTA CRUZ
T20S, R16E
T20S, R17E
T21S, R16E
T21S, R17E
R15E
83
82
Empire
Gulch
Canyon
CORONADO



LEGEND

- Cienega Creek
- County Line
- FEMA Floodplains
- USGS HUCS
- Section Lines
- Perennial streams
- Streams
- Springs

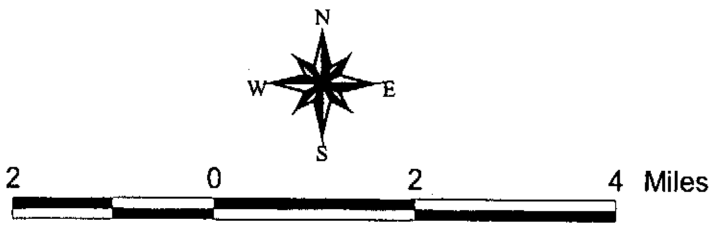
Land Ownership

- BLM
- CORONADO N.F.
- PRIVATE
- STATE TRUST
- PARKS & RECREATION
- FT. HUACHUCA

Transportation

- Interstate
- State Hwy
- Improved Road

Background map is the USGS 100,000 series DRG.



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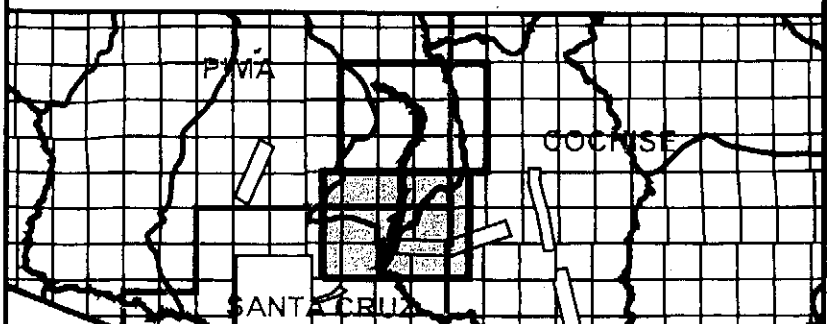

Index of Sheets and Vicinity Map

CIENEGA CREEK NAVIGABILITY STUDY
Land Ownership Map

Prepared for: Arizona State Land Department
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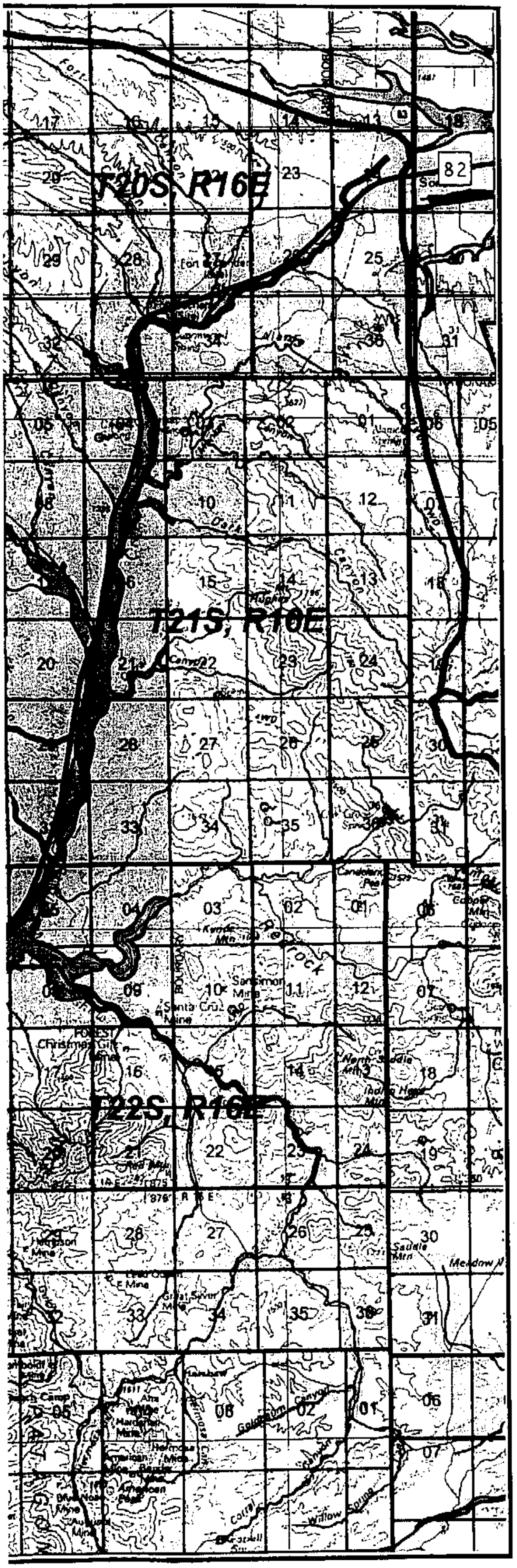
June 2000

Sheet 2 of 2



LEGEND

- Sonoita Creek
- County Line
- FEMA Floodplains
- USGS HUCS
- Section Lines
- Perennial streams
- Streams
- Springs

Land Ownership

- BLM
- CORONADO N.F.
- PRIVATE
- STATE TRUST
- PARKS & RECREATION
- FT. HUACHUCA

Transportation

- Interstate
- State Hwy
- Improved Road

Background map is the USGS 100,000 series DRG.

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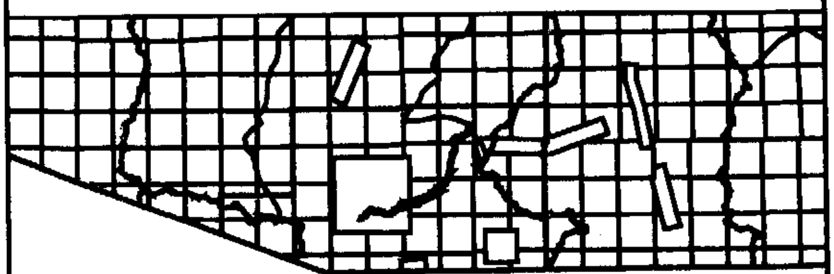
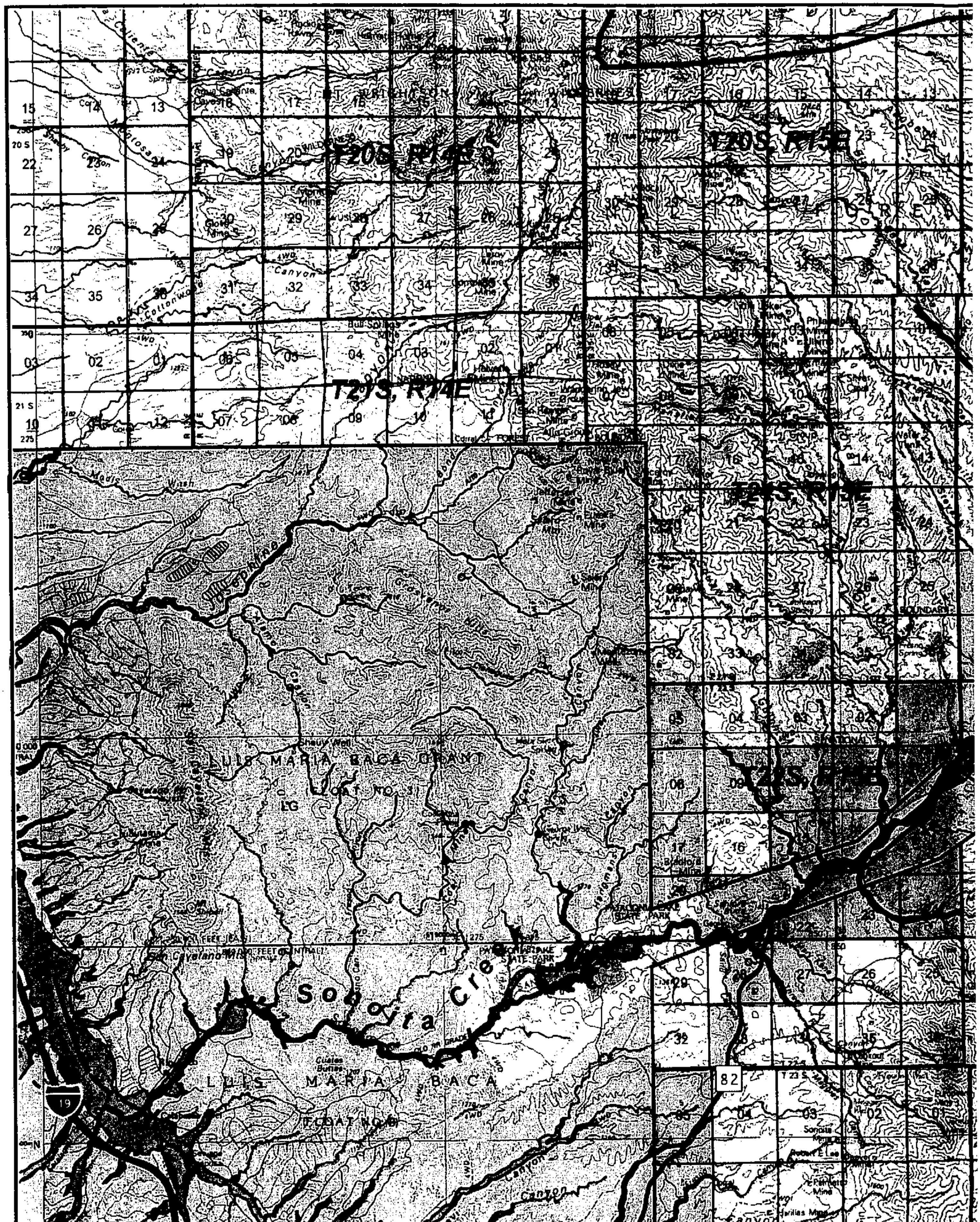


Vicinity Map

SONOITA CREEK NAVIGABILITY STUDY
Land Ownership Map

Prepared for: Arizona State Land Department
By: JE FULLER HYDROLOGY & GEOMORPHOLOGY, INC.

June 2000



T20S, R14E
T20S, R15E
T21S, R14E
T21S, R15E
LUIS MARIA BACA GRANT
FLOAT NO. 3
Sonoita Creek
LUIS MARIA BACA
82
19

Separator Page To Facilitate Scanning

APPENDIX C-2

USGS STREAMFLOW DATA

09484560 CIENEGA CREEK NEAR PANTANO, AZ

LOCATION.--Lat 31°59'08", long 110°33'57", NW1/4 sec.1, T.17 S., R.17 E., Pima County, Hydrologic Unit 15050302, on downstream end of first pier from right bank of bridge on Interstate Highway 10, and 1.2 mi southeast of Pantano.
DRAINAGE AREA.--289 mi^2.

Annual peak discharges

Water year	Date	Annual peak discharge (ft^3/s)	Discharge codes	Water year	Date	Annual peak discharge (ft^3/s)	Discharge codes
1958	08-11-58	20,000	ES,HP	1975	09-02-75	1,550	
1968	07-26-68	1,870		1976	08-10-76	4,650	
1969	07-22-69	990		1977	09-11-77	3,800	
1970	07-20-70	1,770		1978	10-06-77	900	
1971	08-03-71	2,240		1979	08-12-79	860	
1972	09-13-72	1,930		1980	09-07-80	630	
1973	02-22-73	878		1981	07-06-81	8,310	
1974	07-19-74	2,570					

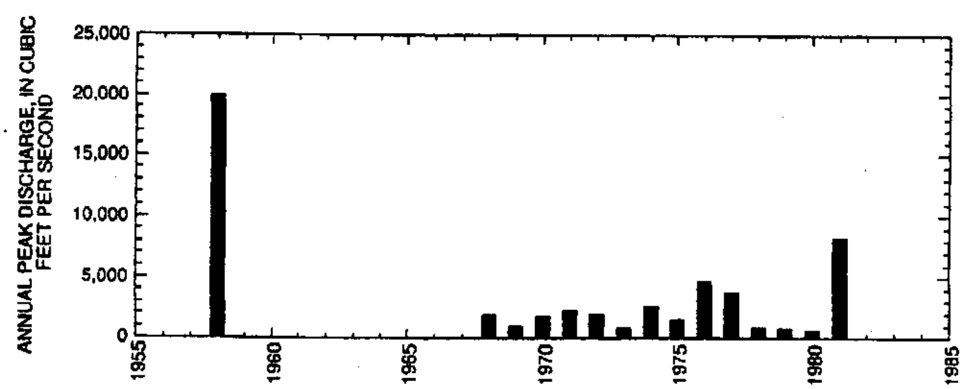
Magnitude and probability of instantaneous peak flow based on period of record 1958, 1968-81

Discharge, in ft^3/s, for indicated recurrence interval in years, and exceedance probability, in percent					
2 50%	5 20%	10 10%	25 4%	50† 2%	100† 1%
1,880	4,020	6,150	9,930	13,700	18,500
Weighted skew	(logs) =	0.36			
Mean	(logs) =	2.30			
Standard dev.	(logs) =	0.37			

† Reliability of values in column is uncertain, and potential errors are large.

Basin characteristics

Main channel slope (ft/mi)	Stream length (mi)	Mean basin elevation (ft)	Forested area (percent)	Soil index	Mean annual precipitation (in)	Rainfall intensity, 24-hour: 2-year (in)	Rainfall intensity, 24-hour: 50-year (in)
59.8	31.2	4,890	13.0	2.5	16.6	1.9	4.1



09484600 PANTANO WASH NEAR VAIL, AZ

LOCATION.--Lat 32°02'09", long 110°40'37", in SW¹/₄SE¹/₄ sec.14, T.16 S., R.16 E., Pima County, Hydrologic Unit 15050302, on right bank 60 ft upstream from dam, 2.2 mi southeast of Vail, and 20 mi southeast of Tucson City Hall.

DRAINAGE AREA.--457 mi^2.

PERIOD OF RECORD.--January 1959 to September 1974, water years 1975-89 (annual maximums only), October 1989 to current year.

GAGE.--Water-stage recorder and concrete weir. Elevation of gage is 3,205 ft above sea level, from topographic map. January 1959 to September 1974 (water-stage recorder) and October 1974 to September 1989 (crest-stage gage) at same site and datum.

REMARKS.--Records poor. No known diversion above station. Records published herein represent flow by gage. Infiltration flow is not included. Base runoff past gage station consists of downvalley underflow that is brought to the surface by the concrete dam 60 ft downstream which extends to bedrock.

EXTREMES FOR PERIOD OF RECORD.--Maximum discharge, 12,000 ft^3/s Oct. 1 or 2, 1983, gage height, 15.25 ft, from inside high-water mark, from rating curve extended above 2,000 ft^3/s on basis of slope-area measurements at gage heights 10.9 and 24 ft; no flow June 26 to July 13, Aug. 7, 1971, result of work on infiltration gallery, June 27 to July 13, 1973, result of ponding during construction work on dam, and May 28 to June 12, July 12, 13, 17, 18, 1974.

EXTREMES OUTSIDE PERIOD OF RECORD.--Maximum discharge since at least 1930, about 38,000 ft^3/s, Aug. 11, 1958, gage height, about 24 ft, from floodmark, from slope-area measurement.

Annual peak discharges

Water year	Date	Annual peak discharge (ft^3/s)	Discharge codes	Water year	Date	Annual peak discharge (ft^3/s)	Discharge codes
1958	08-11-58	[1]38,000	ES,HP	1978	10-06-77	1,300	
1959	08-17-59	9,310		1979	12-18-78	790	
1960	08-09-60	7,300		1980	09-07-80	1,300	
1961	08-28-61	5,280		1981	09-22-81	13,000	
1962	09-26-62	1,500		1982	08-23-82	3,400	
1963	08-25-63	9,700		1983	08-03-83	1,840	
1964	09-10-64	9,960		1984	10-02-83	12,000	
1965	09-12-65	5,880		1985	08-20-85	363	
1966	08-13-66	7,410		1986	08-17-86	1,020	
1967	08-18-67	7,680		1987	09-24-87	1,370	
1968	12-20-67	2,640		1988	07-29-88	7,420	
1969	08-05-69	857		1989	07-21-89	803	
1970	07-20-70	6,850		1990	07-24-90	3,960	
1971	08-19-71	8,700		1991	03-02-91	129	
1972	09-07-72	1,460		1992	07-10-92	834	
1973	10-04-72	371		1993	07-11-93	1,840	
1974	07-20-74	1,780		1994	09-11-94	2,370	
1975	09-02-75	1,200		1995	01-05-95	650	
1976	07-25-76	5,200		1996	09-01-96	2,250	
1977	09-10-77	1,600					

[1]Highest since 1930.

Discharge rating table developed October 1992

Gage height (ft)	Discharge (ft^3/s)	Gage height (ft)	Discharge (ft^3/s)
6.0	558	10.0	3,520
6.5	818	11.0	4,600
7.0	1,100	12.0	5,790
8.0	1,770	13.0	7,110
9.0	2,580	13.7	8,100

09484600 PANTANO WASH NEAR VAIL, AZ--Continued

Basin characteristics

Main channel slope (ft/mi)	Stream length (mi)	Mean basin elevation (ft)	Forested area (percent)	Soil index	Mean annual precipitation (in)	Rainfall intensity, 24-hour	
						2-year (in)	50-year (in)
46.3	43.5	4,500	15.0	1.75	15.4	1.9	2.9

09484600 PANTANO WASH NEAR VAIL, AZ--Continued

MEAN MONTHLY AND ANNUAL DISCHARGES 1960-74, 1990-96

MONTH	MAXIMUM (FT3/S)	MINIMUM (FT3/S)	MEAN (FT3/S)	STANDARD DEVIATION (FT3/S)	COEFFICIENT OF VARIATION	PERCENT OF ANNUAL RUNOFF
OCTOBER	6.7	0.10	1.9	1.9	1.0	2.5
NOVEMBER	3.0	0.10	1.2	0.73	0.59	1.7
DECEMBER	50	0.10	6.4	14	2.1	8.7
JANUARY	111	0.10	8.4	24	2.8	11.3
FEBRUARY	36	0.10	4.7	7.9	1.7	6.4
MARCH	18	0.12	3.4	3.9	1.2	4.6
APRIL	5.2	0.32	2.1	1.3	0.62	2.8
MAY	2.0	0.19	1.3	0.48	0.37	1.7
JUNE	3.6	0.07	1.2	0.83	0.68	1.6
JULY	50	0.66	12	14	1.2	16.0
AUGUST	93	0.52	20	26	1.3	27.0
SEPTEMBER	105	0.16	12	21	1.8	15.7
ANNUAL	13	1.8	6.2	3.8	0.61	100

MAGNITUDE AND PROBABILITY OF ANNUAL LOW FLOW
BASED ON PERIOD OF RECORD 1960-74, 1991-96

PERIOD (CONSECUTIVE DAYS)	DISCHARGE, IN FT3/S, FOR INDICATED RECURRENCE INTERVAL, IN YEARS, AND NON-EXCEEDANCE PROBABILITY, IN PERCENT					
	2 50%	5 20%	10 10%	20 5%	50# 2%	100# 1%
1	0.43	0.19	0.06	0.00	0.00	0.00
3	0.46	0.20	0.05	0.00	0.00	0.00
7	0.54	0.23	0.05	0.00	0.00	0.00
14	0.61	0.31	0.11	0.00	0.00	0.00
30	0.69	0.36	0.23	0.16	0.09	0.06
60	0.82	0.44	0.29	0.19	0.11	0.08
90	1.0	0.58	0.37	0.24	0.13	0.08
120	1.4	0.65	0.40	0.26	0.15	0.10
183	2.1	0.86	0.49	0.29	0.15	0.09

MAGNITUDE AND PROBABILITY OF INSTANTANEOUS PEAK FLOW
BASED ON PERIOD OF RECORD 1958-96

DISCHARGE, IN FT3/S, FOR INDICATED RECURRENCE INTERVAL IN YEARS, AND EXCEEDANCE PROBABILITY, IN PERCENT					
2 50%	5 20%	10 10%	25 4%	50 2%	100 1%
2,600	6,450	10,400	17,200	23,900	32,100

WEIGHTED SKEW (LOGS) = 0.00
MEAN (LOGS) = 3.41
STANDARD DEV. (LOGS) = 0.47

MAGNITUDE AND PROBABILITY OF ANNUAL HIGH FLOW
BASED ON PERIOD OF RECORD 1960-74, 1990-96

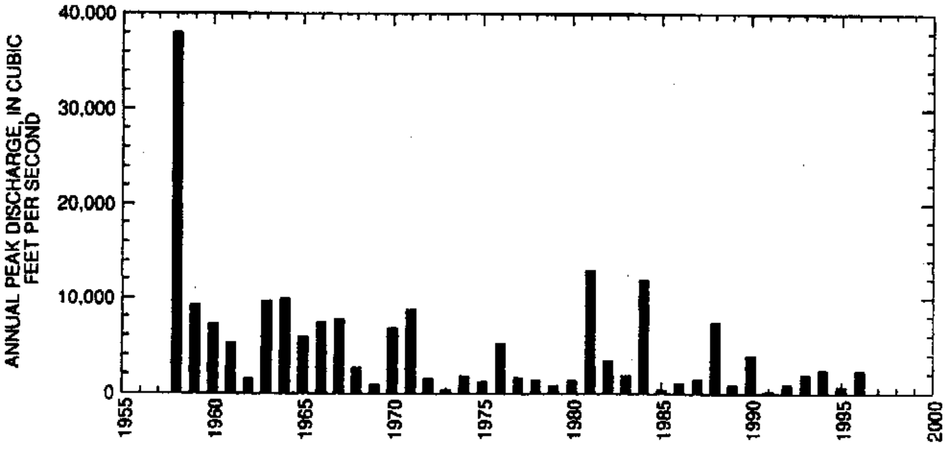
PERIOD (CONSECUTIVE DAYS)	DISCHARGE, IN FT3/S, FOR INDICATED RECURRENCE INTERVAL, IN YEARS, AND EXCEEDANCE PROBABILITY, IN PERCENT					
	2 50%	5 20%	10 10%	25 4%	50# 2%	100# 1%
1	300	655	983	1,510	1,990	2,550
3	144	317	478	740	979	1,260
7	76	168	254	394	522	673
15	46	102	156	244	326	424
30	30	64	93	139	179	225
60	19	39	55	81	102	126
90	14	29	40	57	70	85

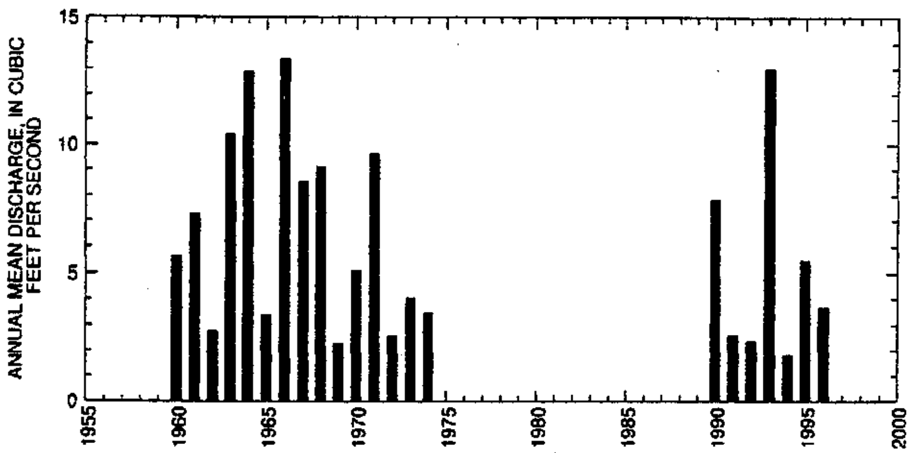
DURATION TABLE OF DAILY MEAN FLOW FOR PERIOD OF RECORD 1960-74, 1990-96

DISCHARGE, IN FT3/S, WHICH WAS EQUALED OR EXCEEDED FOR INDICATED PERCENT OF TIME																
1%	5%	10%	15%	20%	30%	40%	50%	60%	70%	80%	90%	95%	98%	99%	99.5%	99.9%
130	15	4.7	3.3	2.7	2.0	1.6	1.4	1.2	0.93	0.71	0.43	0.22	0.09	0.08	0.00	0.00

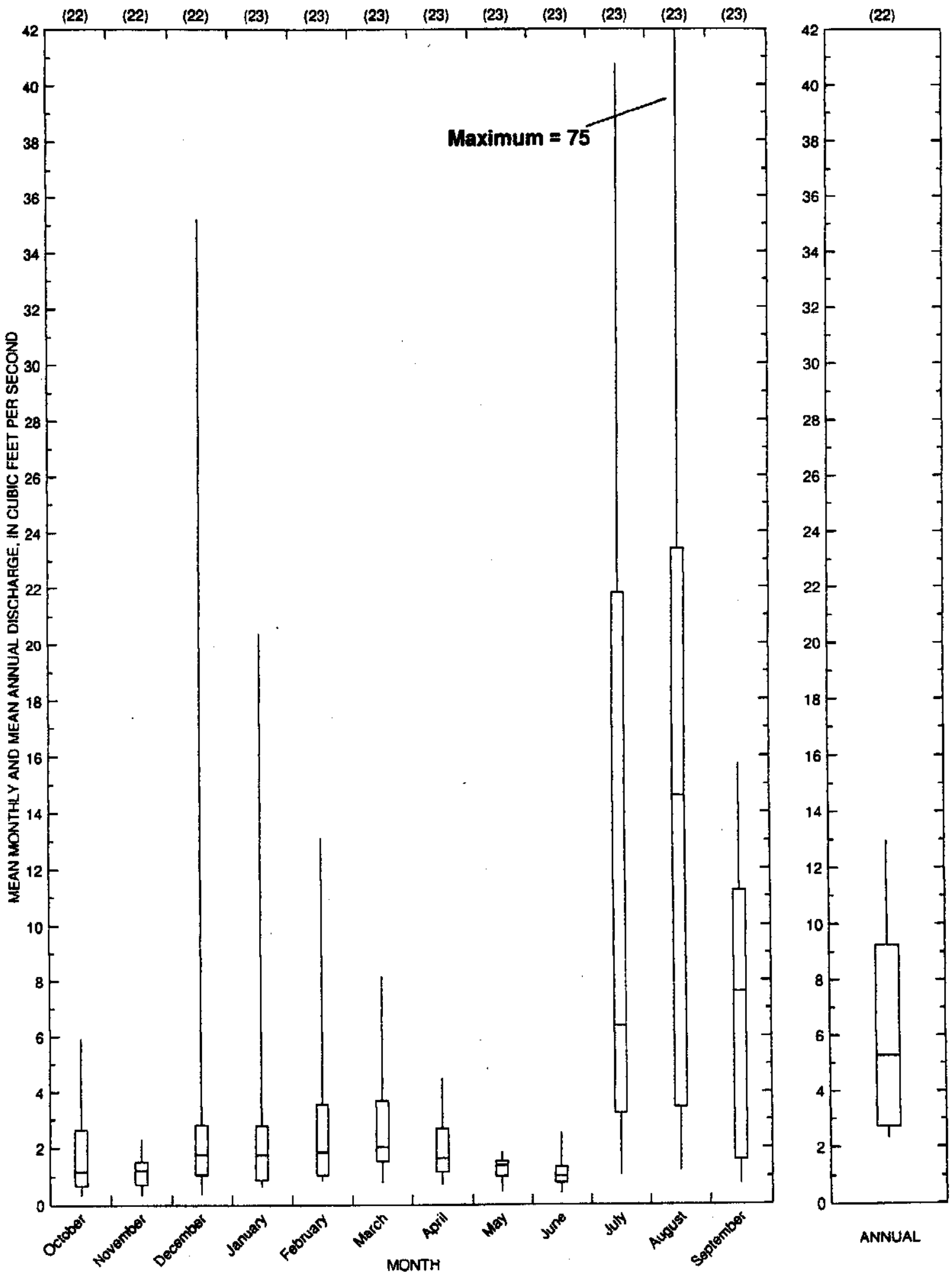
Reliability of values in column is uncertain, and potential errors are large.

09484600 PANTANO WASH NEAR VAIL, AZ--Continued





09484600 PANTANO WASH NEAR VAIL, AZ--Continued



PROJ: ASLD/Nav/Cienega Creek
DETAIL: Estimated Hydraulic Parameters

Hydraulic Parameters were estimated using observed minimum and maximum stream widths and assuming a rectangular section and overall valley slope to perform a Manning's rating for both the minimum and maximum observed stream widths.
The sections were rated for flow exceedance values from USGS gage no: 9484600

Observed minimum stream width (typical) =	6	feet
Observed maximum stream width (typical) =	20	feet
Overall stream slope =	46.3	feet/mile
	0.0088	feet/feet
Assumed Manning's roughness coeff (n) =	0.04	

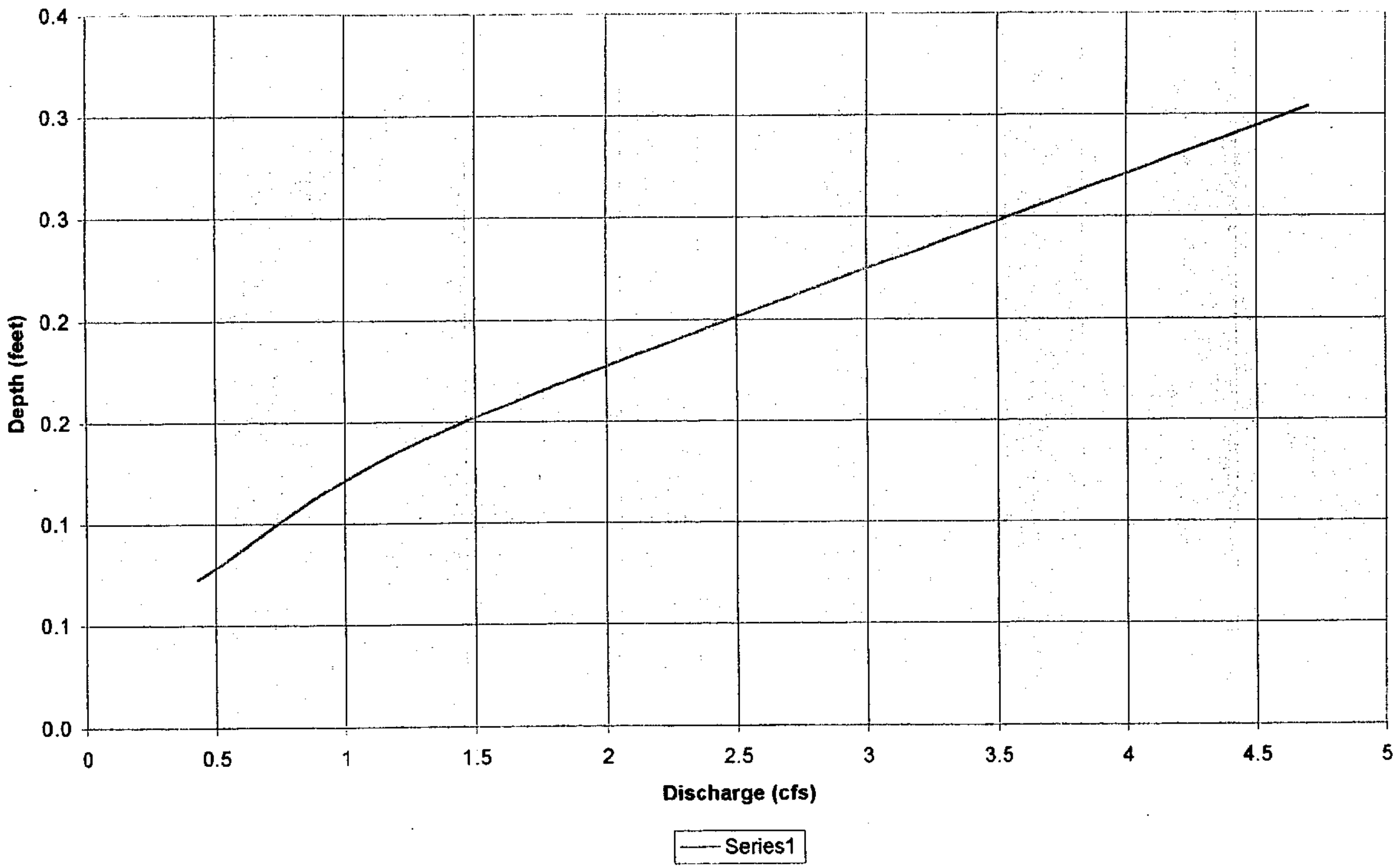
Estimated Hydraulic Parameters

Flow Exceedance (%)	Discharge (cfs)	Min. Width Depth (feet)	Hydraulic Parameters Velocity (ft/s)	Width (feet)
10	4.7	0.4	1.9	6
50	1.4	0.2	1.2	6
90	0.43	0.1	0.7	6

Flow Exceedance (%)	Discharge (cfs)	Max. Width Depth (feet)	Hydraulic Parameters Velocity (ft/s)	Width (feet)
10	4.7	0.2	1.2	20
50	1.4	0.1	0.7	20
90	0.43	0.0	0.5	20

Flow Exceedance (%)	Discharge (cfs)	Average Hydraulic Parameters Depth (feet)	Velocity (ft/s)	Width (feet)
10	4.7	0.3	1.6	13
50	1.4	0.1	1.0	13
90	0.43	0.1	0.6	13

Cienega Creek Rating Curve



APPENDIX C-3

ANECDOTAL AND HISTORICAL REFERENCES

Cienega Creek Anecdotal Citations list

Dowell, Gregory Paul, 1978, "History of the Empire Ranch", Masters Thesis, University of Arizona.

This work is cited in the report. I've enclosed the portion of the book which I copied. Page 42 describes how water was pumped from Cienega Creek to the Total Wreck Mine (discussed on page 12 of the report).

Eddy, Frank M., 1958, "A Sequence of Cultural and Alluvial Deposits in the Cienega Creek Basin, Southeastern Arizona", Masters Thesis, University of Arizona.

This work is cited in the report. I've enclosed the portion of the book which I copied. Page 12 refers to the Cienega creek as a "permanent stream".

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

This work is cited in the report. Page 1 provides a brief description of the pre-1900 condition of the streams in the Cienega Valley (attached).

Heffner, Harry L., 1960, "Reminiscences about Empire Ranch", Transcript from a tape recording of Heffner's experiences as manager of the Empire Ranch, as told to Charles U. Pickrell, Tucson, Arizona.

I made hand written notes on the following two pages (which are never specifically mentioned in the text of the report):

Pages 5: Heffner states that "Vail Station is where water of the Cienega disappeared Into the sands then back up again to the Rillito."

Page 13: Heffner states that "nobody pumped water in those days. Land wasn't considered worth anything unless it had a spring or running water."

Smith, George E.P., 1911, "La Cienega Sub-Surface Dam", Engineering & Contracting Magazine, July 26, 1911 issue, pages 110-111

This article describes the sub-surface dam described on page 12 and 13 of the report and is where the descriptions of the base flow at the dam come from. A copy of the article is attached.

HISTORY OF THE EMPIRE RANCH

by

Gregory Paul Dowell

A Thesis Submitted to the Faculty of the

DEPARTMENT OF HISTORY

In Partial Fulfillment of the Requirements
For the Degree of

MASTER OF ARTS

In the Graduate College

THE UNIVERSITY OF ARIZONA

1 9 7 8

CHAPTER 1

WALTER VAIL AND THE FOUNDING OF THE EMPIRE

On July 13, 1876, two youthful adventurers stepped off a stage a Tucson, Arizona Territory. Walter Lennox Vail and Herbert R. Hislop had known one another for less than a month. Although they had no experience in livestock, they invested in a small ranch fifty-two miles southeast of Tucson. The novice stockmen quickly turned their energies to building a herd, locating markets for beef, and seeking new acreage with adequate water. At a time when other pioneer ranchers failed to adapt to maurading Apaches, tight finances, and the harsh climate, Vail and Hislop successfully established the foundations for a great cattle empire.

The grasslands bordering the valleys of southeastern Arizona were well-suited for cattle raising. Heavy stands of grama, sacaton, and salt grasses formed a near-continuous covering along the mesas, draws, and foothills. The region also was covered with a scattered growth of mesquite, palo verde, and prickly pear cactus, all of which served as additional forage during dry seasons.[1]

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[1] J. J. Thornber, The Grazing Ranges of Arizona (Tucson: University of Arizona Agricultural Experiment Station, Bulletin 65, 1910), pp. 265, 268, 270, 275, 334.

Of the three primary valleys in the area, the Cienega was the smallest and the last to be used for ranching. This valley occupies a broad rolling tract bounded on the north by the Rincon Mountains, on the south by the Huachucas, on the east by the Whetstone Mountains, and on the west by the Santa Rita range. Cienega Creek ran north through the vast basin, emptying into Pantano Wash at the foot of the Rincons. The land was watered by seasonal rainfall and springs along the base of the Santa Ritas. Scattered natural reservoirs in the foothills trapped additional water after infrequent rains. The valley sloped gently downward from an elevation of 4,500 feet near the Huachucas to 3,200 feet at Pantano Wash. Like the Santa Cruz and San Pedro valleys, to the east and west respectively, the Cienega's stands of perennial and seasonal foliage provided ample year-round forage for the support of livestock.[2]

Beginning with their earliest explorations, the Spaniards had been impressed with the stock raising potential of this region. Between 1687 to 1710, Eusebio Francisco Kino, a Jesuit missionary explorer, drove herds into the valleys and founded a cattle industry here among the Piman speaking natives. With Mission Dolores as a base of operations, he supplied beef for exploration and missionary

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[2]J. J. Wagoner, History of the Cattle Industry in Southern Arizona (Tucson: University of Arizona, 1952), p. 41.

outposts as far north as the Gila River. From these seminal herds, a network of thriving _rancherias_ (stock ranches) were established under Kino's supervision at the villages of Quiburi, Tumacacori, San Xavier del Bac, Guebavi, Sonoita, and elsewhere. In 1699, Kino delivered 150 head of cattle from the Dolores herd to the _rancheria_ Sonoita located near the headwaters of Cienega Creek. In the course of his six trips through the region of the Pimas, Father Kino directed the movement of over six thousand cattle to the patchwork of Jesuit missions and the ranches that supported them. Following Kino's death in 1711, cattle-raising languished.[3]

Despite the establishment of military garrisons at Tubac (1752) and Tucson (1776), attempts at stockraising in the southern valleys were unsuccessful until the early 1780s. The resumption of ranching followed vigorous military efforts to control hostile Indians. The relative peace that ensued encouraged a wave of mining, and Spaniards entered the Santa Cruz, Cienega, and San Pedro Valleys to raise beef for the miners. Stock raisers petitioned the

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[3]Wagoner, _Cattle Industry_, 10, 24; Herbert Eugene Bolton, _Kino's Historical Memoir of the Pimería Alta_ (2 vols., Cleveland: The Arthur H. Clark Company, 1919), I, p. 57.

crown for vast tracts of land, and by 1785, thousands of hardy Andalusian cattle roamed on these royal grants.[4]

However, several decades of peace and ranching prosperity on the frontier ended during the Mexican drive for independence from Spain, in the 1820s. Apache raiding caused ranchers to abandon their herds and flee to Tucson and Tubac for safety. Despite the danger of attack, several ranchers revived their operations and others started new ventures on Mexican land grants. Prominent among these haciendas were the San Rafael de la Zanja near Tubac, the San Jose de Sonoita south of the Santa Ritas, and the San Ignacio del Babocomari in Cienega Valley. From 1831 to 1850, however, Apache raiding escalated and ranchers moved away. Abandoned cattle scattered along the valleys and reverted to a wild state. As late as 1846, wild herds roamed in large numbers. In December, the Mormon Battalion, marching from Santa Fe to California, battled several bulls who attacked their wagons in the San Pedro Valley near present-day Charleston.[5]

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[4] Hubert Howe Bancroft, History of Arizona and New Mexico, 1530-1888 (San Francisco: The History Company, (1889), p. 382; Richard J. Morrisey, "History of the Cattle Industry in Arizona" (M.A. thesis, University of California, 1941), p. 12; Rufus Kay Wyllys, Arizona: The History of a Frontier State (Phoenix: Hobson & Herr, 1950), p. 62.

[5] Bert Haskett, "Early History of the Cattle Industry," Arizona Historical Review [AHR], VI October 1935), p. 6; Richard J. Morrisey, "The Early Range Cattle Industry in Arizona," Agricultural History, XXIV (July 1950), p. 151; Wagoner, Cattle Industry, pp. 24-29.

When the California Gold Rush drew emigrant parties through the Southwest, they found few ranches operating in the southern valleys. Booming prices in California prompted a number of trail drives from Texas, but the drovers passed quickly through Apache country. When the region passed into American hands with the Gadsden Purchase in 1854, only a few Mexican families had cattle, most of which were clustered near Tubac. Ranching picked up in 1857, when the army stationed troops at Fort Buchanan on Sonoita Creek to protect the new mining activity near Tubac. Families located in the Cienega Valley and Santa Cruz Valley to supply beef to the garrison. William C. Wordsworth ran a small ranch seven miles north of Fort Buchanan, carrying on a lucrative trade with the army and nearby mining encampments. In 1859, William S. Grant received the government contract to supply beef to all the troops in Arizona, but the outbreak of the Civil War caused him to go bankrupt.[6]

The Civil War brought temporary ruin to the cattle trade. In 1861 the army withdrew all federal troops from

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[6]Richard H. Williams, "History of Livestock in Arizona," Arizona, VI (September 1916), pp. 6, 15; Morrisey, "History of the Cattle Industry," pp. 19, 26, 27; Wagoner, Cattle Industry, p. 31; Gilbert J. Pederson, "A Yankee in Arizona: The Misfortunes of William S. Grant, 1860-1861," Journal of Arizona History [JAH], XVI (Summer 1975), pp. 127, 132; Constance Wynn Alsthuler, Latest From Arizona: The Hesperian Letters, 1859-1861 (Tucson: Arizona Pioneers' Historical Society, 1969), p. 121.

Arizona; and ranchers abandoned the Sonoita, San Pedro and Santa Cruz valleys. However, with the arrival of the California Volunteers, small scale ranching sprung to life in the southern valleys. With the establishment of a garrison at Fort Crittenden (near old Buchanan), operators located on the Sonoita again to supply fresh beef.[7]

After the Civil War, several factors favored the establishment of permanent ranches south of Tucson. Drovers from California and Texas trailed large herds into the region to supply the military. One drover, Thomas Hughes, started his Pennsylvania Ranch in 1869 near Camp Crittenden in the southern extreme of Cienega Valley. Tully & Ochoa located herds south of the Rincons, near Pantano Wash. At the same time, the federal government sought to resolve local Indian problems. By executive order, President Grant on December 14, 1872, created a reservation for the Chiricahua Apaches east of the Dragoon Mountains. This stimulated a large demand for beef. Although small renegade bands continued to prey on settlers, the Apache threat appeared ended. Coupled with these events, the Southern Pacific Railroad began laying track east from Los Angeles in 1874 toward Yuma, intent upon tapping the mineral resources of Arizona. News of the railroad raised the prospect of

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[7]Haskett, "Cattle Industry," AHR, VI, p. 12; Wyllys, Arizona, pp. 149, 158.

economic prosperity and induced more settlers to try their hand at ranching in the southern part of the territory.[8]

Cienega Valley soon showed signs of extensive settlement. L. A. Hardin, of the Tucson cattle firm of Hardin & Martin, located five thousand head at the mouth of the Cienega near the Rincons. A few miles to the south, D. A. Sanford ran a substantial herd of sheep and cattle on his Meadow Valley Ranch. Tucson merchant, E. N. Fish, also maintained a herd on the Cienega, twelve miles north of Camp Crittenden. Since profits seemed assured by the heavy government demand for beef, Arizona's cattle industry drew widespread attention.[9]

Walter L. Vail, an Easterner, was one of many attracted to the burgeoning livestock trade in the Southwest. Born in Liverpool, Nova Scotia, on May 15, 1852, Vail spent most of his childhood on the family's 160-acre farm near

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[8]Wagoner, Cattle Industry, pp. 33-34; Harry G. Cramer III, "Tom Jeffords--Indian Agent," JAH, XVII (Autumn 1976), pp. 265-267; David F. Myrick, Railroads of Arizona, Vol. 1: The Southern Roads (Berkeley: Howell-North Books, 1975), p. 16. Construction of Camp Crittenden was authorized on March 4, 1868, to replace the unhealthy and poorly located Fort Buchanan. Constance W. Alsthuler, "The Naming of Camp Crittenden," JAH, VII (Summer 1967), p. 141.

[9]Tucson Citizen, May 23, August 22, 1974; Wagoner, Cattle Industry, p. 38; Haskett, "Cattle Industry," AHR, VI, pp. 25-26; A.P.K. Safford, "Message of the Governor to the Eighth Legislative Assembly," Journals of the Eighth Legislative Assembly of the Territory of Arizona (Tucson Office of the Arizona Citizen, 1875), pp. 37-38.

Vail, and together they continued west to California. Soon after meeting Walter Vail, they planned a trip to Arizona.[14]

Vail and Hislop left Los Angeles by stage on July 5, 1876, and arrived in Tucson eight days later. They presented a letter of introduction from Nathan Vail to a family friend, Governor Anson P. K. Safford, who advised them about various ranches for sale around Tucson. Vail and Hislop spent a month visiting local ranches, including the Fish and Silverberg holdings Walter had seen the previous year. They narrowed the choice down to three attractive properties: Fish and Silverberg's ranch along Empire Gulch in Cienega Valley, the Rincon Ranch owned by Joaquin Tellez, and Charley Paige's Happy Valley Ranch on the eastern slope of the Rincon Mountains.[15]

On August 22 Vail and Hislop purchased Fish and Silverberg's Empire Ranch and its 612 head of cattle. E. N. Fish, a Tucson hardware merchant and land promoter, and his business partner Simon Silverberg, acquired the 160-acre

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[14]Edward Vail, "Ranch Reminiscences," manuscript of a speech presented at the Pioneers' Meeting, December 29, 1926, Tucson, Folder 7, Box 1, Vail Papers, AHS; Herbert R. Hislop to Amy Hislop, July 31, 1876, in Bernard L. Fontana (ed.), An Englishman's Arizona: The Ranching Letters of Herbert R. Hislop, 1876-1878 (Tucson: The Overland Press, 1965), p. 13. Fontana provides a wealth of information on Herbert Hislop's family background, based on information from Mrs. John H. Hislop, the widow of Herbert's son.

[15]Herbert R. Hislop to Amy Hislop, July 3, September 23, 1876; Herbert R. Hislop to Edith Hislop, August 7, 1876, in Fontana (ed.), An Englishman's Arizona, pp. 17, 27-30, 35.

tract only two months earlier from Fish's brother-in-law, William Wakefield, at a price of $500. The merchants wanted $3,800 for the ranch and cattle, but to expedite the sale, they settled on a considerably lower price of $1,174. Walter Vail asked Nathan for a loan to pay his half of the investment[16] (see Fig. 1, for ranch location).

The Empire lay fifty-two miles southeast of Tucson on the eastern slope of the Santa Rita Mountains. The property overlooked a shallow depression called Empire Gulch, through which a spring-fed rivlet bordered by cottonwoods coursed eastward to Cienega Creek. Included were meadows thickly covered with sacaton and salt grass, a dependable water supply, a thick-walled adobe ranchouse to ward off the harsh Arizona climate, and a large corral with a heavy gate to protect against "Apaches or other horse thieves." Writing to Nathan Vail on July 18, Hislop expressed enthusiasm over the ranch:

> I like it very much; it reminds me of Brighton Downs, as it is very much the same sort of country and there seems to be plenty of water about it. The house might be made very comfortable indeed with

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[16]William Wakefield to Edward N. Fish and Simon Silverberg, June 19, 1876, Real Estate Deeds, Book 2, pp. 502-503, Pima County Recorder's Office, Tucson; E. N. Fish and Simon Silverberg to Walter L. Vail and Herbert R. Heslop [sic], August 22, 1876 (deed), Folder 1, Box 1, Empire Ranch Papers [ERP], Special Collections, University of Arizona Library [UAL]; Herbert R. Hislop to Nathan Vail, July 18, 1876, Box 2, Vail Papers, AHS.

laying out a little money on it. It is nicely situated on an elevation, and has a very nice corral.[17]

The origin of the name Empire Ranch remains unclear. Edward Vail claimed that Walter re-named the Fish holdings after their purchase in 1876, claiming "he would make an Empire of it someday." However, in writing to his sister on November 25 of that year, Herbert Hislop stated: ". . . it was called the Empire Ranch before we bought it and we have not altered the name." Other accounts suggest that either Fish called the quarter-section spread "the Empire" in a promotional flurry to make it more attractive, or that Wakefield named the ranch after the nearby Empire Mountains. Certainly, the evidence weighs against Edward Vail's romanticized version.[18]

The ranch house hardly resembled a structure befitting the title "Empire." The four-room adobe building lacked windows and doors, had no furnishings, and was in need of plastering when Vail and Hislop moved in. During their first four months there, they undertook nearly all improvements themselves in order to avoid the high wages demanded by Tucson's carpenters.

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[17]Herbert R. Hislop to Nathan Vail, July 18, 1876, Box 2; Edward Vail, "Empire Story," Folder 7, Box 1, Vail Papers, AHS.

[18]Edward Vail, "Empire Story," Folder 7, Box 1, Vail Papers, AHS; Herbert Hislop to Amy Hislop, November 25, 1876, in Fontana (ed.), An Englishman's Arizona, pp. x, 45; Will C. Barnes, Arizona Place Names (Tucson: University of Arizona, 1935), p. 146.

They did, however, hire two Indians to plaster the thick adobe walls of the corral and ranch house. The sturdy corral enclosed a 100-square foot area and was connected to the rear of the ranch building. An entry way eighteen-feet wide ran between the four rooms of the house and provided the only access to the corral. A heavy gate at the end of the corridor secured their horses from Apache thievery. Vail and Hislop well-understood the value of good riding stock to range management, and that recurring losses could mean the difference between success and failure. Consequently, they rounded up their horses nightly and kept them locked in the corral.[19]

The most attractive asset of the ranch was the dependable watercourse through the property. Near the western perimeter of the property, several large springs poured a constant flow of fresh water into Empire Gulch. Wishing to "claim" the pasture and foothills lying back of the stream, Vail and Hislop, like other ranchers, "appropriated" the

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[19]Herbert Hislop to Amy Hislop, August 7, September 23, October 22, 1876, in Fontana (ed.), An Englishman's Arizona, pp. 28-29, 37-39, 43, 46; Edward Vail, "Empire Story," Folder 7, Box 1; Watler Vail to Edward Vail, March 24, 1877, Box 2, Vail Papers, AHS; Harry L. Heffner to Charles U. Pickrell, typescript interview, June 4, 1960, Special Collections, UAL.

Pennsylvania, to negotiate for the leasehold--but quickly called him back. Walter and Nathan Vail had turned to an alternate scheme that would benefit both the Total Wreck and the Empire Ranch.[16]

On November 10, Walter Vail purchased the nearby Meadow Valley Ranch from Don A. Sanford for eighty thousand dollars. The purchase extended the Empire's cattle range five miles farther north along Cienega Creek and doubled the size of the ranch. They installed a powerful forty horsepower pump on Cienega Creek, two miles southeast of the Total Wreck, and ran a six-inch iron pipeline from the pump to an elevated area east of the mining camp. Here, the company erected two fifty thousand gallon redwood tanks, which furnished ample water for both the mill and the camp.[17]

As the water system neared completion, the mining camp enjoyed a boom. The company extended a tunnel from the 200-foot level to the surface on the side of the hill nearest the mill. Workers sunk the main shaft to 350 feet and started on three new levels in the mine. Aboveground,

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[16] Edward Vail, "Story of a Mine," pp. 8-9, Folder 7, Box 1, Vail Papers, AHS; Mining and Scientific Press (San Francisco), October 14, 1882, p. 245; Tucson Weekly Citizen, May 21, 1882. Prior to completion of the pipeline from Cienega Creek, all of Total Wreck Camp's water needs were served by a mule-drawn tank wagon, driven by Edward Vail's boyhood friend Philip Moore. Edward Vail, "Story of a Mine," p. 13, Folder 7, Box 1, Vail Papers, AHS.

[17] Tombstone Weekly Epitaph, November 13, 1882; Tucson Weekly Citizen, November 13, 1882; Edward Vail, "Story of a Mine," pp. 8-9, Folder 7, Box 1, Vail Papers, AHS.

Richardson sold his interest to another prominent rancher, Oscar T. Ashburn. Together, Vail and Ashburn placed several thousand Empire yearlings on this eastern range, then sold them as three-year-old steers to feeder operations in Montana. Besides acquiring the Whetstone and San Pedro range, Vail, on March 21, 1887, purchased the Mary Kane Ranch located four miles southwest of the Empire. The Kane property completed Vail's control over the remaining pastureland between Empire Gulch and Old Camp Crittenden to the south.[29]

Although newly acquired land helped forestall the effects of overstocking, Vail needed further relief if the Empire range was to be preserved. The fragile groundcover could not continue to support his twenty-three thousand cattle, especially if calve production remained at four thousand per year. Range crowding became so bad that a flash flood in July of 1887 drowned over one hundred cattle that could not escape the flood-swollen Cienega Wash. Vail stepped up shipments to pastures in the Salt River Valley, but

[29] Articles of Incorporation, Whetstone and San Pedro Land and Cattle Company, Pima County Recorder's Office, Tucson; Harry L. Heffner to Mary Boice, February 5, 1954, Heffner Papers, UAL; Arizona and Its Resources, p. 53; "Edward Vail Reminiscences," Folder 7, Box 1, Vail Papers, AHS. Richardson arrived in Arizona in 1880 and engaged in mining in Cochise County. He later turned to ranching on the Santa Cruz River, acquiring the Rancho San Rafael de la Zanja land grant. Oscar F. Ashburn came from Ohio in 1874 and operated the Salero Ranch on Sonoita Creek. In 1884 he relocated on the San Pedro River, below Benson. "Autobiography of Rollin Rice Richardson," AHS.

CHAPTER 4

THE RISE TO CORPORATE MATURITY

A serious drought gripped southern Arizona during the early 1890s, forcing the owners of the Empire Ranch to make heroic decisions concerning their breeding and marketing operations. In an attempt to preserve thinning range-cover, Vail and Gates shipped additional cattle by rail to leased pastures in California. As the drought worsened, deteriorating ranges hastened the Empire's final shift to a breeder operation, sending its young stock to fatten outside the Territory. When the Southern Pacific raised its rates, Vail and Gates defied the railroad's presumed monopoly over livestock transit by conducting a successful trail drive to San Diego. To guard dwindling financial reserves and secure more acreage, the Empire joined with another Arizona ranch, the Chiricahua Cattle Company, in organizing a subsidiary cattle company for the purpose of obtaining rangeland in Oklahoma and the Panhandle of Texas. By 1897, when Vail and Gates moved their business headquarters to the financial centers of Los Angeles and Kansas City, the Empire Land and Cattle Company had achieved corporate maturity.

As overstocking increased in the late 1880s, Vail and Gates had begun shipping more yearlings and two-year-olds

By 1902 Walter Vail and Carroll Gates were absorbed largely by California affairs. From the standpoint of management, the Empire Ranch entered into a static period of operations, with no significant changes in approach to regular breeding and sales. For the most part, ranch foreman Harry L. Heffner oversaw the affairs of the home ranch in Arizona, selecting which ranges to stock and which cattle to market. Vail and Gates determined where and at what prices the livestock sold.

Between 1902 and 1904, the only major operational adjustment on the Empire Ranch was in the volume of cattle sold. The size of shipments correlated directly with climatic conditions on the home range. Heavy rainfall and calf crops boosted sales in excess of fifty-three hundred head for 1902 and 1903. By the fall of the latter year, over twelve thousand cattle roamed the Cienega Valley. However, Arizona's climate reversed itself during the winter and spring, and by June of 1904, ranchers suffered drought-related losses on all the southern ranges. Empire shipments plummetted to seventeen hundred head for the year, with 1,593 being sent to the Panhandle in late May. Only heavy rains in July and August prevented the Empire from losing a major portion of its breeder herds. The effects of the brief drought, however, were clearly felt the following year. The mortality rate among calves had been so high in the Mascarenas Ranches near the international line in Sonora.[37]

In 1928, over a half-century after Walter Vail settled the original 160-acre tract, the Vail family sold the Empire Ranch to the Chiricahua Ranches Company. The Chiricahua, under Frank Boice's directorship, had been ordered to remove twenty thousand cattle from leased rangeland on the San Carlos Indian Reservation. Rather than liquidate their herds, Boice decided to extend his range holdings in the southern part of the state. On February 15, 1928, the Chiricahua bought title to the Crittenden range from the Vails and the estate of Oscar Ashburn for ninety thousand dollars. Three months later the Vail Company sold Boice the entire Empire range in Pima County for fifteen dollars per acre. By agreement, they left their eight thousand Hereford stock to fatten on the range until July 15, 1929, at which time the bulk of the herds were transferred to Pauba. The heritage of Vail family stockraising on the Empire had come to an end.[38]

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[37] Tucson Arizona Cattleman, December 2, 1918; March 31, April 14, October 6, 1919; Wagoner, Cattle Industry, p. 58; Nogales Border Vidette, February 13, 1926; Lease Agreement, Baca Float Mining and Cattle Company to Vail and Ashburn, October 14, 1920, Folder 9, Box 10, ERP, UAL; Fay Ewell Parker, tape interview by E. F. Schaaf (1973), UAL.

[38] Richard G. Schaus, "Hereford Tradition of Arizona's Boices Is Deeply Rooted," American Hereford Journal, (July 1, 1959), pp. 532-730; Petition for Confirmation of Contract, Estate of Oscar F. Ashburn, Probate Records,

A SEQUENCE OF CULTURAL AND ALLUVIAL DEPOSITS IN THE CIENEGA CREEK BASIN, SOUTHEASTERN ARIZONA

by

Frank W. Eddy

A Thesis Submitted to the Faculty of the

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2

THE CURRENT ENVIRONMENT

Introduction

Discussion of the present environmental conditions may be treated in several ways. An analysis of the Cienega Valley is important to an understanding of the interrelationships between terrain, climate, flora, and fauna. In addition, the current setting may serve as a point of departure for a study of the environmental changes of the past. The contemporary environment is described in this chapter. Material relating to various segments of the past environment is treated by specialists in the appendices. Correlation of these data has been undertaken in Chapter 5.

The Physiographic Setting

BASIN AND RANGE PHYSIOGRAPHY:

The area covered in this study lies in the Mexican Highland section of the basin and range physiographic province described by Fennemen (1949) as consisting of isolated dissected block fault mountain ranges separated by aggraded desert plains. In southeastern Arizona, these plains consist of long, open ended troughs trending northwest by southeast which are formed by down faulted blocks. They lie roughly parallel to one another and contain the major drainages of the area. These rivers flow northwestward to a junction with the westward draining Gila River which joins the Colorado River near the head of the Gulf of California.

LOCAL PHYSIOGRAPHY:

An unusual example of basin and range physiography is situated between two of these drainages, the San Pedro and Santa Cruz valleys. This minor structural trough differs from the important surrounding drainages in its short length and higher elevation. Locally this basin has been referred to as the Cienega Valley (Schrader, 1915:43). It may be described as an elevated, intermontane plateau surrounded by two major ranges of upthrust, generally north-south trending mountain blocks (Fig. 1).

The western range includes the Empire and Santa Rita Mountains and the Canelo Hills. The eastern range consists of the Whetstone and Mustang Mountain masses. The whole basin forms a rectangular unit blocked by the northeast-southwest trending Empire Mountains at the northern end of the plateau and at the southern end by the northwest-southeast trending Canelo Hills.

The crescent shaped, western mountain block was formed largely through faulting. The structure is monoclinal with a gentle dip to the east. The fault scarp of this range faces westward toward the Santa Cruz Valley and presents a steeper aspect than the more gently sloping east face which largely follows the monoclinal dip. The rugged topography has been produced by faulting and deep erosional dissection. The west range rises to an altitude of 9,432 ft. at Mount Wrightson (Old Baldy) and then slopes off to the north and south to an elevation of 6,000 ft. (Schrader, 1915:37-9).

A brief statement by Darton (1933, footnote 19) concerning the Whetstones describes them as an uplifted block. A section through the northwest end pictures a monoclinal dip to the west with an escarpment facing the San Pedro Valley (Darton, 1933, Fig. 39). A maximum elevation is attained at Apache Peak which lies at an altitude of 7,684 ft.

Erosion of these block fault ranges has transported detrital material into the down faulted basin of the Cienega Valley to form a mantle of considerable thickness. This detritus is of Pleistocene(?) age and has been the predominant factor in shaping the present land surface. The pediment formed from the detritus is in an advanced stage of dissection forming long sloping, nearly flat topped ridges (Schrader, 1915:43). It is on this erosion surface along the courses of the present drainages that the recent flood-plain alluviation has taken place. A present cycle of alluvial erosion has resulted in the cutting of arroyos which measure up to 25 or more feet in depth.

CIENEGA CREEK BASIN:

In the upper half of its course, the Cienega Valley ("Outer Valley," Cooley, Appendix A) is a nearly equidimensional basin which is modified to a long, narrow, finger-like projection at its lower end. Measured from the base of the Santa Rita Mountains on the west to the base of the Whetstone Mountains on the east, it is 15 miles across (Schrader, 1915: 43). The detrital material filling the basin has largely been supplied from the Santa Ritas and in consequence has forced the present drainage toward the base of the Whetstone and Mustang Mountains. This factor has given the basin an assymetrical form in cross section with the maximum depth skewed to the east adjacent to the Whetstone Mountains. The west flank of the basin drops from an altitude of approximately 5,000 ft. at the base of the Santa Rita Mountains to 4,500 ft. at the creek. This decline gives the pediment a slope of approximately 50 ft. to the mile (Schrader, 1915:43). The creek falls at a gradual pace from south to north at about 50 ft. to the mile although this drop is locally interrupted by bedrock outcroppings forming abrupt falls in the vicinity of the junction with the Matty Canyon tributary. At the outlet of the basin, which lies at an elevation of 4,200 ft., the stream is forced into a narrow canyon cut into the foothills of both the Empire and Whetstone Mountains.

THE DRAINAGE PATTERN:

Cienega Creek, the primary through flowing drainage of the valley, is a permanent stream which heads in the Canelo Hills on the south. It flows northward into Pantano Creek which joins Rillito Creek, a major tributary of the Santa Cruz River. The western lateral intermittent tributaries include Empire Gulch, which is derived from the Santa Rita Mountains, and the Gardner Canyon drainage heading out of Mount Wrightson from Apache Springs. The considerably shorter intermittent eastern drainages, such as Matty and Wood Canyons, flow northwesterly from the Whetstones and Mustangs to a junction with Cienega Creek (Fig. 1).

SPRINGS:

An important factor in a consideration of the ground water of the area is a system of natural springs which occur just below the summit of the main masses of both the Santa Rita and Whetstone Mountains (U. S. Forest Service Map, Coronado National Forest, 1953). Most of the major canyons head out of one or more of these subsurface outlets, although many have gone dry within the last half century (Swanson, 1951: 12).

Climatic Patterns

SOUTHWESTERN DESERT CLIMATES:

The climate of southern Arizona is part of a larger unit of tropical and subtropical desert areas (BHh) defined by Trewartha (in Goode, 1956:9) as a dry climate (B), with the maximum dryness occurring in the winter (W) half of the year as compared to the summer half, and all months containing average temperatures above freezing (h).

The primary factors in a consideration of desert climates are those of moisture and temperature. It is these determinants which are directly responsible for the growth and distribution of plant and animal communities.

The precipitation pattern for Arizona exhibits two semi-annual peaks separated by intermittent periods of dryness. Summer rains are brought by a shift northwestward of the subtropical anticyclone in the Gulf-Caribbean area moving moisture laden air at its western end from the west Texas-New Mexico region to the New Mexico-Arizona region

(Bryson, 1957:6).

This dominant pattern is replaced in winter by one in which the westerly jet stream shifts southward to a mean position of 35 degrees north latitude. The winter rains are brought about by migratory low pressure systems and troughs of low pressure associated with this jet wind (Bryson, 1957:4). The dry periods occurring in the intermittent seasons are a result of the lag of one pattern behind the other.

Summer storms occur as the result of a build up of thunderhead cloud masses which reach a peak in a short period, distribute precipitation in large quantities often over extremely local areas, and disappear leaving clear skies again. The sharp, intense nature of these storms produces rapid runoff and gully erosion due to the inadequate protection of the vegetative cover.

Winter storms are marked by the appearance of dark sheet clouds over large areas of the sky. Precipitation is more often general, for a more extended period, and of less intense nature than that which occurs during the summer rainfall peak. The increased cloudiness over more extended periods reduces the extremely high evaporation rate. This diminution results in a greater amount of actual moisture entering the soil for use by plants and animals.

The rainfall pattern described for Arizona is similar for most of northwestern Mexico. It is on the basis of this general agreement that Bryson (1957:11) has established a "Sierra Madre Occidental" precipitation type. Local variations indicated by Fouriers Hormonic analysis have suggested three sub-types to the larger pattern. One each for the Gila and Rio Grande Valleys and a Patagonia sub-type encompassing the Cienega Valley. A final pattern of significance is the extension of a Pacific coast rainfall province eastward across the Sierras of California at high elevations to form an "Upland" rainfall type (Bryson, 1957:11).

METEOROLOGICAL DATA:

Data compiled by Smith (1956) from the United States Forestry Service records gathered at the Canelo Ranger Station in Santa Cruz County, provide the only information available on actual meteorological statistics. The station was operated through the years 1910 to 1953 after which observations were discontinued. The instruments were located on the north flanks of the Canelo Hills in the Babocomari River drainage basin at an elevation of 5,000 feet.

The mean maximum summer precipitation occurs during July and August with 8.96 inches of rainfall recorded (Smith, 1956, Table 26). This figure is more than twice the winter rainfall peak which occurs during the months of December through February when a mean total of 3.95 inches fall. The total of the two maximum peaks is 63.0 percent of the mean annual total for the year which is 18.70 inches.

An important source of soil moisture affecting plant growth and subsurface water storage is obtained from snowfall. At Canelo, snow occurs in measurable quantities from November to March with a peak during the winter precipitation season (Smith, 1956, Table 31). A mean of 10.7 inches occurs annually although this can hardly be representative of that falling at higher altitudes.

The mean maximum temperature of 90.2^{O} farenheit occurs in June just before the cooling onset of the summer rainfall season (Smith, 1956, Table 14). The mean minimum temperature of 23.3^{O} occurs in January coincident with the winter rainfall season. The mean for the month of December, a typical figure for the winter rainfall season, is 41.4 degrees farenheit. A mean of 73.4^{O} farenheit occurring in July is representative of temperatures occurring during the summer rainfall season.

The extreme yearly range of temperature controls the agricultural growing season which is defined on the basis of spring and autumn frosts. At Canelo, the average date for the last killing frost occurs on the first of May while the first autumn killing frost occurs on October 18 giving the area 170 days of growing season (Smith, 1956, Table 21).

Temperatures as a whole tend to vary widely within a single 24-hour period due to the general clear skies and lack of an insulating blanket of clouds.

Arizona lies in a zone characterized by low humidity. The annual relative humidity ranges from 40 to 60 percent which often drops as low as 5 percent or less on summer afternoons in the southeastern portion of the state (Smith, 1956:84). These yearly averages are paralleled by great diurnal fluctuations. Normally the highest relative humidity occurs just before sunrise and drops to a minimum during the early afternoon paralleling the pattern for the daily temperature fluctuations.

The state as a whole receives more sunshine than any other part of the United States. Southeastern Arizona has clear skies and sun from 80 to 85 percent out of the total possible sunshine (Smith, 1956, Fig. 11).

The high percentage of possible sunshine and minimum amount of blanketing clouds results in a high evaporation rate of surface water and evapotranspiration of plants. Evaporation for most of the state averages between 6 and 7 feet per year (Smith, 1956:93).

SUMMARY:

The Cienega Valley lies within a climatic area characterized as a dry subtropical desert. Its precipitation pattern follows that of a larger region encompassing the Southwestern United States and Northwestern Mexico and referred to as the "Sierra Madre Occidental" type. The valley additionally falls within a more restricted region referred to as the "Patagonia" precipitation sub-type. Thus it is a distinctive unit which is set off from the surrounding San Pedro and

Santa Cruz River Valleys climatically. This distinctiveness in turn affects a specialized natural and possibly human ecology.

Life Zones

SANTA RITA LIFE ZONES:

Bailey (1923), while carrying out a study of the bird communities inhabiting the Santa Rita Mountains, briefly noted the plant associations encountered on the west face of the mountains. The lower Sonoran zone was found to occur from the Santa Cruz River up on to the flanks of the mountains and to be composed of cactus, ocotillo, mesquite, cats claw, and zizyphs (Bailey, 1923:8).

The upper Sonoran zone extends over the greater part of the mountain flanks and contains the checker barked juniper, Mexican nut pine, Emory and Arizona live oaks, and manzanita. This zone was also defined at an altitude of 5,000 ft. at Gardner's Ranch on the east flank of the Santa Ritas. Juniper, a characteristic member of this belt has been observed by the author growing both on ridges forming part of the Davidson Canyon drainage northwest of the Cienega Valley and above Matty Canyon east of the Cienega Ranch headquarters.

From 6,000 to 9,000 feet, the Transition zone is encountered. The dominant Arizona or Ponderosa pine is found associated with the

Chihuahua and White pines as well as Douglas spruce, madrone, and locust (Bailey, 1923:8). One small patch of Canadian zone aspen was found on a cool northeast slope at 9,000 feet elevation (Bailey, 1923: 9).

No published information is available on the Whetstone and Mule Mountains lying across the Cienega Valley from the Santa Ritas. A statement by a local ranch foreman, Mr. Fred Barnett, indicates the existence of a sparse growth of Transition zone pines on the flanks of the Whetstones.

CIENEGA VALLEY FLORA:

The description of the Cienega Valley flora presented here is based largely on the observations of the author supplemented by those of Fred and Harry Barnett, local ranch operators.

The valley proper contains a vegetation cover which characterizes it as a member of the upper Sonoran life zone; although this situation has been modified somewhat by the recent desication due to erosion. The dissected mountain pediments support a rich growth of grama grass (Bouteloua) which has been responsible for a flourishing cattle industry within the historic period. Small, scattered mesquite (Prosopis) trees are to be found on the ridge slopes, and live oak (Quercus) clusters are to be found along the upper tributary drainages and scattered on slopes high up against the base of the Santa Rita and Whetstone flanks.

Yucca (Yucca) is a common associated cactus and agave (Agave) is to be found on the divide between the Davidson and Cienega Creek drainages.

The alluvial flats occurring along the main drainage lines supports quite a different cover consisting of a heavy sacaton growth. Mr. Fred Barnett relates that within the last 50 years these sacaton flats have been invaded and largely dominated by a fairly dense mesquite woods. The network of roots this woods has sent down into the underlying alluvium, sometimes to depths of 20 ft. or more as evidenced by exposures of tap roots in the arroyo walls, should be kept in mind when considering Carbon-14 dates.

Cottonwood (Populus) groves are found along the major drainages wherever there is sufficient surface or subsurface water to support them and black walnut (Juglans) occurs in Matty Canyon.

Agricultural fields on the former flood-plain flats below the Cienega Ranch headquarters contain local dense thickets of sunflowers (Helianthella). Arrow weed (Pluchea) is also found as thickets on moist sandbanks in portions of the Matty and Cienega drainage beds.

The unusual anomaly of the permanent flowing Cienega Creek accounts for the growth of some water plants such as Cress and in the recent past for the formation of a small cienega at the junction of the Empire Gulch and Cienega Creek. According to Mr. Fred Barnett, remnants of this marsh are still to be seen.

SUMMARY:

The Cienega Valley, due to its high elevation, greater precipitation, and cooler temperatures, supports a mesquite-grassland cover which contrasts markedly with the true desert flora of the lower and warmer adjacent Santa Cruz and San Pedro River Valleys. This plant habitat in turn could have offered a rich field for exploitation by peoples with an economy focused on the gathering of plant food products or to a subsistence pattern which was seasonally geared to such an endeavor.

Fauna

While undertaking the geological study, Cooley sighted a small group of javalina (*Pecari*) in the mesquite wood adjacent to Cienega Creek. Mr. Harry Barnett reports that they commonly frequented the oak cover at the base of the Whetstone Mountains. This same habitat also supports the mule deer (*Odocoileus hemionus*). The more open grasslands at the base of the Mustang Mountains support small refugee herds of antelope (*Antilocapra americana*). The pronghorn were formerly common grazers in open range lands of both the upper and lower Sonoran life zones (Olin, 1954:24).

During the early hours of the night and again in the early morning, the call of the coyote (*Canis latrans*) is of common occurrence.

This member of the dog family is distributed throughout all of the life zones of the Southwest (Olin, 1954:39).

A badger (Taxidea) was observed by the author. This animal's preferred habitat is deep alluvial soil where it may burrow with little obstruction and live off of rodents. It frequents all of the life zones of the Southwest but is most numerous in the desert valleys of the lower Sonoran zone (Olin, 1954:55).

The desert cottontail (Sylvilagus), while not as common as the jack rabbit, may be observed in the mesquite woods and in the breaks of sacaton grass on the alluvial flats. This animal is common to most types of terrain and both of the Sonoran life zones (Olin, 1954:66). The jack rabbit (Lepus) may occasionally be seen on the alluvial flats during the day but may be observed far more frequently by the headlights of a vehicle at night. The genus ranges over most of the Southwest and both the Sonoran life zones (Olin, 1954:68).

Gopher burrows, while not common, are occasionally seen in the Cienega Creek area. This small rodent (Thomomys) is common to both of the Sonoran life zones (Olin, 1954:80). A second rodent seen only at night is the kangaroo rat (Dipodomys). This animal was only observed on the grama grass ridges in the vicinity of the Empire Ranch. Its common range is in the upper portion of the lower Sonoran life zone (Olin, 1954:83).

In summary, it appears that the Cienega Valley, with its upper

Sonoran mesquite-grassland cover, supports a rich variety of browsing and grazing animals as well as many types of smaller rodents. This population in turn supports a smaller number of large predators; the whole serving as an important potential source of food for those full and part time hunting peoples which might have occupied the valley.

Historic Fluctuations

PRE-ARROYO CUTTING:

Bartlett (1854), while employed in conducting a boundary survey between the Southwestern United States and Mexico, made limited observations on the local environment of the Cienega Valley in early September of 1851. He (Bartlett, 1854:383) described a plateau, thought to have been the Cienega Valley (Wasley, 1958), as being similar to the western Praires. It was covered with short grass on the ridges and the depressions, which lay 50 to 100 ft. lower than the plain, contained pools of water, more luxuriant grass, and groves of small oaks. Mustangs or wild horses were observed as well as many deer and antelope (Bartlett, 1854:384).

The party proceeded in a southerly direction from Rain Valley toward the Canelo Hills. While crossing what may have been the upper portion of Cienega Creek or one of its tributaries, the mule drawn supply wagon became bogged down in a swamp area where the rank grass reached above the mens heads.

These observations correspond in many respects to the situation found in the Cienega Valley today, with the exception of the swamp areas and the apparent general lack of mesquite woods along the streams. The drainages were running clear on or near the surface to the extent that a four wheeled, mule drawn wagon could make their crossing several times. Sheer walled arroyo banks, such as one observes today, seem to have been absent.

ARROYO CUTTING:

About the turn of the century, certain alterations took place in the composition and exuberant nature of the Cienega Valley environment. This change was primarily brought about by arroyo cutting which has been variously attributed to both climatic desication and over grazing by the cattle industry. This cycle of erosion presumably started in the 1880's in the adjacent and better documented areas of the surrounding river valleys (Antevs, in Smiley, 1955:157). This cycle may have been delayed somewhat in the Cienega Valley due to the more ample nature of the ground cover necessary to check erosion. This supposition is supported somewhat by the statement of a local ranch owner, Mr. E. Hilton, who related to Mr. Harry Barnett that when he was a boy, it was possible to drive across the valley floors in a buggy without obstructions. The age of Mr. Hilton has been estimated at about 65 years. It would then seem that serious arroyo cutting had not commenced in the 1890's. Mr. Fred Barnett who had come up from Sonoita to spend a few days in the Matty Canyon area in 1905 informs me that, as near as he can remember, "the arroyo was not a third as deep as it is today." Obviously the cutting began sometime between these two periods and the year 1900 does not seem to far out of line for an estimate.

The result of this dissection of the former flood plain has been a general lowering of the water table, a desication of soil moisture, and the prohibition of flood-plain and dry farming. The plant cover has suffered considerably. Mr. Fred Barnett has observed a general replacement of grasslands by mesquite woods along the drainages within the last fifty years and a drying up of several cienegas which formerly existed on Cienega Creek.

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CULTURAL AND ENVIRONMENTAL HISTORY OF CIENEGA VALLEY SOUTHEASTERN ARIZONA

Frank W. Eddy
Maurice E. Cooley
with sections by
Paul S. Martin
Bruce B. Huckell

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1. CIENEGA VALLEY

An interrelationship between human culture and environment through time is evident in the area near the junction of Matty Wash and Cienega Creek in the Empire Valley of southeastern Arizona (Fig. 1.1). Archaeological sites, ranging in date from about 1000 B.C. to historical occupation, show association with the Recent alluvial floodplain deposition laid down by Cienega Creek. This relationship indicates that man was living on a ground surface that had been gradually built up by almost continuous alluviation. During the last 3500 years, this process effected a vertical spread of human material remains throughout an average thickness of 9 m of alluvium. The earliest cultural manifestations were identified as temporary and semipermanent campsites occupied by hunters and gatherers of the Cochise culture during the San Pedro stage (Sayles and Antevs 1941; Sayles 1983). Later cultural deposits, dated after A.D. 1, yielded pottery of the Hohokam agriculturalists like those then living in the Tucson area.

The human occupation occurred in a grassland environment that underwent periodic shrub cover fluctuations. Modern fauna inhabited the prairies and shrub growth along slow-moving ponded streams. Several pronounced environmental fluctuations affected the local population. The dry post–A.D. 1200 arroyo cutting probably desiccated the area in a fashion similar to current conditions, thereby eradicating the local ponded marshes and diminishing an important wild plant food supply. The succeeding wet period, with indications of a heavy ground cover, may have restored the supply of marsh plant foods but it intensified the difficulty of floodplain farming. It is possible that the apparent absence of historic Indian occupation indicates that the major emphasis on hunting and gathering of plant and animal foods from early to late within the study area may have extended to the historic period, and that the sharp environmental changes were responsible for the abandonment of the area after A.D. 1500. Inferences regarding the interrelationship of man and his natural surroundings are based on these kinds of environmental stability and change.

Information concerning the changing environment was obtained by studying the sedimentary and erosional processes associated with the deposition of the Recent alluvium, by pollen analysis, and by identifying charcoal specimens, freshwater and land snails, and the remains of animal bones. The relationships of these lines of evidence aided interpretations of past climates and of the prehistoric distribution of vegetation and wildlife. The varied cultural deposits indicated both human adaptations to the fluctuations of the environment and to social changes within the community.

The locality investigated is in the narrow V-shaped junction of Matty Wash and Cienega Creek in Sections 25 and 26, Township 18 south and Range 17 east. This area is approximately 60 miles (96.6 km) southeast of Tucson and 16 miles (25.75 km) northeast of Sonoita between the Empire and Whetstone mountains. The broad region between these mountains that is occupied by the Cienega Creek drainage system is generally termed the Empire Valley, although in older reports it has been referred to as Cienega Valley (Eddy 1958). As it is used in this report, Cienega Valley refers to the floodplain of Cienega Creek and the adjacent low ridges and terraces (Fig. 1.2).

PRESENT ENVIRONMENT

An understanding of the present terrain, climate, vegetation, and wildlife is essential to an interpretation of the environments of ancient man in the Cienega Valley. The changing environment of the valley, represented physically by arroyo cutting, is an index to the study of ancient cultures and environments.

The climate of the Empire Valley supports a moderately rich natural vegetation ranging from grasslands to woodland, in contrast to the Sonoran desert that is dominated by shrubs and cacti. The grasslands have been invaded by mesquite along the lower drainages and by oak at higher elevations. Mesquite appears to be a recent introduction into this valley.

Before 1900 the streams were sluggish, flowing through dense cienegas or bogs choked with tall grass. These ponds provided permanent and temporary homes for water-dwellers such as beaver and waterfowl. The grasslands, less affected by erosion, probably supported grazing animals throughout the past century. Grasslands mixed with oak and mesquite sheltered deer and javelina. In spite of the relatively rich supply of natural plant and animal foods available in the past, malarial conditions associated with the swampy areas may have been an obstacle to permanent human settlement.

Physiography

The Empire and Whetstone mountains reach altitudes of over 2121 m and consist of igneous, metamorphic, and sedimentary rocks varying in age from Precambrian to Mesozoic. Between the mountain fronts and the floodplain

5. CULTURAL AND ENVIRONMENTAL HISTORY

Cultural history in Cienega Valley begins with the San Pedro stage of the Cochise culture at a time when the general environmental conditions were becoming more favorable for semipermanent occupation. Although there is little evidence of human activity before 1000 B.C. in Cienega Valley, earlier stages of the Cochise culture have been described for southern Arizona (Sayles and Antevs 1941; Sayles 1983) and Ventana Cave (Haury 1950). The presence of perennial water in the area today during a period of drought (Thomas 1963) suggests that at least some water was available during the relatively dry period of the early Recent, termed the Altithermal period by Antevs (1955), and that people could have been in the valley before the San Pedro stage. A sidescraper (Fig 2.1 *a*) found in Unit 7 at Arizona EE:2:12 (Fig. 5.1) may possibly be from a pre-San Pedro occupation. A radiocarbon date of approximately 1500 B.C. was obtained from Unit 7, where the sidescraper was found.

Evidence of sites older than the San Pedro stage is limited by the exposures uncovered through arroyo cutting and the amount of erosion that occurred in all of Recent time. The basal part of the late Recent alluvium may have been laid down in a depositional environment similar to that of the San Pedro stage and may thus contain older, but still concealed, sites. Localities that were occupied before the deposition of the late Recent alluvium sequence probably have been subjected to vigorous erosion during the early Recent and, consequently, many sites may have been destroyed. Also, much of the evidence for sites in the upland areas adjoining Cienega Valley may have been removed by erosion occurring there throughout Recent time.

EARLY SAN PEDRO STAGE

San Pedro stage sites, found buried on sandbars (mainly Unit 5) and slopes adjacent to the ancient floodplain, represent semipermanent and temporary campsites. The distribution of the sites shows a close association with cienegas and ponds of the old floodplain (see Fig. 4.1 *a*). The sedimentary features of Units 4, 5, and 6, and the pollen record, indicate that no major environmental change affected Cienega Valley during the San Pedro stage. The environment was stable, with enough moisture for the cienegas and for a grassland and shrub cover on the nearby uplands. Oak and grass covered most of the gravel terraces. Mesquite, identified from charcoal specimens (see Table 2.1), probably grew on the terraces or on lowlands bordering the floodplain, as well as on the floodplain itself. The pollen record near Section MC–6 shows plants often called weeds, composites and chenopod-amaranths, were the dominant types represented in the deposits of Units 4, 5, and 6.

Faunal remains excavated from San Pedro stage sites indicate the presence of animals similar to those of modern times. The grassland supported antelope; grassland and shrub cover supported mule deer, cottontail, and jackrabbit; and the forests of the nearby mountains supported elk, bighorn sheep, and whitetail deer.

The general environment produced excellent conditions for plant gathering and small game hunting for the San Pedro people. Recovered artifacts were undoubtedly used for gathering and hunting activities. The stone grinding and pounding tools imply the use of seeds, nuts, and berries for food. Cutting, scraping, and chopping activities were undoubtedly used in the skinning and preparation of animals. Some animals may have been cooked in deep earth-oven pits like those found at Arizona EE:2:30.

Maize pollen extracted from Units 4 and 6 near Section MC–6 (see Fig. 4.3) strongly suggests that part of the San Pedro subsistence pattern was based on maize cultivation. Corn probably was planted in areas bordering cienegas where little flooding occurred. Farming may have been limited to the floodplain where soil moisture was maintained by a shallow water table. The nearby uplands were undergoing erosion, which limited soil formation, and, consequently, farming.

The occupation of the site at Arizona EE:2:30 was concurrent with the formation of some of the peaty beds, representing deposition in cienegas, at Section MC–5 (see Fig 4.1 *a*). The midden at the site underlies Unit 3 and unconformably overlies Unit 100. The midden dips at a slightly steeper angle than the M_1 and M_2 marker beds. The M_1 marker bed is younger than the M_2 marker bed, but M_2 may be equivalent to the upper part of the midden. The marshes represented by the deposition of the peaty sediments below this marker bed at Section MC–5 and of Unit 4 sediments elsewhere in Cienega Valley were concurrent with the habitation at Arizona EE:2:30 and likely were exploited for edible marsh plants (Fig. 5.1).

Population during the San Pedro stage was probably fairly small compared with later periods, but such evidence is scanty because most sites were buried by more than 3 m of alluvium. An important cultural feature is the indicated stability of the local group that occupied Arizona EE:2:30. The large number of pits, the extensive midden, flexed human burials, and the pit houses at Arizona EE:2:30 all evince a semisettled way of life that provided the logical transition to true village communities and agriculturalism of later times. The other sites of this period represent only temporary camps, which may have been used by groups operating out of a base camp at Arizona EE:2:30.

LATE SAN PEDRO STAGE AND EARLY PIONEER PERIOD

The addition of pottery to the San Pedro stage cultural inventory marks the transition to the early Pioneer Hohokam culture. Pit houses were the characteristic habitation unit of the Pioneer period. Except for pit houses and ceramics, there was little change in the material culture from that of the early San Pedro stage. Although evidence is scarce for this period, subsistence techniques were probably similar to those of the preceding San Pedro stage.

The proximity of a Vahki-Estrella dated site (Arizona EE:2:10) to a San Pedro stage site (Arizona EE:2:30), and the midden at the base of Unit 3 alluvium between the two sites, possibly reflect a continuous occupation of the area. Fluvial-laid material mixed with the midden indicates that early Unit 3 deposition was concurrent with the occupation of the pit house at Arizona EE:2:10. Unit 3 deposits overlapped eastward on the prealluvial valley floor and buried the older San Pedro sites (including Arizona EE:2:30), but Arizona EE:2:10 may have been along the margin of the alluvial floodplain and consequently was not buried until later.

In general, the environmental conditions of the early Pioneer period were similar to those of the San Pedro stage. Cienegas continued to occur in the western and central parts of the floodplain (see Table 3.2). Although influxes of Unit 3 fluvial sediments came from both sides of the valley, the areas occupied by the cienegas shifted slightly. The M_1 marker bed at Section MC–5 was formed as a result of one of the eastward shifts of cienega deposition. If the M_1 marker bed were projected from Section MC–5 to Arizona EE:2:10, it would occupy a stratigraphic position near or at the base of Unit 3 in the area of the pit house. Thus, this cienega was also available for the collection of edible marsh plants during early Pioneer period times (Fig. 4.1 *b*).

LATE PIONEER PERIOD

Near the beginning of the late Pioneer period, the cienegas began to dwindle. With the encroachment of fluvial-laid materials, the cienegas were restricted to the southwestern part and several small areas in the eastern part of the valley. The shrinkage of the cienegas and the enlargement of the alluvial floodplain added to the potential farming area of Cienega Valley throughout the Pioneer period. A probable shift in environmental conditions caused the formation of an apparently integrated system of channels (see Fig. 4.1 *c*) between about A.D. 200 to 300 and A.D. 600. The channeling was not deep enough to drain the cienegas, thereby not appreciably affecting maize agriculture. The recording of maize pollen in sediments deposited at this time near Section MC–6 supports the inference that conditions were suitable for growing maize. In addition, the pollen record (see Fig. 4.3) indicates no significant environmental change during this time, mainly because both profiles are in areas not affected by the channeling. After the channels were cut, filling took place. The cienegas were enlarged locally, but were restricted chiefly to the west side of the valley.

The deposition of alluvium over all the lowlands may have influenced the occupation of ridges adjoining the floodplain. Occupation of ridge localities in the valley is noted for the first time at Arizona EE:2:40. The occupation at Arizona EE:2:10 continued as the alluvial deposits were extended throughout Cienega Valley (Fig. 5.1).

COLONIAL AND SEDENTARY PERIODS

Throughout the Colonial and Sedentary periods the environmental conditions, except perhaps during the deposition of the K marker bed (see Fig. 4.1*d*), were generally unstable compared with the preceding periods. Fluvial material, mainly from Matty Wash, was laid down on most of the floodplain; consequently, many of the cienegas were filled. The deposition of the K marker bed indicates a temporary expansion of the cienegas. After the deposition of the K marker bed, the alluvial deposits reflect a shift in environmental conditions. Scour-and-fill became the dominant sedimentary process and fluvial sediments were deposited throughout Cienega Valley. A shift in the environmental conditions is indicated by an abrupt increase of chenopod-amaranths and a decrease of composites recorded in the pollen profile near Section MC–6 (see Fig. 4.3). This change in the pollen took place near the Unit 3 and Unit 4 contact, and it nearly coincides with the change from cienega (Unit 4) to fluvial deposition (Unit 3). Because no pollen was extracted from the corresponding stratigraphic interval in upper Unit 3, this pollen shift was not substantiated in the profile at Section MC–5.

The fluvial deposition that occurred throughout the valley during the Sedentary period and, to a lesser extent, the Colonial period, probably increased the effective farming area on the floodplain. A pollen sample obtained from the upper part of Unit 3 near Section MC–6, deposited during this time, yielded 99 percent maize pollen. This unusual record provides evidence of a cornfield in an area previously occupied by a cienega.

Sites of the Colonial and Sedentary periods are found on the floodplain and on adjacent ridges (see Figs. 1.3, 4.1*d*). For these periods population increase is inferred from the number of villages surveyed on the terraces and the widespread distribution of sites on the floodplain. The population may have reached a maximum during the Sedentary period, and may have continued through the early Classic at this peak.

CLASSIC PERIOD

The environmental conditions of Cienega Valley during the late part of the Sedentary period and the early part of the Classic were probably similar. At some time during this interval, however, fluvial deposition probably ceased, followed by stripping and eventually arroyo cutting (Fig. 5.1). The arroyos represent only the end stage of this erosional interval. Conditions favoring erosion were caused by an unstable environment, in turn reflecting an unstable climate. Precipitation must have been particularly unreliable, with fluctuations similar to modern southeastern Arizona (see Figs. 2.16, 4.2). The effects of the inferred drought of the late Sedentary and early Classic periods, often referred to as the Great Drought, may not have been as severe as present effects because the arroyos at that time were smaller and had a more limited distribution than the modern ones (Fig. 4.1 *b*).

Archaeological controls were insufficient to determine how the local inhabitants adapted to this changing environment or whether they abandoned the area because of the drought and arroyo cutting. In any event, some modification in floodplain cultivation methods (Hack 1942: 29) must have been necessary near the newly formed arroyos. Based on three main factors, occupation appears to have been continuous until A.D. 1300. First, most ridge sites occupied during the Sedentary period also contained early Classic remains. Second, not all of the floodplain was affected by arroyo trenching. No arroyo extended upstream along Cienega Creek south of the area investigated, and floodplain farming could have been practiced there without interruption. Third, the permanent water supply in Cienega Valley today indicates that an adequate supply would have been available in the area during this period.

As drought conditions abated, perhaps during the middle Classic period, the environment stabilized and precipitation became more reliable. Less environmental fluctuation is reflected in the fine-grained sediments and soil of Unit 2, the Sanford formation. During the late Classic, streamflow was sluggish, and cienegas were present on parts of the floodplain until they were destroyed by arroyo cutting that began in historical times.

Pollen evidence of maize agriculture during the Classic period is absent, but the size and number of villages of the Tanque Verde phase denote its continuance. Population, as measured by the number of villages, continued through the early Classic period (Tanque Verde phase) with the same relative size as during the previous Sedentary period; for the late Classic, only one site was located dating to the Tucson phase.

The cause of the population decline and eventual abandonment of Cienega Valley is not known from the available information. Although the effects of arroyo cutting and filling of the cienegas on the areas of occupation are uncertain, these sharp differences in environmental conditions must have had a strong influence on the Classic period occupation.

DISCUSSION

Environmental conditions before about A.D. 300 were generally stable; those after A.D. 300 showed considerable fluctuation. Continuity appears in the similarity of life forms three thousand years ago compared with those observed in Cienega Valley today. Fluctuations in the environment are recorded in the alluvial stratigraphy and in the pollen records as changing conditions shifted the areas occupied by cienegas. The sedimentary pattern on the floodplain has been interrupted by influxes of fluvial deposits and twice by arroyo cutting (during the twelfth or thirteenth century and at present). The channels cut some time between A.D. 200 to 300 and 600 apparently had only a minor influence on the floodplain deposition.

To what extent the past environments of Cienega Valley influenced the development of prehistoric communities can only be inferred. The early cienega environments on the floodplain provided optimum conditions for plant gatherers and small game hunters. The continuity in chipped stone tools throughout the cultural sequence means that hunting and gathering were an integral part of the economy. The extent of the cienegas perhaps limited floodplain areas available for cultivation, in turn limiting the role of maize as a stable food in the total subsistence pattern. As the floodplain expanded through alluviation and the cienegas diminished, the area available for farming increased, and a corresponding rise in population occurred until a peak was reached in late Sedentary or early Classic times. Although the factors that caused the decline in population and abandonment of Cienega Valley in the Classic period cannot be determined with certainty, they probably were closely related to the sharp environmental changes that took place at that time.

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any head which will probably be maintained in these wells will not exceed 44 hp. Taking into account shaft losses, piping losses and loss in efficiency of the pump as time goes on, it may be assumed that 50 hp. applied to the pump is a reasonable figure. The load or the sub-station calculated from the proven efficiency of operation and line would be then 480 kw. supplied to the 10,000-volt line feeding the pumping station.

Assuming that it is necessary to run this system an average of 200 days a year, 24 hours a day, the installation will consume 2,208,000 kw-hrs. To an installation of this size it may be assumed that power can be supplied from a water power plant at not more than 1.5 cts. per kw-hr., making a total cost for 10,000 acres of land $34,000 per annum, for power, or $3.40 per acre per annum for the 10,000 acres. Taking into consideration the climate existing in this locality and the soil which this water will supply, this is an extremely reasonable irrigation power charge.

The actual method by which the charge for power will be made to this particular pumping circuit, however, is that there will be charged against this section of land a sum representing the cost of the final development of power set aside to supply this pumping system for the Indian Department when it is all completed, and this pumping area will then pay the actual cost of furnishing such power. This will reduce the power cost to about one-third of that estimated above. So far as depreciation, renewals, repairs and attendance is concerned, it without doubt will compare well with any system of its kind heretofore constructed. The wells themselves are of a character which will probably last indefinitely. The equipment is one which it is believed will present a minimum of repairs.

Under the above assumption of operation, there will be 24,000 acre-feet of water lifted an average of 50 ft. at a cost for power of $34,000, or at a cost of $1.42 per acre-foot, making $0.0285 the cost per acre-foot one foot high, which is the figure upon which comparison should be made with other installations as to power cost.

The State Legislature of Connecticut has voted $1,000,000 for the improvement of the harbor at New London, with a view to making it an ocean terminal.

The Cienega Sub-Surface Dam Near Tucson, Arizona.

BY G. E. P. SMITH.*

In the irrigated sections of the west many streams are popularly believed to carry considerable quantities of underflow and in many places subsurface dams have been projected or discussed for the purpose of intercepting the underflow and raising it to the surface. Few such dams, however, have been built, notable exceptions being those of Pacoima Wash in California and Agua Fria River in Arizona.

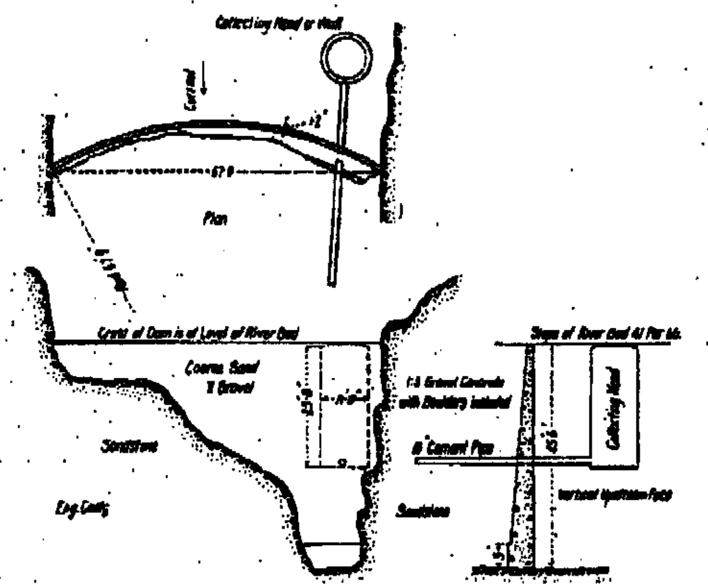

Fig. 1—Plan, Profile and Section of Subsurface Dam, Pantano Wash Near Tucson, Ariz.

An account of such a structure is of interest in two ways: First, the design is required to meet unique conditions; and second, the amount of water recovered contributes to our knowledge of the underflow of stream.

At the head of the Cienega Ranch irrigating ditch, near Tucson, the conditions appeared to be favorable to the construction of a subsurface dam. The river here narrows between hard sandstone walls to a width of 67 ft., and the traditions of the locality were that bedrock was reached by sounding rods at a maximum depth of 12 ft. The gradient of the river is 41 ft. per mile, the summer floods are sudden and torrential and the great difficulty of maintaining an ordinary ditch head against the severe floods occurring every summer made it desirable to take the water out through a pipe conduit laid at a safe depth below the river bed. It was expected also that a considerable volume of underflow would be recovered.

The construction of the dam, conduit and collecting basin has been carried out during the spring of 1911. The surface flow was very small and the danger of floods at that season of the year was negligible. The excavation of the river, gravel was carried down to a depth of 25 ft. with slip scrapers. At that depth the width of the river bed between rock walls was 22 ft. and a trench with lagging was started, its cross width being 12 ft., narrowing to 9 ft. when bedrock was finally uncovered for the full width of the river bed.

In order to keep down the seepage water during the excavation and construction centrifugal pumps were used, the combined discharge for several weeks approximating 4 second-feet, due in part to the draining out of the sand reservoir above the site.

The dam is of the arch type as shown by Fig. 1, and is built of plain concrete. The upstream face is vertical and the radius of curvature is equal to the span length, 67 ft. The top width is 14 ins., and the bottom width at the extreme depth of 45 ft. 6 ins. is 5 ft. A view of the completed structure is seen in Fig. 2.

The concrete was proportioned 1 cement to 5 of river gravel and boulders were driven into the mushy mixture after it was placed in the forms. The concrete was bonded to the rock surface with neat cement. On the sides of the canyon the rock face was blasted off so as to form a square skewback to take the thrust of the arch. The elevation of the top is that of the normal river bed. Six days sufficed for the concreting, part of the form work being done at night.

Whether or not the structure as built will withstand the floods has not been proven as yet. If the top portion should fail, the upper 5 or 6 ft. can be rebuilt of reinforced concrete and with sufficiently heavy section so that it will be permanent.

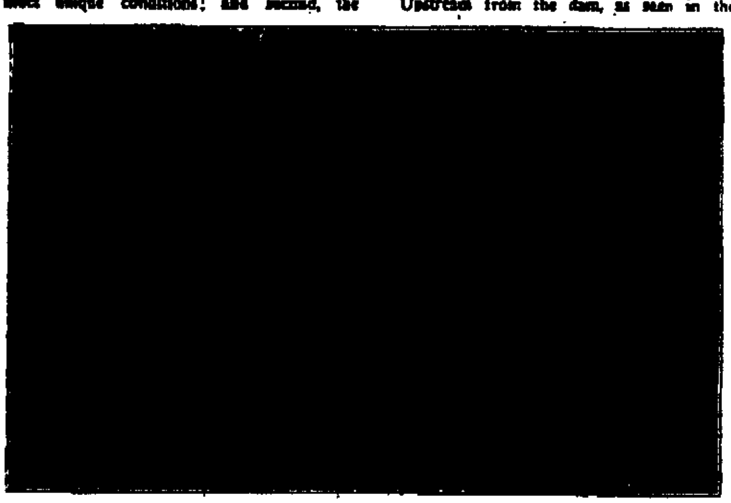

Fig. 2—View of Subsurface Dam and Collecting Head.

Upstream from the dam, as seen in the plan, Fig. 1, is a concrete cylinder of 8 ft. inside diameter and 25 ft. depth, to serve as a collecting head. Its thickness is 8 ins. The inflow is upward from the bottom and laterally through 200 holes each 2 ins. in diameter and protected by coarse ¼-in. mesh screen. The conduit of 16-in. cement pipe is started at the bottom of the cylinder and is laid on a

*Irrigation Engineer, Agricultural Experiment Station, University of Arizona, Tucson, Arizona.

level for 80 ft., thence on an upward incline for 260 ft. to the Cienega ditch, the bottom of which is 4 ft. lower than the river bed. The cement pipe was 1½ ins. thick and under the pressure head of 28 ft. leaked badly at first, but has slowly improved in that respect.

The surface flow of water one-fourth mile above the site on June 2 was 0.6 sec.-ft. and the ditch was carrying 1.5 sec.-ft., the underflow thus added being approximately 1 sec.-ft. On previous years the flow at the ranch at this season has been about one-half of a second-foot in the morning and the ditch has been dry at evening, due to the extremely high rate of evaporation during the day.

The improvements were designed and successfully constructed by Mr. R. R. Schweitzer, manager of La Cienega Land & Cattle Co. The total cost including labor, supervision, supplies, rent of pumping machinery, and cement at $2.15 per barrel was $7,360. A second-foot of water used for fruit and alfalfa ranching at Tucson can be capitalized at $18,000.

GENERAL ARTICLES AND CLASSIFIED ITEMS

Method and Cost of Constructing a Jetty by Dumping Stone from Trestle.*

The work in question is the construction of the south jetty for the improvement of Aransas Pass, Texas.

Owing to the shallow depth of water in which the south jetty lies, varying from 0 to 19 ft., it would have been impossible to carry the stone on barges and place it from floating derricks. The method previously used on the Galveston jetties was adopted and a trestle for a railroad of standard gage was constructed along the line of the jetty. This method has the advantage of permitting work to be done at times when rough weather would have stopped all work from barges. For the portion in the water, the piles were creosoted with 24 pound treatment. The bents were driven on 14-ft. centers and capped with a 12x12 in. timber, 10 ft. long. The piles were cut off at a height of 8 ft. above mean low water. Upon the caps were placed two 12x14 in. stringers, upon which the rails, weighing 56 lbs. to the yard, were laid. Each stringer was composed of two pieces, each 6x14 ins. and 28 ft. long, laid side by side, breaking joints and bolted together at each bent with screw bolts. The piles were driven to a penetration of 15 ft., inclined toward each other at the top, with a batter of 3 ft. in 24 ft., their tops being about 6 ft. apart, Fig. 1. The lumber was sound heartwood of longleaf yellow pine, and the piles green shortleaf or loblolly pine, 12 ins. at large end and 9 ins. at the small end.

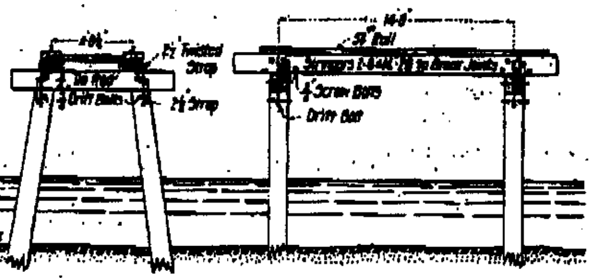

Fig. 1.—Trestle Used in Building South Jetty, Aransas Pass, Texas.

A transfer wharf was erected on the mainland and the stone cars coming from the quarry were transferred to a transfer barge and towed across to a similar wharf on Mustang Island. The barge was fitted with standard tracks and carried nine cars at a load. The transfer wharf had a hinged apron, raised and lowered by winches, and when in operation it rested on the barge, making a continuous track for the locomotive. The contractor was paid for the wharf and trestle, but all side tracks, turnouts, switches, and transfer appliances had to be provided by the contractor at his own expense and became the property of the United States at the termination of the contract.

The stone used at first was a dense sand stone weighing 140 lbs. per cu. ft., with some of the crest blocks granite of 166 lbs. weight. The stone used lately is all limestone, very dense, hard, and brittle, weighing 170 lbs. per cu. ft. As the stone is paid for by the ton, instead of by the cubic foot, it is advisable to use as light stone as is regarded capable of withstanding the waves. Practically, it is a question of using stone from the nearest quarry, as the freight on the stone is the largest item in the cost.

The pile trestle was pushed out at least 800 ft. in advance of the jetty mound, and from this an apron of stone, 3 ft. thick and 80 ft. wide, was formed by throwing the stone by hand from the cars. (Fig. 3). At least one-third of the pieces in the apron were to be one-man stone, and no piece was to weigh more than 500 lbs. Quarry run is used, including spalls and chips weighing only a few pounds. This apron takes the place of the brush mattress; it is unaffected by the teredo, and the small and large pieces fit together, forming a floor for the mound. The main object of this apron is to protect the piles in the trestle from scour; it does, however, support the center of the jetty. As the stone is thrown by hand from the side of the car and not placed by slope, it naturally falls into two mounds on each side of the track which are subsequently leveled down by the waves so as to form a continuous apron. In the deeper water the stone has farther to fall and, consequently, is more scattered; at the outer end the width of the apron is about 40 ft. It would be better if this apron were to project 10 ft. on each side of the completed jetty, at least on the channel side, to prevent the slope blocks from undermining by currents racing along the jetty. The slope blocks then settle in the sand and, exposing the crest blocks to wave action, they are rolled down the side of the jetty. It would be necessary to place this extra width either from barges or to use a light derrick with skips on a car. The barge method would probably be cheaper. The barge would be anchored fore and aft along the line of the jetty; and with lines moved across the line of the jetty, distributing the material uniformly.

On top of the apron is placed a core of quarry run of the stone weighing between 15 lbs. and 2 tons. This portion of the jetty is known as the mound. It is unloaded from the cars by manual labor, the larger pieces being pushed over the sides of the flat cars by pinch bars, pieces of steel about 5 ft. long, drawn to a sharp point at one end and at the other flattened to a wedge shape and about 4 or 5 ins., bent to an angle of 45°. This overlaps the apron on each side by about 5 to 10 ft. The mound extends to 1 ft. above mean low water. As placed from the cars its top width is about 20 ft., with side slopes of 1 on 1.

The slopes below mean low tide are covered about 6 ft. thick with stone weighing not less than 3 tons, with average weight of 5 tons; but increasing in weight as the work advances gulfward to a minimum weight of 6 tons and average of 10 tons. Next is placed the crest covering of three rows of blocks, placed on a bedding of small stone at an elevation of 1 ft. above mean low water, and so arranged that the pieces bond together, to prevent any direct flow of water through the crest. The top of the crest is 5 ft. above mean low water, and the width varies from 15 ft. to 20 ft.

The slopes above water and alongside the crest are the last to be placed. These blocks and the crest blocks are approximately the shape of a rectangular parallelopipedon and weigh at the inner end of the jetty 5 and 6 tons, and for the outer half 8 to 12 tons. The side slopes are about 1 on 2.

The slope and crest blocks are handled by a derrick, which is built on a standard flat car and operated by a 25-h. p. hoisting engine. Its capacity is from 10 to 12 tons. The car is secured to the trestle by chains and clamps, and loaded cars are brought to it one at a time by the locomotive to be unloaded. About 12 cars per day can be unloaded. In placing, the inspector uses care to see that the various pieces dovetail into each other with the minimum amount of voids. Large cavities and gaps between the blocks are filled up with smaller stone.

Where the incompleted structure is liable to serious damage from waves, as small a length of jetty as practicable is under construction at any one time. Generally the trestle is 200 ft. in advance of the apron; the apron should be 1,000 ft. in advance of the mound, and the mound protected below water as fast as possible. The portion above water can wait. In winter, the work should be kept well closed up. The profiles of the South Jetty show that when the apron is kept about 1,000 ft. ahead of the mound in 15 ft. of water the amount of scour when the mound is placed is about 2 ft., but when, owing to the stone failing to arrive from the quarry in correct proportions, the mound is advanced to within 200 or 300 ft. of the end of the apron, the scour is as much as 7 ft.

The groin on land was built of a mound of riprap, of stone weighing from 15 lbs. to 2 tons, without crest or slope covering. Its top was 8 ft. above mean low water, width 14 ft., and slopes 1 on 2. Before placing the stone, the sand was removed under the central portion of the groin to an elevation of 2 ft. above mean low water. On either side, trenches 10 ft. wide were excavated to the level of mean low water, extending to the outside edges of the groin. These trenches were then filled with small riprap to an eleva-

TABLE I.

Station.	Depth of water, Feet.	Trestle per linear foot.	Apron & Mound. Tons.	Apron & Mound. Cost.	Slope. Tons.	Slope. Cost.	Crest. Tons.	Crest. Cost.	Total per linear foot.
0–20	4.0	[illegible]	8.48	$39.10	2.08	$11.00	2.80	$12.67	[illegible]
20–30	[illegible]	[illegible]	18.60	[illegible]	2.30	11.35	2.00	13.11	67.71
30–40	11.5	[illegible]	19.71	82.17	[illegible]	[illegible]	[illegible]	14.72	[illegible]
40–50	7.3	[illegible]	17.29	82.22	11.09	[illegible]	[illegible]	[illegible]	[illegible]

*Abstracted from a paper by Maj. Geo. P. Howell, U. S. A., in "Professional Memoirs," June-September, 1911.

Appendix D
Stream Navigability Investigation for Sonoita Creek

Stream Navigability Investigation

for

Sonoita Creek

From: the Headwaters
To: Santa Cruz River

Prepared for:

Arizona State Land Department
1616 West Adams Street
Phoenix, Arizona 85007
(602) 542-4621

June 2000

Prepared by:

JE FULLER
HYDROLOGY & GEOMORPHOLOGY, INC.

5235 S. Kyrene Road, Suite 205
Tempe, Arizona 85283

In Association With:

Stantec

Stantec Consulting
7776 Pointe Parkway
Suite 290
Phoenix, AZ 85044

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PREFACE

This report was prepared under contract to the Arizona State Land Department (ASLD). This report summarizes information gathered relating to the navigability of Sonoita Creek in southeastern Arizona. Information presented in this report is intended to provide data for the Arizona Navigable Stream Adjudication Commission (ANSAC) from which ANSAC can make a recommendation to the Arizona Legislature regarding the navigability of the stream. This report does not make a recommendation or draw any conclusions regarding title navigability.

The report consists of the following parts:

- Historical information from periods prior to and including the time of statehood are discussed with respect to river uses, modes of transportation, and river conditions.
- Hydrologic and geomorphic information are presented to document both past and present stream conditions as they relate to navigability.
- Land ownership information is presented in GIS format to identify the location of public vs. private land boundaries.

This study was performed by JE Fuller/ Hydrology & Geomorphology, Inc. (JEF), and Stantec Consulting, Inc. (SC). The study was completed under a Continuing Services Addenda to Stantec's On-call Contract No. 08 for the ASLD on behalf of ANSAC. Project staff included: V. Ottosawa-Chatupron/ASLD, Project Manager; J. Fuller/JEF, Project Manager; J. Wallace/JEF, Project Engineer; and T. Lehman/JEF, GIS Task Leader. Data summarized in this study were obtained from numerous agencies, libraries, and collections named within the report. Use of this document is governed by ASLD and ANSAC.

EXECUTIVE SUMMARY

JE Fuller/ Hydrology & Geomorphology, Inc. (JEF) was retained by the Arizona State Land Department (ASLD) to prepare a document with information related to the navigability of Sonoita Creek. The study reach extends from the headwaters near Sonoita, Arizona, to its confluence with the Santa Cruz River near Rio Rico, Arizona (Figure ES-1). The table below shows the latitude and longitude of the beginning and ending points of the study reach. ASLD will present the report to the Arizona Navigable Streams Adjudication Commission (ANSAC).

Table ES-1. Sonoita Creek Navigability Study Reach Limits		
Location along Cienega Creek	**Latitude**	**Longitude**
Santa Cruz River Confluence	32°27.7'N	110°58.8'W
Headwaters divide	31°41.0'N	110°39.5'W

The basic approach to this study was to develop a database of information to be used by ANSAC in making recommendations concerning 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:

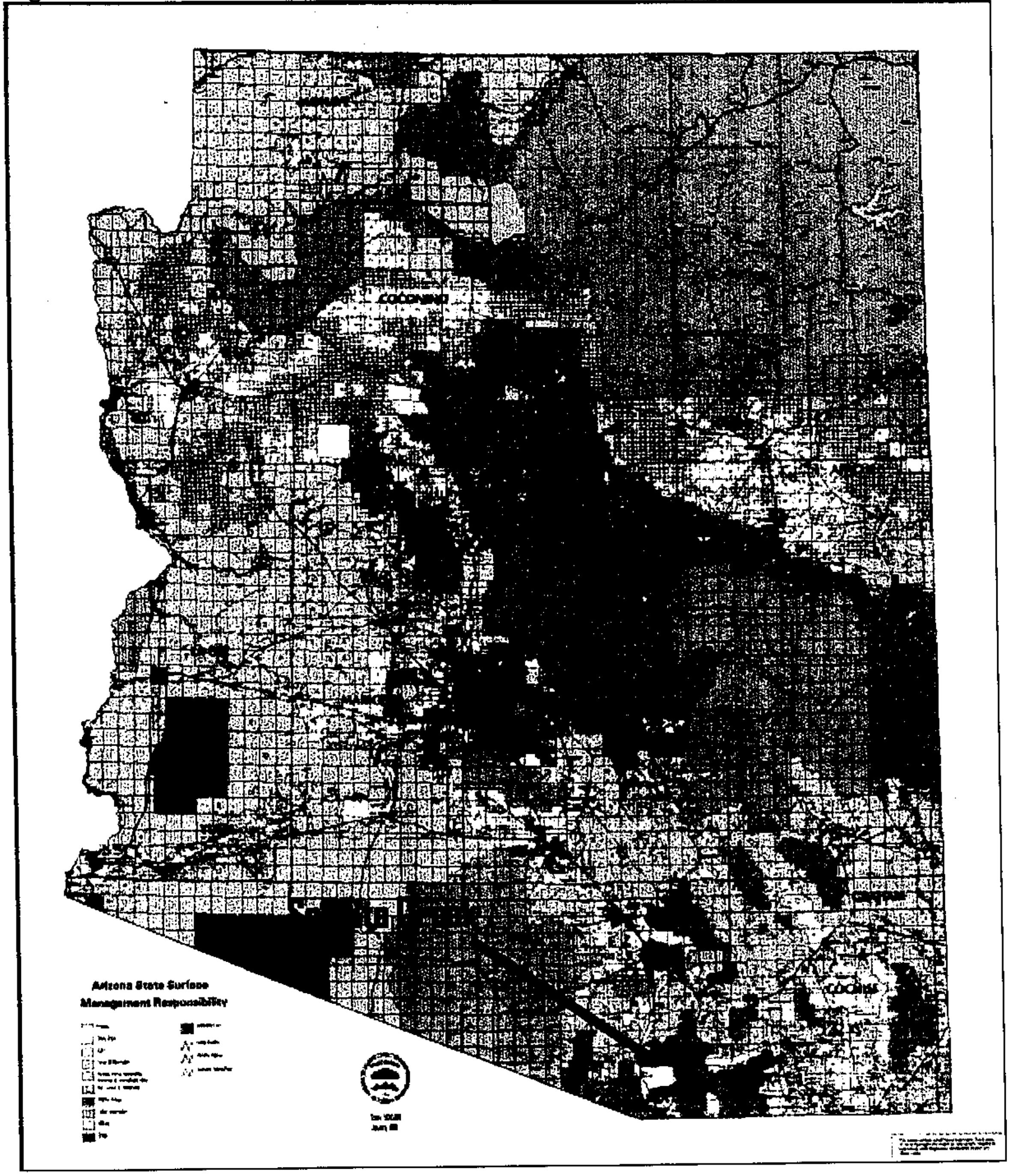
- Historical Uses of the Stream. Data describing actual uses of the stream as of the time of statehood were collected to help answer the question, "Was the stream used for navigation?"

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

Specific tasks for the study included agency contact, a literature search, summary of data collected from agencies and the literature, and preparation of a final report. The objectives of the agency contact task were to inform community officials of the study, to obtain information on historical and potential stream uses, and to obtain access to data collected by agency personnel on the stream. For the latter task, public officials from agencies having jurisdiction along the stream segments were contacted. The objective of the literature search was to obtain published and unpublished documentation of historical stream uses and stream conditions. Information collected from agency contacts was supplemented by published information from public and private collections.

The literature search focused on three subject areas: (1) history, (2) hydrology and geomorphology and (3) land ownership. Historical data provide information on actual stream uses as of the time of statehood, but also provide information on whether stream conditions would have supported navigation. This document summarizes uses of the stream and the adjacent river valley in historic times, with special emphasis on the establishment, growth, and development of towns, irrigation systems, and commercial activities where applicable.

Figure ES-1: Sonoita Creek Location Map



Hydrologic/hydraulic data are the primary source of information regarding susceptibility to navigation. These data include estimates of flow depth, width, velocity, and average flow conditions as of the time of statehood, based on the available modern records for natural stream conditions as of the time of statehood, as well as for existing stream conditions. Existing state land ownership data were compiled into a GIS database that identified the location of public vs. private land along the stream. The results of the data collection are summarized in the following paragraphs.

History

Archaeological studies indicate that human occupation of the Sonoita Creek area dates back to 2000 BC. Exploration of the area by the Spanish began in the 1600's. The first Anglo-American settlement in the Sonoita Valley was at Fort Buchanan, which was established on Sonoita Creek in 1857. Soon after, cattle ranching began in the Sonoita Valley to supply beef to the fort. The first railroad through the Sonoita Valley was the New Mexico and Arizona line, which began service in 1881, and connected the Southern Pacific Railroad at Benson with the Mexican Railroad at Nogales. During the late 1800's Patagonia became established as a shipping center for cattle and mining ore. Historical references to Sonoita Creek are scarce, although the record indicates that the stream was used for irrigation and watering of cattle. A 1912 photograph of Sonoita Creek shows a shallow surface flow perhaps a few inches in depth. No record of boating on Sonoita Creek was identified in the course of this study.

Hydrology & Geomorphology

Sonoita Creek drains a 265 square mile watershed that extends to the tops of the Santa Rita and Patagonia Mountains. The stream consists of sandy channel 10 to 20 feet wide which flows within a floodplain that ranges from 100 to 2,000 feet wide. The banks of the main channel are lined with riparian or grassland vegetation. No evidence was collected that indicated that the location or alignment of the stream has varied significantly since the time of statehood.

Most of the stream is normally dry, except the reach at the Nature Conservancy's Patagonia-Sonoita Creek Preserve and at Patagonia Lake. Patagonia Lake was formed by construction of a dam in 1968 to regulate the downstream water supply, and is now owned and operated by the Arizona State Parks Department. Estimated flow depths and widths for Sonoita Creek at typical flow rates indicates that acceptable boating conditions do not exist except during small floods. There is no evidence in the record to suggest that Sonoita Creek was ever used for commercial or recreational boating of any kind in the past, except on Patagonia Lake (created in 1968).

Land Ownership

A Geographic Information System (GIS) mapping product was developed depicting the spatial relationship between the studied stream and land ownership. Mapping of the study area was performed utilizing ESRI ArcView 3.2 GIS software. The base layers for the GIS were obtained from the Arizona Land Resources Information System (ALRIS) maintained by the Arizona State Land Department (ASLD) as modified by Stantec Consulting Inc. for the ANSAC Small Watercourse and Minor Watercourse Pilot Study. In addition, floodplain data from the Federal Emergency Management Agency (FEMA) National Flood Insurance Program (NFIP) Q3 Flood Data were processed for presentation with the Stantec data. Finally, the U.S. Geological Survey (USGS) 100,000 series digital raster graphic (DRG) maps were used as supplemental background for these maps.

Navigability Criteria

A.R.S. Section 37-1128 mandates a presumption of non-navigability if certain criteria apply to the study reach as of February 14, 1912. Data developed as a part of this study are summarized below for each of those criteria established by A.R.S. Section 37-1128 (each numbered item lists the criteria in italics followed by the associated finding of the study):

1. *The stream flowed only in direct response to precipitation and was dry at all other times.* Some reaches of Sonoita Creek are perennial or intermittent, flowing year-round in response to discharge of springs, interception of groundwater, and sustained runoff. Most reaches are normally dry and flow only in direct response to precipitation.

2. *No sustained trade and travel occurred both upstream and downstream in the watercourse.* No evidence was found to indicate that sustained trade or travel occurred in boats either in the upstream or downstream direction on Sonoita Creek.

3. *No profitable commercial enterprise was conducted by using the watercourse for trade and travel.* No evidence was found to indicate that commercial enterprise of any kind was conducted using the watercourse for trade or travel in boats, although the creek alignment was probably used to drive cattle.

4. *Vessels customarily used for commerce on navigable watercourses in 1912, such as keelboats, steamboats or powered barges, were not used on the watercourse.* There is no evidence to suggest that any types of vessels were ever used on Sonoita Creek.

5. *Diversions were made from the watercourse to irrigate and reclaim land by persons who made entries under the Desert Land Act of 1877.* No evidence that entries under the Desert Land Act of 1877 were made for diversion of flow from Sonoita Creek. The natural flow of Sonoita Creek was diverted for irrigation purposes at several locations within the study area, and continues to be stored and used at Patagonia Lake.

6. *Any boating or fishing was for recreational and not commercial purposes.* No evidence was found of boating or commercial fishing on Sonoita Creek as of the time of statehood. Fish recorded in the natural portions of Sonoita Creek include minnows

and other non-sport or commercial species. Patagonia Lake is stocked with sport fish for recreation purposes.

7. *Any flotation of logs or other material that occurred or was possible on the watercourse was not and could not have been regularly conducted for commercial purposes.* No record of use of Sonoita Creek for flotation of logs or other material was found in historical documentation.

8. *There were bridges, fords, dikes, manmade water conveyance systems or other structures constructed in or across the watercourse that would have been inconsistent with or impediments to navigation.* The research did not reveal evidence of any structures that would have been an impediment to navigation at the time of statehood. The dam on Sonoita Creek at Patagonia Lake was constructed in 1968. It is likely that there were numerous fords or other crossings existing along the 30 mile study reach. Some of these structures may have been impediments to some types of navigation.

9. *Transportation in proximity to the watercourse was customarily accomplished by methods other than by boat.* Based on the evidence collected, transportation in proximity to the stream was customarily accomplished by foot, horse, wagon, or railroad as of the time of statehood.

10. *The United States did not regulate the watercourse under the Rivers and Harbors Act of 1899.* No evidence was found in the research to indicate that Sonoita Creek was regulated under this code as of the time of statehood.

INTRODUCTION

Information presented in this report is intended to provide data for the Arizona Navigable Stream Adjudication Commission (ANSAC) from which ANSAC can make a recommendation to the Arizona Legislature regarding the navigability of Sonoita Creek. This report does not make a recommendation or draw any conclusions regarding title navigability. The report consists of the following parts:

- History
- Hydrology & Geomorphology
- Land Ownership

"Sonoita" is a Spanish word meaning a small wetlands. Sonoita Creek was named for the wetlands that were once found along its river valley prior to settlement of the area by Anglo-Americans. Sonoita Creek is located in Santa Cruz County in southeastern Arizona. The Sonoita Creek watershed is bounded by the Santa Rita Mountains to the north, the Canelo Hills to the east, the Patagonia Mountains to the south, and the Santa Cruz River Valley to the west (Figure 1).

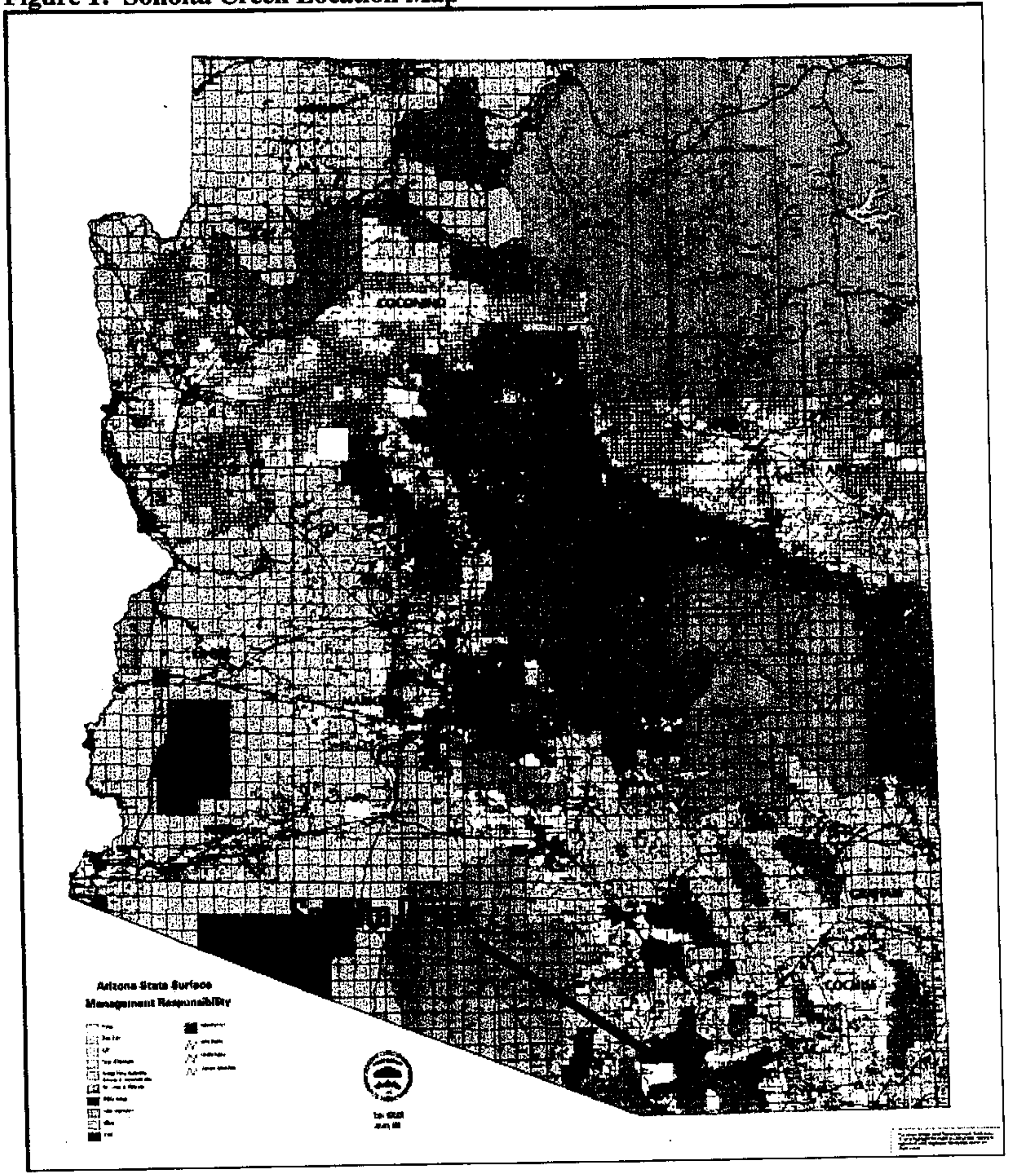
HISTORY

Early Explorers and Settlers

Archaeological data indicate that human occupation of the Sonoita Valley dates back to 2000 BC (Nature Conservancy, 2000), and includes an extended period of occupation by the Hohokam culture up to 1400 A.D (Eddy & Cooley, 1983). Exploration of the area by the Spanish began in the 1600's when Father Eusebio Francisco Kino, a Jesuit missionary explorer, delivered 150 head of cattle to the rancheria Sonoita located near the headwaters of Sonoita Creek (Dowell, 1978). The Jesuits were driven from the area in 1751 by a Native American rebellion and were replaced by Franciscans in 1767. From the early 1780's to the mid 1800's, the Spanish and Mexican governments granted large land holdings known as "floats" to local cattlemen. In 1820, the San José de Sonoita Land Grant was issued by Mexico (Nature Conservancy, 2000), although the settlers on the land grants and the rest of the Sonoita Valley continued to experience problems with raiding Indians. Apache raids drove many of the cattle raisers away from their ranches (Dowell, 1978).

The first Anglo-American settlement in the Sonoita Valley was at Fort Buchanan, which was established on Sonoita Creek in 1857. The fort was built about midway between the towns of Sonoita and Patagonia, and was established to help protect new mining activity near Tubac from Apache Indian raids. Soon after the Fort Buchanan was founded, cattle ranching began to flourish in the area to supply beef to the fort and local miners. Because Fort Buchanan was isolated and difficult to maintain, it was ineffective in stopping raids and was abandoned in 1861 at the outset of the Civil War. Camp Crittenden, established in 1867 at almost the same location as Fort Buchanan, was somewhat more successful but was abandoned in 1873 in favor of a location at Fort Huachuca near Sierra Vista.

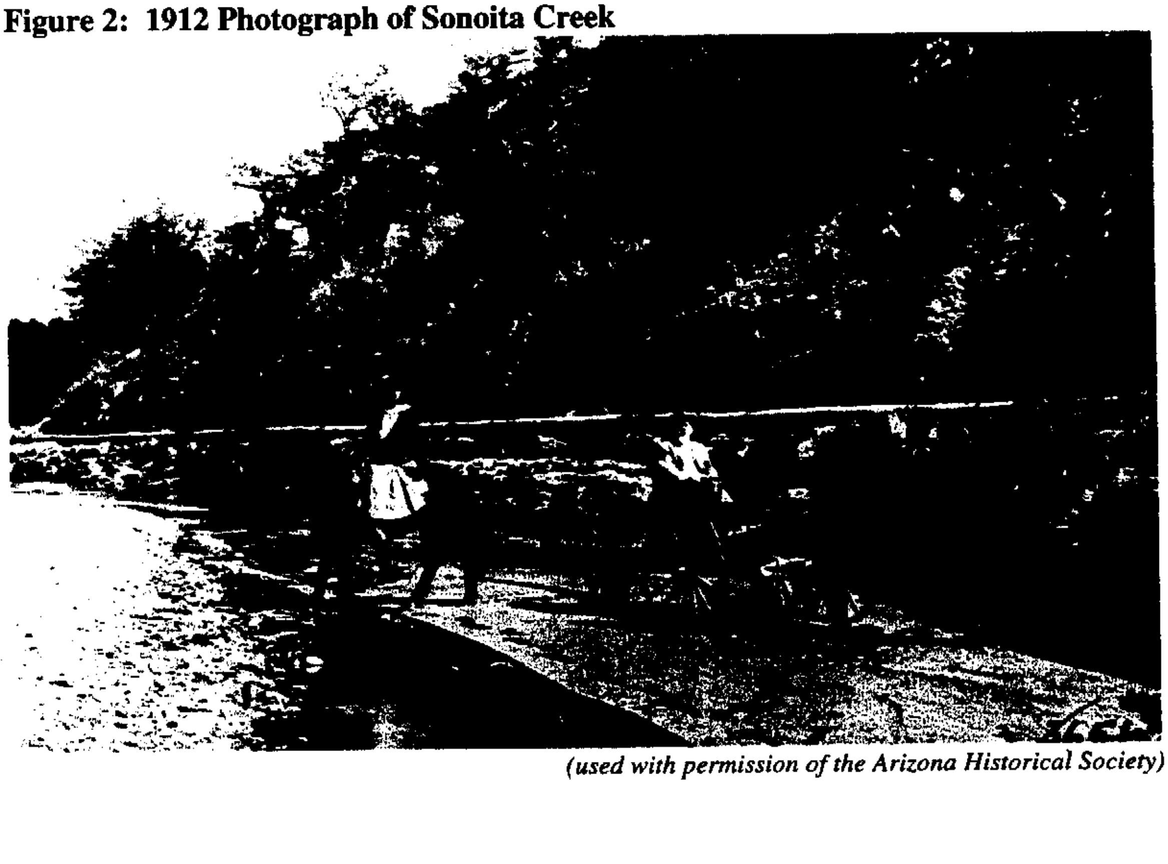
Figure 1: Sonoita Creek Location Map



The first railroad through the valley was the New Mexico and Arizona Line, which began service in 1881, and connected the Southern Pacific Line at Benson to the Mexican Railroad at Nogales. One of the first Anglo settlers in the Sonoita Valley was Rollin Richardson, who came to the valley in 1882 (Mihalik, 1985). Richardson acquired ownership of much of the land stretching along the Sonoita Valley between the towns of Patagonia and Sonoita. In 1896 Richardson moved to what is now the site of the Town of Patagonia, located on Sonoita Creek. The following year, in 1897, the Southern Pacific Railroad took over the New Mexico and Arizona line and Patagonia became established as a shipping center for cattle and mining ore. Hotels, boarding houses, an opera house, restaurants, and bars were built to serve the expanding population (Patagonia Community Association, 2000).

Historical references to the condition of Sonoita Creek are scarce. However, the Pennington family was known to have used irrigation ditches from Sonoita Creek to irrigate a field behind Fort Buchanan in 1857 (Serven, 1965). A photograph found at the Arizona Historical Society (AHS) shows a horse and rider alongside a horse and buggy on Sonoita Creek in 1912 (Figure 2). The photograph shows shallow surface flow perhaps a few inches in depth and about 20 feet wide, with a pipeline on the far bank. The location of the photograph along the stream is not known.

Figure 2: 1912 Photograph of Sonoita Creek



(used with permission of the Arizona Historical Society)

Wildlife and Habitat

The Sonoita Valley was home to a variety of flora and fauna in the years prior to statehood. During his stay at Fort Buchanan on Sonoita Creek (1857-1861), a medical officer named L. Irwin noted that the stream vegetation included ash, sycamore, buttonwood, cottonwood, hackberry, black walnut, elm, and mesquite. In the same report Irwin notes wildlife of the area to include panthers, leopard, wildcat, lynx, grey wolf, coyote, red fox, grey fox, grizzly and brown bear, badger, pole cat, weasel, raccoon, beaver, various species of squirrels, antelope, and white and black tailed deer (Serven, 1965). Interestingly, fish are not mentioned in the report.

The Sonoita Valley is still home to a wide variety of wildlife and habitat. The Nature Conservancy, which operates the Patagonia-Sonoita Creek Preserve downstream from the Town of Patagonia, purchased the preserve in 1966 as its first Arizona project with the support of the Audubon Society. The Nature Conservancy (2000) describes the preserve as follows:

> *"The preserve protects a magnificent example of the cottonwood-willow riparian forest. These are the largest (over 100 ft. tall) and oldest (130 years old) Fremont cottonwood trees anywhere. It is one of the few remaining sites where this once-common forest type still persists. Arizona black walnut, velvet mesquite, velvet ash, canyon hackberry, and various willows are found in slightly different habitats throughout the preserve. Remnant wetlands or Sonoitas, a once-common feature of Sonoita Creek floodplain, and the most endangered natural community in Arizona, are also found at the Preserve. A significant number of rare and sensitive plant species are found in the Sonoita Creek watershed. The Patagonia-Sonoita Creek Preserve is best known for the over 260 bird species observed here. Several unique, unusual, and rare species such as the gray hawk, green kingfisher, thick-billed kingbird, northern beardless tyrannulet, violet-crowned hummingbird, and rose-throated becard attract birdwatchers from around the world. Other animals utilizing the preserve include mountain lion, bobcat, white-tailed deer, javalina, coatimundi (chulo), coyote, desert tortoise, occasional rattlesnakes and several toads and frogs. This perennial stream, fed by surface and underground springs, is one of the very few remaining which supports four native fish species, among the most endangered in the southwest."*

Ranching, Agriculture and Mining

Based on the literature review, the economy of the Sonoita Valley in the late 1800's and early 1900's was largely supported by mining and ranching, while crop agriculture played a minor role. There was considerable mining activity in the Patagonia Mountains and surrounding ranges in the late 1800's. However, by the early 1900's Santa Cruz County no longer had a major role in the Arizona mining economy (Seibold, 1979), although small claims are still active in the area. The ghost towns of Mowry, Duquesne, Harshaw, Washington Camp, and others bear mute testimony to the glory days of mining in the Sonoita Valley. Ranching appears to have been the other main economic mainstay at the time of statehood. The Rail X Ranch occupied much of the Sonoita Valley during the early 1900's (Seibold, 1983).

Transportation

Transportation through the Sonoita Valley was primarily by foot, horseback, horse-drawn wagon, or railroad. There is no record in the literature of boating or other use of Sonoita Creek to run passenger craft or typical commercial craft such as keelboats, steamboats, or powered barges. The first railroad through the valley was the New Mexico and Arizona (NM&A) Line constructed along nearly the entire length of Sonoita Creek in 1881-1882. The line was built between Nogales and Benson to connect the Southern Pacific Railroad with the Sonoran Railway in Mexico (Walker & Bufkin, 1979). At the height of its traffic, the NM&A provided daily service to and from the Mexican port of Guaymas on the Gulf of California (Nature Conservancy, 2000).

The railroad line was apparently susceptible to erosion damage during floods on Sonoita Creek. A storm washed out a number of bridges in 1929 and as a result the NM&A line was abandoned below Patagonia (Thornburg, 1958). In one interesting anecdote, a standoff between two prominent members of the Patagonia community took place during flooding that occurred on Sonoita Creek on August 8, 1937 (Seibold, 1983). The confrontation occurred as debris piled up against the piers of one of the Southern Pacific Railroad bridges over the stream. One of the city fathers, a Mr. R.C. Blabon, advocated demolition of the bridge with a homemade bomb (which Mr. Blabon had with him at the bridge for that purpose) for fear that the clogged bridge would flood the town. However, another prominent citizen and Southern Pacific Railroad foreman, Mr. Charlie Mapes, argued to wait for his signal to blow the bridge. Mr. Mapes prevailed and the debris slowly cleared and no damage was done.

Other Uses of Sonoita Creek

Apart from the use of the water in the stream for grazing of cattle and isolated uses for irrigation, there is no indication in the research to indicate that other use was made of the stream as of the time of statehood.

Summary

Archaeological and historical records indicate that the Sonoita Valley has been occupied for several thousand years. Anglo occupation of the area began with Spanish exploration in the 1600's, although it was not until Fort Buchanan was established on Sonoita Creek in 1857 that the area became permanently inhabited by Anglo-Americans. Settlement consisted primarily of cattle ranching operations with small farms and mining towns. The New Mexico and Arizona Line railroad reached the area in 1881, and led to establishment of the town of Patagonia as a shipping center for cattle and mining ore. Historical references to Sonoita Creek are scarce, but the record indicates that it was used for irrigation and watering of cattle. A 1912 photograph of the stream shows a shallow surface flow perhaps a few inches in depth. There is no record in the literature of boating of any kind on Sonoita Creek.

HYDROLOGY

Geographic and Hydrologic Setting

The Sonoita Creek watershed extends from the confluence with the Santa Cruz River near the community of Rio Rico, Arizona to the headwaters located near the community of Sonoita, Arizona (Figure 3). The 265 square mile watershed is bounded by the Santa Rita Mountains to the north, the Canelo Hills to the east, the Patagonia Mountains to the south, and the Santa Cruz River Valley to the west, and ranges from just over 9,400 feet at Mt. Wrightson to 3,400 feet at Rio Rico. Vegetation within the watershed varies from Arizona Upland desert scrub in the lower elevations, to Oak-Woodland and Ponderosa Pine in the upper elevations of the Santa Rita Mountains. Vegetation along Sonoita Creek varies depending on stream conditions. Cottonwood-willow riparian forests are found at some wetter locations, and Upper Sonoran desert and grassland dry wash species such as palo-verde and mesquite are found along dry reaches. Table 1 provides a number of watershed characteristics for Sonoita Creek as measured at the U.S. Geological Survey (USGS) stream gauge near Patagonia (#09481500), which is located a short distance upstream of Patagonia Lake (Figure 3).

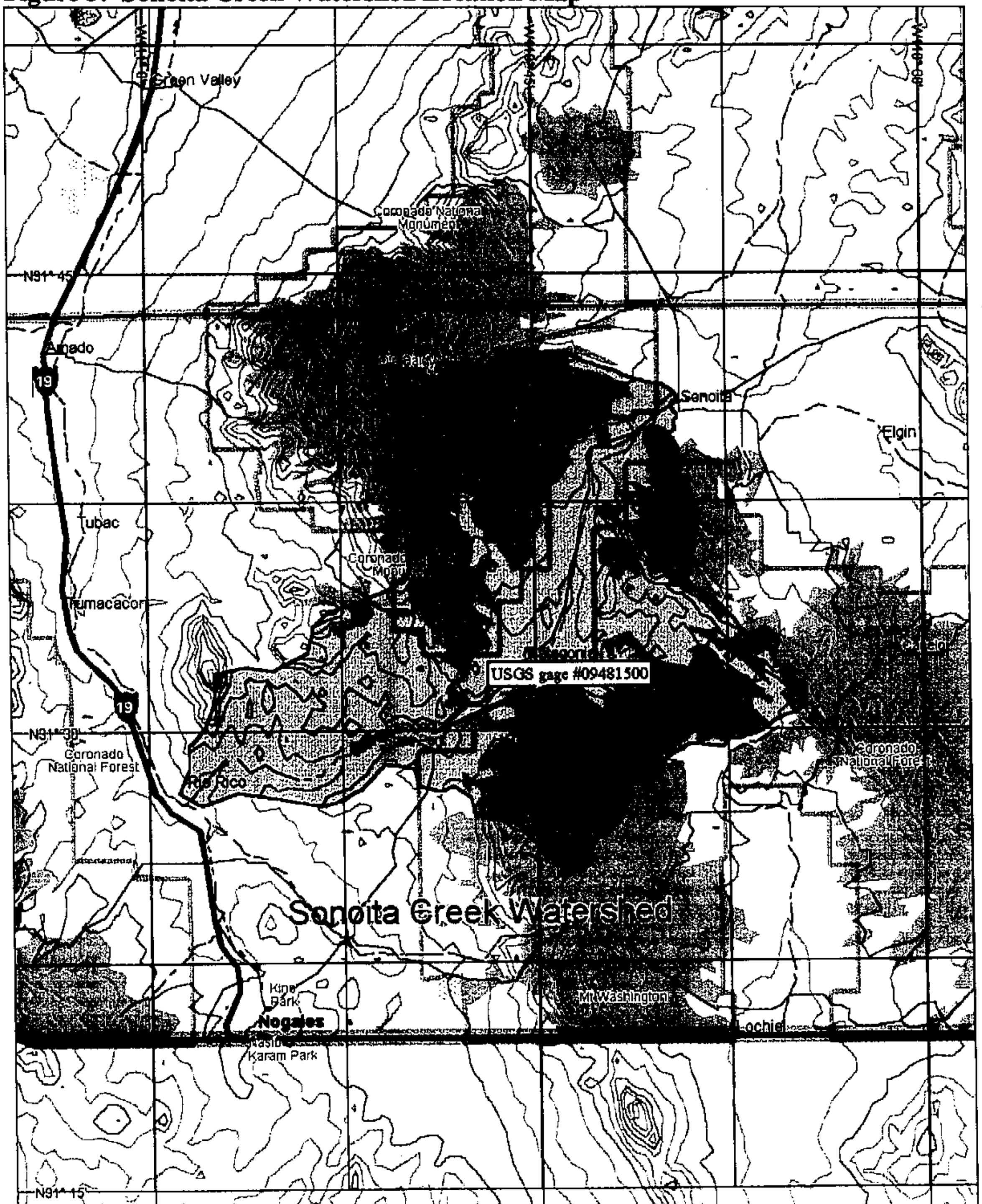
Table 1. Sonoita Creek Navigability Study
Stream Characteristics Sonoita Creek near Patagonia (#09481500)

Watershed Characteristic	Value
Stream length	21.7 mi.
Main channel slope	76.7 ft./mi.
Mean basin elevation	4800 ft.
Mean annual precipitation	19.3 in.
Forested area	52 %
Drainage area	209 $mi.^2$
Period of record	1931-33, 1936-72

Data Sources

Hydrologic data for Sonoita Creek are available from the USGS gauge near Patagonia (#09481500). Additional data were collected during the field investigation, and from records and anecdotal information available in the literature. The period of record for the USGS gauge includes 1931-1933 and 1936-1972.

Figure 3: Sonoita Creek Watershed Location Map



3-D TopoQuads Copyright © 1999 DeLorme Yarmouth, ME 04096 1 mi Scale 1 : 300,000 Detail 8-7 Datum WGS84

Statehood Hydrology

No hydrologic records of stream flow from the year of statehood (February 14, 1912) were identified during this study. Hydrologic data for the time of statehood are therefore limited to anecdotal accounts, a single photograph, and the survey notes of Government Land Office (GLO) surveyors' notes on file at the Bureau of Land Management Records office in Phoenix. The surveyor notes reviewed were compiled from eight separate surveys (White, 1876a; White, 1876b; White, 1876c; Roskruge, 1883; Wolfley, 1885; Wallace, 1888; Contzen, 1903; Hesse, 1907). Unfortunately, none of the GLO surveys were conducted during the year 1912. The earliest survey was conducted in November 1876, and the latest was dated July 1907. The Sonoita Creek study reach crosses a total of 28 Township and Range section lines. The GLO survey notes made mention of Sonoita Creek on 19 of these 28 section line traverses. The GLO survey notes made specific mention of a dry Sonoita Creek at the following six section line crossings:

1. T20S-R16E. The boundary of sections 24/25 in Township 20 South Range 16 East approximately one mile downstream of the headwaters of Sonoita Creek (June 1885) (Wolfley, 1885)
2. T21S-R16E. The boundary of sections 20/29 in Township 21 South Range 16 East just upstream of the Corral Canyon confluence (November 1876) (White, 1876b)
3. T22S-R16E. The northern boundary of section 5, the boundary of sections 5/6, the boundary of sections 6/7, and the western boundary of section 7 in Township 22 South Range 16 East, upstream of Patagonia (July 1907) (Hesse, 1907)

The thirteen remaining GLO survey references to Sonoita Creek did not specify whether the creek contained running water or was dry. However, surveyor tendencies tend to suggest that lack of any mention of running water implies a dry stream bed. These types of anecdotal accounts indicate that only short reaches flowed perennially in response to springs or shallow bedrock which forced ground water to the surface.

Post-Statehood Hydrology

The USGS stream gauge provided the only systematic record of flow in Sonoita Creek. Tables 2 to 4 and Figure 4 provide a summary of streamflow data and flood frequency predictions based on the USGS records (Pope et. al., 1998). Downstream of the USGS gauge, the natural hydrology of Sonoita Creek was altered by construction of a dam in 1968 at what is known today as Patagonia Lake. An agreement was made with downstream water users to provide for an annual release of water of at least 1,200 acre feet by monthly releases of up to 200 acre feet per month (3.3 cfs), not including spillway flow during floods, to allow for a regular distribution of flow throughout the year (Bradbeer, 1978). In 1974, the 640-acre lake was purchased by the State of Arizona and turned over to the Arizona State Parks Board for management as a recreational facility. Patagonia Lake is located approximately seven miles west of the Town of Patagonia and approximately 1.7 miles downstream of the USGS gauge.

Table 2. Sonoita Creek Navigability Study Mean Monthly Streamflow Data for Sonoita Creek near Patagonia (#09481500)												
Month	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**
Mean	7.5	9.9	5.5	4.1	2.5	1.6	13	25	9.2	3.9	4.0	10
Max	52	96	16	12	10	8.6	112	151	71	20	118	107
Min	1.1	0.99	0.87	0.49	0.06	0.00	0.06	1.5	0.05	0.03	0.32	0.99
Period of Record: 1931-1933, 1936-1972												

Table 3. Sonoita Creek Navigability Study Streamflow Statistics for Sonoita Creek near Patagonia (#09481500)	
Flow Characteristic	**Flow Rate**
Annual Mean Flow	8.1 (cfs)
Maximum Annual Mean	33 (cfs)
Minimum Annual Mean	1.9 (cfs)
Lowest Daily Mean (many dates)	0 (cfs)
Highest Daily Mean (Dec. 20, 1967)	1,780 (cfs)
Max. Instantaneous Peak Flow (Oct. 2, 1983)	16,000 (cfs)
Annual Mean Runoff	5,864 (acre-feet)
Flow value exceeded 10% of the time	11 (cfs)
Flow value exceeded 50% of the time	3.2 (cfs)
Flow value exceeded 90% of the time	0.45 (cfs)

The USGS gage data indicate that the stream is perennial during most years. While the average monthly flow rates are all greater than zero, the minimum average monthly flow is zero for the month of June, indicating that the stream can dry up completely during the driest part of some years. The highest average flows occur during the summer monsoon months of July and August, with a slight rise in average flow rates during the month of February. Field and anecdotal evidence suggests that most of Sonoita Creek flows less frequently than at the USGS gauge.

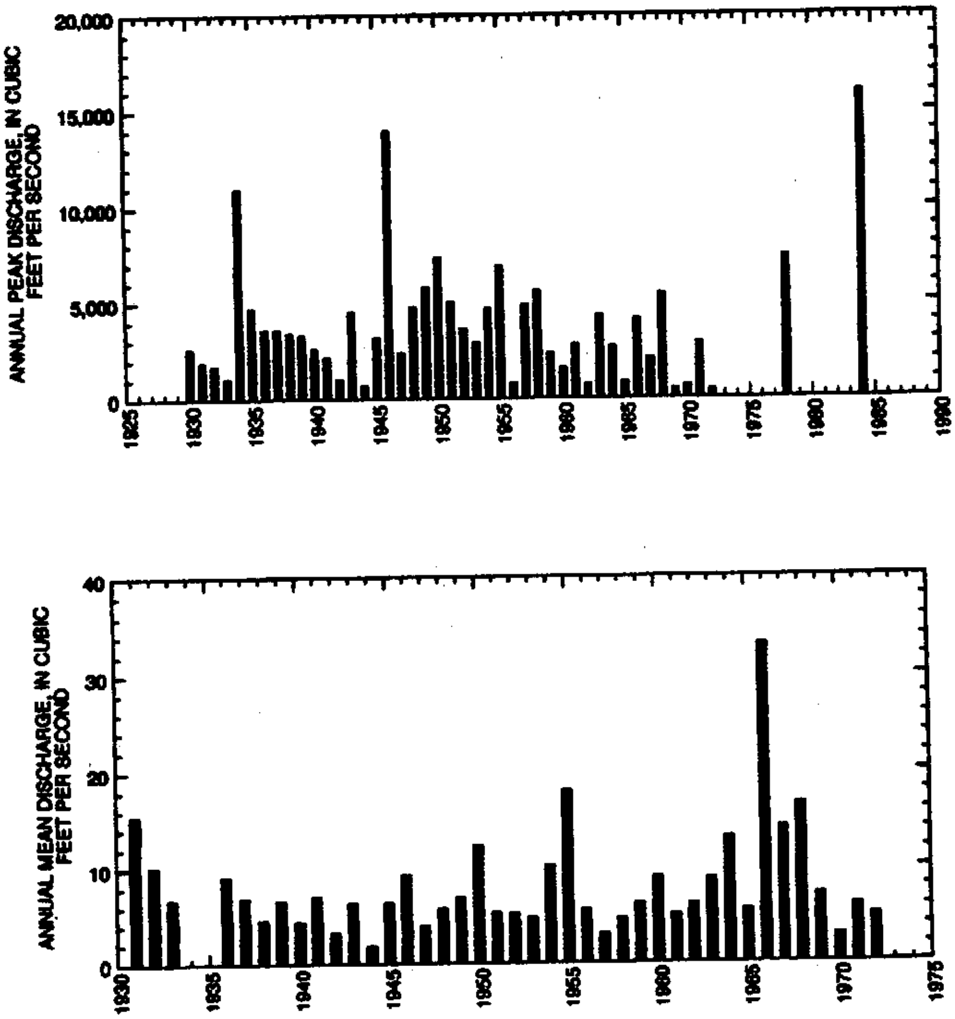
Downstream of the dam at Patagonia Lake, regulated releases average about 3.3 cfs, a rate equivalent to the median (50%) discharge at the USGS gauge. Storage behind the dam effectively moderates the natural flow rate, eliminating small flood peaks and seasonal high flows that originate upstream.

Floods

Scientific records of floods on Sonoita Creek are limited. No specific accounts of flooding on or before February 14, 1912 were found. The largest flood of record on the U.S.G.S. stream gauge near Patagonia had a peak of 16,000 cfs and occurred on October 2, 1983. Other large floods occurred in 1929 and 1937 (See History discussion above), and in 1946 (14,000 cfs, Figure 4). The USGS gauge records that flows occurred every year the gauge was maintained. Most of the annual peaks occurred during the summer monsoon or in early fall. No years of zero flow occurred during the period of record.

Table 4. Sonoita Creek Navigability Study Peak Discharges for Sonoita Creek near Patagonia (#09481500)					
2-year	**5-year**	**10-year**	**25-year**	**50-year**	**100-year**
3,130	5,360	7,190	9,950	12,300	15,100

Figure 4: Annual Discharge Data for Sonoita Creek near Patagonia



Climatic Variation

Research from previous navigability studies (CH2M Hill, 1993) indicates that Arizona's overall climate at statehood was not drastically different from existing or pre-statehood conditions. However, the period around the year 1912 was subject to higher than average stream flow, indicating that streams may have been more likely to have been navigable at statehood, than during other, less "wet" periods of Arizona history.[1] 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.

Geomorphology

The main valley of Sonoita Creek ranges from 10 to 20 miles wide, which is cut by an inner valley less than one-half mile wide to a depth of approximately 100 feet (Bradbeer, 1978). The main channel of Sonoita Creek is a dry sand bed channel approximately 10 to 20 feet wide in most places. The average slope of the channel is about 1.4 percent (0.014 ft./ft.). The channel generally has a wide, shallow cross section, except in the perennial reach near the Patagonia-Sonoita Creek Preserve. A straight to slightly sinuous pattern is present in most of the study reach. Low flows are typically braided, but seasonal floods fill the channel and flow in a single channel pattern. No evidence was identified in the historic record or from field investigation that the plan form or location of the stream varied significantly since the time of statehood.

Hydraulic Characteristics

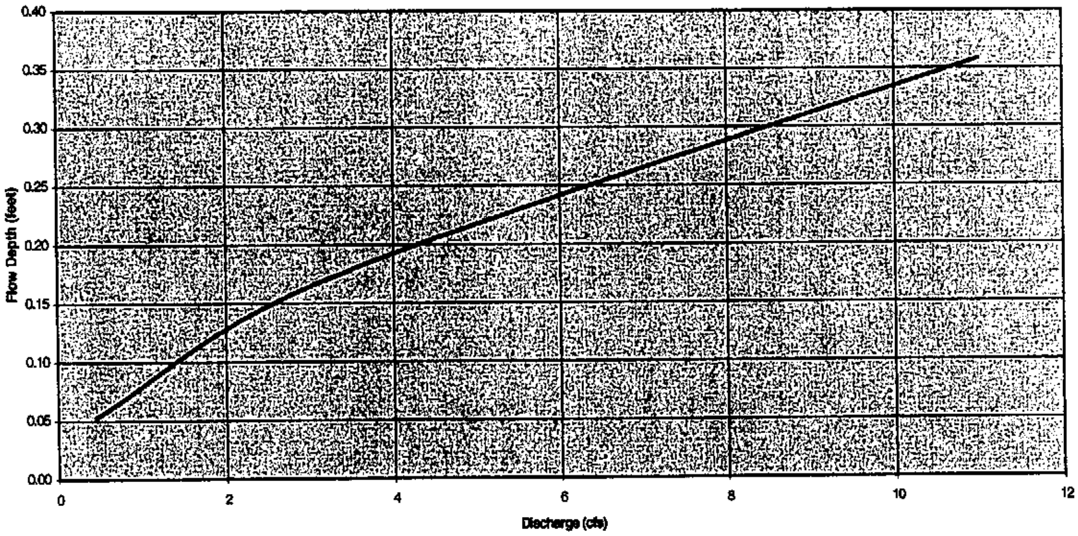
Measured data for typical flow depths and widths for Sonoita Creek as of statehood were not available. Therefore, estimated hydraulic characteristics were developed based on observed stream conditions and historic streamflow records available from the USGS gauge. Table 5 summarizes the range of probable values for stream depth and width at various flow rates. Note that the hydraulic parameters shown below are based on flow data at the USGS gauge site, and probably represent no better than order-of-magnitude estimates of flow conditions at any specific location within the study reach. A rating curve for an assumed cross section developed from field observations is shown in Figure 5.

Table 5. Sonoita Creek Navigability Study
Estimated Range of Hydraulic Characteristics

Flow Duration	Discharge (cfs)	Flow Depth (ft)	Average Velocity (ft/s)	Flow Width (ft)
10 %	11	0.3 – 0.4	1.9 – 2.6	10 – 20
50 %	3.2	0.1 – 0.2	1.2 – 1.6	10 – 20
90 %	0.45	0.0 – 0.1	0.5 – 0.7	10 – 20
Average Annual	8.1	0.2 – 0.4	1.7 – 2.3	10 – 20
2-Year Flood	3,130	8 – 13	19 – 25	10 – 20

[1] Human impacts such as irrigation diversions, etc., have tended to lessen average stream discharge rates obscuring climatic affects on some Arizona streams.

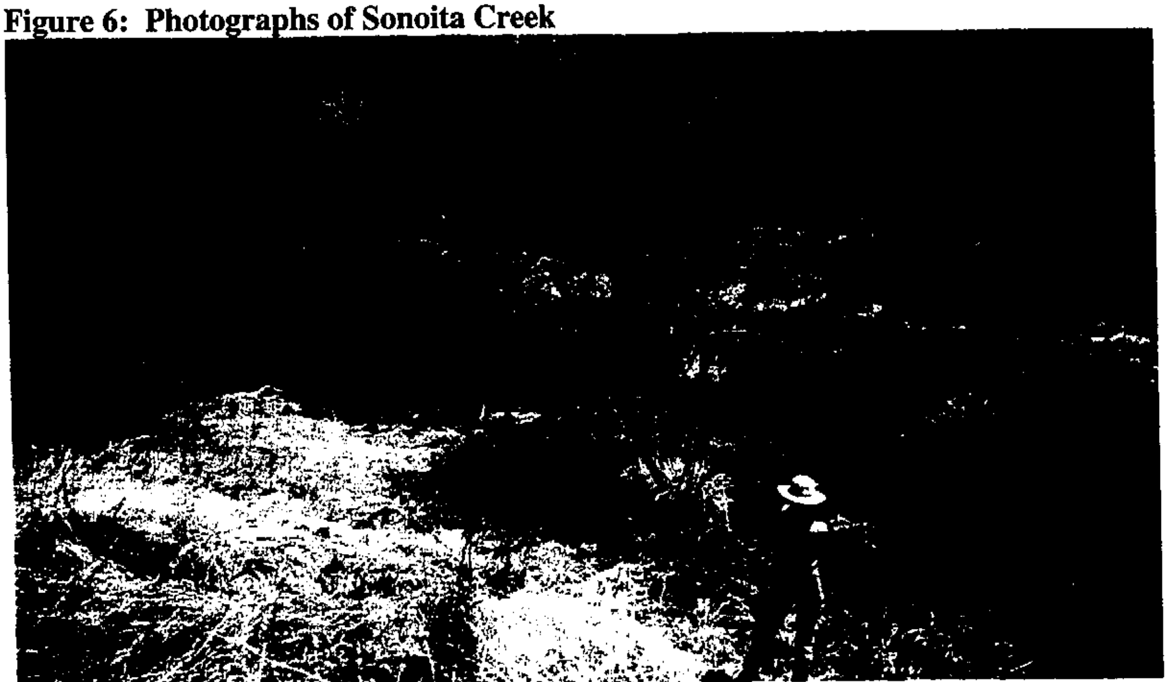
Figure 5. Sonoita Creek Depth-Discharge Rating Curve



Field Investigation

A field investigation was conducted on April 25, 2000 to observe and document typical stream conditions at various locations along its length. Photographs taken at field sites are provided in Figures 6 to 13. The field photographs support the historical descriptions of stream flow conditions, and confirm the variability of flow within the study area.

Figure 6: Photographs of Sonoita Creek

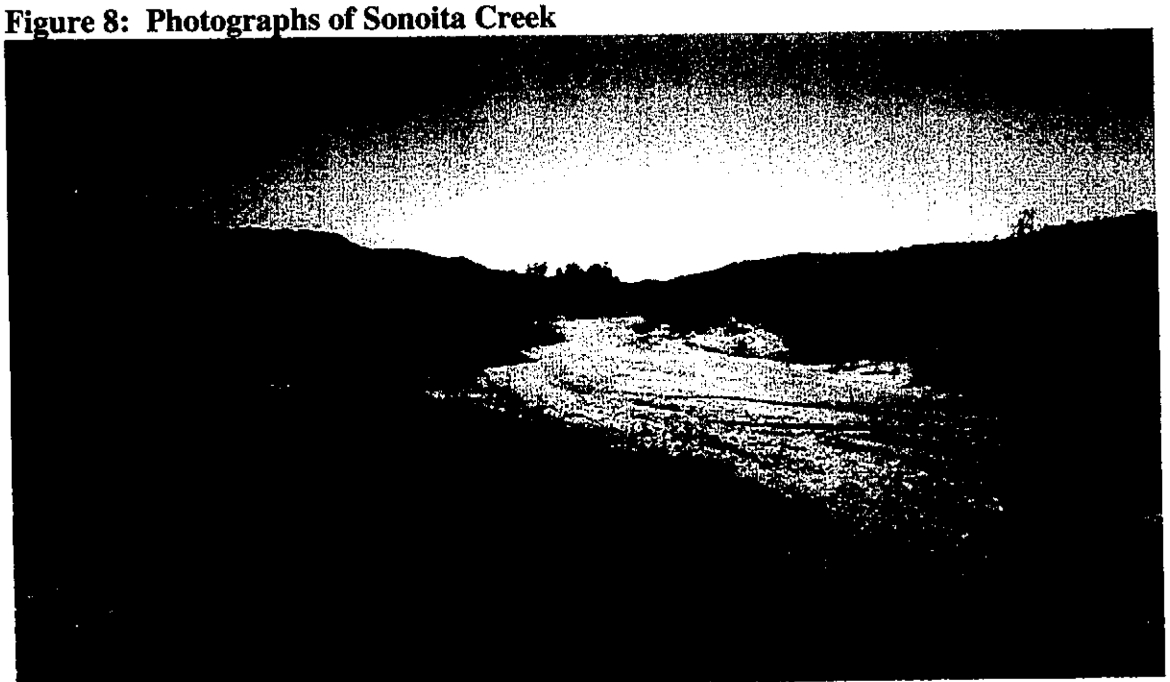


Looking upstream at Cottonwood Spring near the historic site of Fort Buchanan.

Figure 7: Photographs of Sonoita Creek

Looking downstream from Milepost 25 on State Route 82.

Figure 8: Photographs of Sonoita Creek

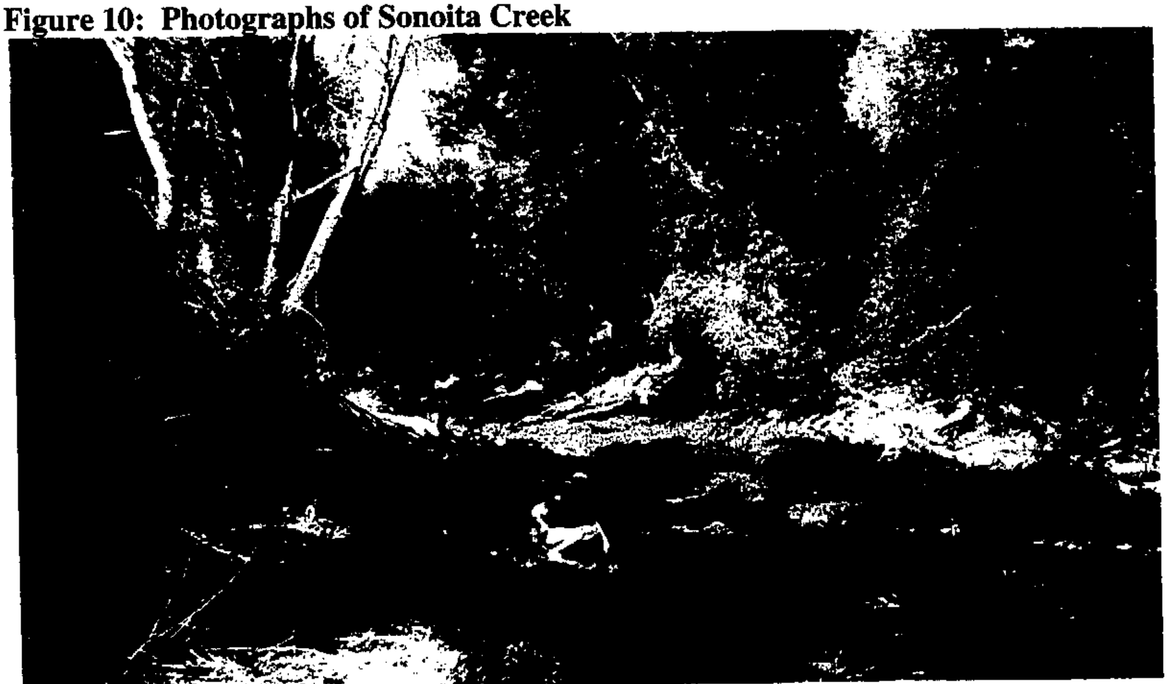


Looking downstream from Rail X Ranch Estates access road located approximately 2 miles east of Patagonia.

Figure 9: Photographs of Sonoita Creek

Looking upstream from within the Town of Patagonia.

Figure 10: Photographs of Sonoita Creek

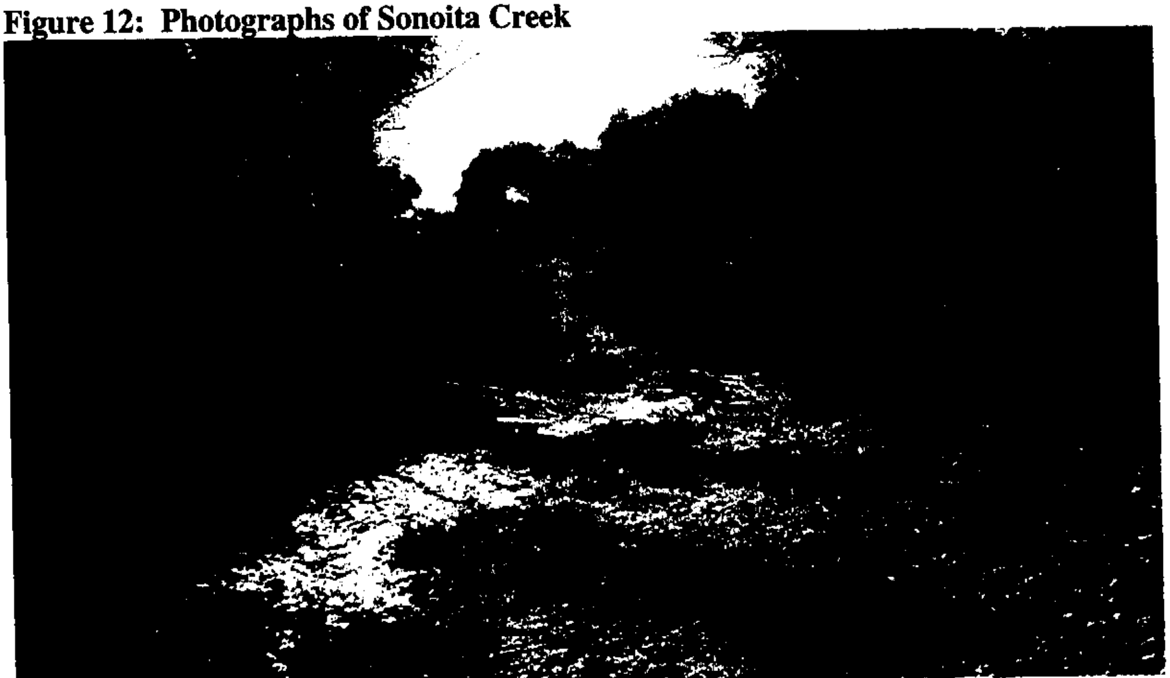


Looking upstream from within the Patagonia Sonoita-Creek Preserve located just west of Patagonia.

Figure 11: Photographs of Sonoita Creek

Closer view of stream within Patagonia-Sonoita Creek Preserve.

Figure 12: Photographs of Sonoita Creek



Looking downstream from the Salero Road crossing approximately 3 miles west of Patagonia.

Figure 13: Photographs of Sonoita Creek

Looking downstream from within the community of Rio Rico near the Santa Cruz River confluence.

Susceptibility to Navigation

Some federal agencies have formally described stream conditions that 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 6 and 7, were developed primarily for recreational boating, not necessarily for commercial boating. Minimum and maximum stream conditions required are summarized in the tables below.

Table 6. 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 7. 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.	5 fps	-	-	10 fps
Source: Cortell and Associates, 1977						

Most Arizona boaters surveyed as a part of previous navigability studies did not agree with the minimum velocity and width criteria given in Table 7. 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 7 are probably intended to indicate what stream conditions are most typically considered "fun."

To evaluate the susceptibility of the study reach to navigation, the depth-velocity-width data for specific discharges shown in Table 5 were compared with boating standards shown in Tables 6 and 7. For the Sonoita Creek gauge location, the data indicate that none of the flows shown in Table 5 would generate acceptable flow depths for use even by canoes, kayaks or tubes, much less by standard commercial craft. Higher flow rates may occur during flash floods, but last only for short periods and would likely be dangerous for boating. Note that the gauge station used for the stream flow data in this assessment was in a reach of perennial flow. Thus the stream flow quantities used in this assessment are most likely higher than flows that would occur elsewhere within the study reach.

Boating

No references to commercial, recreational, or any other type of boating on Sonoita Creek were identified during this study, except on Patagonia Lake, which not built until 1968. No commercial recreational outfitters advertise any operations or excursions on Sonoita Creek.

Summary

Sonoita Creek has perennial, intermittent, and ephemeral reaches that reflect the variety of water supply, subsurface geology, and water use within the river valley. There is no evidence in the record to suggest that the location or alignment of the stream has varied significantly over time, although the stream may have included more wetlands or "Sonoitas" prior to the 1900's. Comparison of estimated flow characteristics for Sonoita Creek with federal boating criteria indicates that acceptable boating conditions do not exist for typical flow conditions. There is no evidence in the record to suggest that Sonoita Creek was used for commercial or recreational boating of any kind in the past, except at the man-made Patagonia Lake. There was no evidence identified for this study that suggests that flow conditions as of the time of statehood would have made the stream susceptible to boating of any kind except possibly during infrequent flood events.

LAND OWNERSHIP

A Geographic Information System (GIS) mapping product was developed depicting the spatial relationship between the studied stream and land ownership. Mapping of the study area was performed utilizing ESRI ArcView 3.2 GIS software. The base layers for the GIS were obtained from the Arizona Land Resources Information System (ALRIS) maintained by the Arizona State Land Department (ASLD) as modified by Stantec Consulting Inc. for the ANSAC Small Watercourse and Minor Watercourse Pilot Study. In addition, floodplain data from the Federal Emergency Management Agency (FEMA) National Flood Insurance Program (NFIP) Q3 Flood Data were processed for presentation with the Stantec data. Finally, the U.S. Geological Survey (USGS) 100,000 series digital raster graphic (DRG) maps were used as supplemental background for these maps. GIS maps for the study reach are attached in Appendix D-1.

Table 8. Sonoita Creek Navigability Study
Base and Reference Layers from ALRIS

Name	Contents
STREAMS	Hydrography consisting of linear features, i.e., streams
SPRINGS	This data set consists of spring locations in Arizona
TRANS123	Statewide transportation data. Linear data representing roads and streets, classes 1, 2, and 3 from the ALRIS database.
LAND	This data set contains a group of integrated data layers. These layers consist of Public Land Survey system data (Township, Ranges and Section), land ownership, and county boundaries.
AZTRS	This statewide coverage consists of the Township, Range, and Section grid lines. This dataset was created by processing the LAND coverage. See the LAND documentation.
HUC	Hydrologic Unit Code areas (drainage basins) in Arizona.
Projection	NAD 27, UTM Zone 12

Ownership Categories

Private
State of Arizona (State Trust)
U.S. Forest Service (Coronado National Forest)
Bureau of Land Management (BLM)
Fort Huachuca
Parks and Recreation

FEMA Floodplains

NFIP Q3 data for Santa Cruz County. ARC/INFO coverages from FEMA converted to ArcView shapefiles and projected to fit with the Stantec data by JEF.

USGS Digital Raster Graphics (DRG)

100,000 scale series DRGs used as additional background map. Includes topography and numerous place names for helpful reference and orientation.

CONTACTS

Agency/Affiliation	Name	Address	Phone
Arizona Historical Society	Ms. Susan Sheehan	949 E. 2nd Street Tucson, AZ 85719	520-628-5774
BLM Tucson Field Office	Ms. Karen Simms	12661 E. Broadway Tucson, AZ 85748	520-722-4289
Santa Cruz County Flood Control District	Mr. Fred Krupp	2150 N. Congress Dr. Nogales, AZ 85621	520-761-7800
U.S. Geological Survey	Mr. Greg Pope	520 N. Park Ave. Suite 221 Tucson, AZ 85719	520-670-6671
BLM Public Records Section	Mr. Jim Hutchison	3707 N. 7th Street Phoenix, AZ 85014	602-650-0511
Patagonia –Sonoita Creek Preserve	Mr. Ed Wilk	P.O. Box 815 Patagonia, AZ 85624	520-394-2400
Patagonia Lake State Park	Ms. Sarah Griffith	P.O. Box 274 Patagonia, AZ	520-287-2791

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APPENDIX D-1

LAND OWNERSHIP MAPS

APPENDIX D-2

USGS STREAMFLOW DATA

09481500 SONOITA CREEK NEAR PATAGONIA, AZ

LOCATION.--Lat 31°30'00", long 110°49'00", $SE^1/_4SW^1/_4$ sec.21, T.22 S., R.15 E., Santa Cruz County, Hydrologic Unit 15050301, on left abutment of former railroad bridge, 5 mi downstream from Patagonia.
DRAINAGE AREA.--209 mi².

Annual peak discharges

Water year	Date	Annual peak discharge (ft³/s)	Discharge codes	Water year	Date	Annual peak discharge (ft³/s)	Discharge codes
1930	08-07-30	2,600		1953	07-14-53	2,870	
1931	07-28-31	1,900		1954	07-20-54	4,670	
1932	07-26-32	1,700		1955	08-12-55	6,920	
1933	07-15-33	1,050		1956	07-19-56	780	
1934	08-00-34	11,000		1957	08-02-57	4,860	
1935	08-23-35	4,700		1958	07-05-58	5,590	
1936	08-09-36	3,600		1959	08-24-59	2,310	
1937	09-06-37	3,600		1960	08-13-60	1,550	
1938	09-09-38	3,400		1961	10-09-60	2,760	
1939	08-08-39	3,300		1962	12-15-61	680	
1940	08-13-40	2,580		1963	08-26-63	4,320	
1941	08-09-41	2,150		1964	09-10-64	2,640	
1942	09-12-42	1,000		1965	09-08-65	806	
1943	08-28-43	4,530		1966	08-18-66	4,120	
1944	08-09-44	669		1967	07-03-67	2,060	
1945	08-06-45	3,140		1968	12-20-67	5,410	
1946	09-30-46	14,000		1969	08-24-69	450	
1947	08-12-47	2,360		1970	08-03-70	622	
1948	08-15-48	4,750		1971	08-11-71	2,860	
1949	08-08-49	5,790		1972	09-09-72	368	
1950	07-30-50	7,300		1978	10-09-77	[1]7,380	HP
1951	08-02-51	5,030		1984	10-02-83	[2]16,000	HP
1952	08-14-52	3,630					

[1]Highest since 1946.
[2]Highest since 1930.

Basin characteristics

Main channel slope (ft/mi)	Stream length (mi)	Mean basin elevation (ft)	Forested area (percent)	Soil index	Mean annual precipitation (in)	Rainfall intensity, 24-hour	
						2-year (in)	50-year (in)
76.7	21.7	4,800	52.0	2.0	19.3	2.0	4.1

09481500 SONOITA CREEK NEAR PATAGONIA, AZ--Continued

MEAN MONTHLY AND ANNUAL DISCHARGES 1931-33, 1936-72

MONTH	MAXIMUM (FT3/S)	MINIMUM (FT3/S)	MEAN (FT3/S)	STANDARD DEVIATION (FT3/S)	COEFFICIENT OF VARIATION	PERCENT OF ANNUAL RUNOFF
OCTOBER	20	0.03	3.9	3.9	0.99	4.0
NOVEMBER	18	0.32	4.0	3.3	0.83	4.1
DECEMBER	107	0.99	10	21	2.1	10.5
JANUARY	52	1.1	7.5	8.9	1.2	7.8
FEBRUARY	96	0.99	9.9	18	1.8	10.2
MARCH	16	0.87	5.5	3.3	0.61	5.7
APRIL	12	0.49	4.1	2.9	0.70	4.3
MAY	10	0.06	2.5	2.4	0.95	2.6
JUNE	8.6	0.00	1.6	2.1	1.3	1.7
JULY	112	0.06	13	19	1.4	13.5
AUGUST	151	1.5	25	27	1.1	26.1
SEPTEMBER	71	0.05	9.2	13	1.4	9.5
ANNUAL	33	1.9	8.1	5.6	0.69	100

MAGNITUDE AND PROBABILITY OF ANNUAL LOW FLOW BASED ON PERIOD OF RECORD 1932-33, 1937-72

PERIOD (CONSECUTIVE DAYS)	DISCHARGE, IN FT3/S, FOR INDICATED RECURRENCE INTERVAL, IN YEARS, AND NON-EXCEEDANCE PROBABILITY, IN PERCENT					
	2 50%	5 20%	10 10%	20 5%	50# 2%	100# 1%
1	0.00	0.00	0.00	0.00	0.00	0.00
3	0.08	0.00	0.00	0.00	0.00	0.00
7	0.11	0.00	0.00	0.00	0.00	0.00
14	0.19	0.00	0.00	0.00	0.00	0.00
30	0.35	0.05	0.00	0.00	0.00	0.00
60	0.70	0.18	0.08	0.03	0.00	0.00
90	1.3	0.52	0.31	0.20	0.12	0.09
120	2.4	1.3	0.97	0.74	0.55	0.45
183	3.8	2.2	1.6	1.2	0.90	0.73

MAGNITUDE AND PROBABILITY OF INSTANTANEOUS PEAK FLOW BASED ON PERIOD OF RECORD 1930-72, 1978, 1984

DISCHARGE, IN FT3/S, FOR INDICATED RECURRENCE INTERVAL IN YEARS, AND EXCEEDANCE PROBABILITY, IN PERCENT					
2 50%	5 20%	10 10%	25 4%	50 2%	100# 1%
3,130	5,360	7,190	9,950	12,300	15,100

WEIGHTED SKEW (LOGS) = 0.22
MEAN (LOGS) = 3.51
STANDARD DEV. (LOGS) = 0.27

MAGNITUDE AND PROBABILITY OF ANNUAL HIGH FLOW BASED ON PERIOD OF RECORD 1931-33, 1936-72

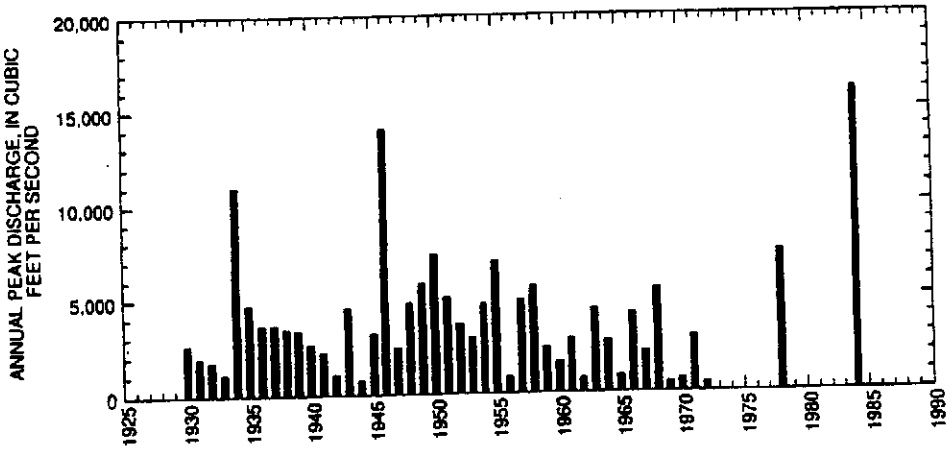
PERIOD (CONSECUTIVE DAYS)	DISCHARGE, IN FT3/S, FOR INDICATED RECURRENCE INTERVAL, IN YEARS, AND EXCEEDANCE PROBABILITY, IN PERCENT					
	2 50%	5 20%	10 10%	25 4%	50# 2%	100# 1%
1	277	599	881	1,310	1,680	2,090
3	132	285	415	608	771	948
7	74	156	225	329	418	516
15	44	92	138	212	282	364
30	29	59	87	131	171	218
60	20	39	54	79	100	124
90	15	28	39	56	71	87

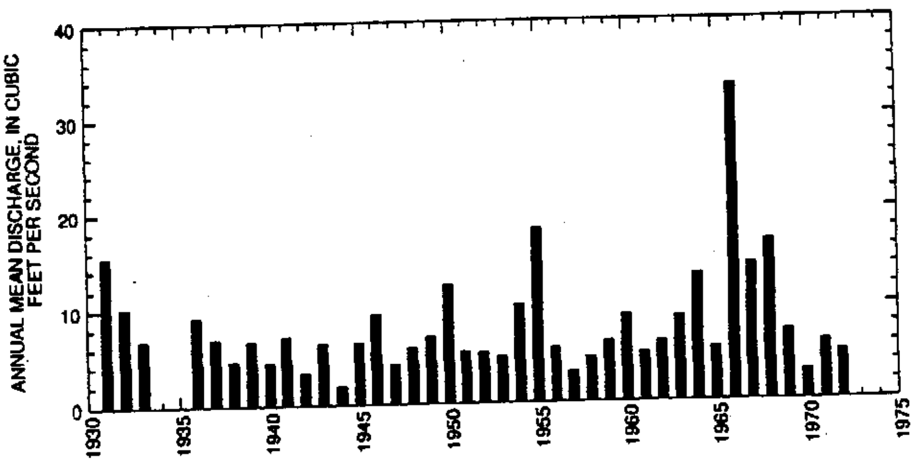
DURATION TABLE OF DAILY MEAN FLOW FOR PERIOD OF RECORD 1931-33, 1936-72

DISCHARGE, IN FT3/S, WHICH WAS EQUALED OR EXCEEDED FOR INDICATED PERCENT OF TIME																
1%	5%	10%	15%	20%	30%	40%	50%	60%	70%	80%	90%	95%	98%	99%	99.5%	99.9%
115	19	11	8.0	7.1	5.3	4.0	3.2	2.6	2.1	1.2	0.45	0.10	0.00	0.00	0.00	0.00

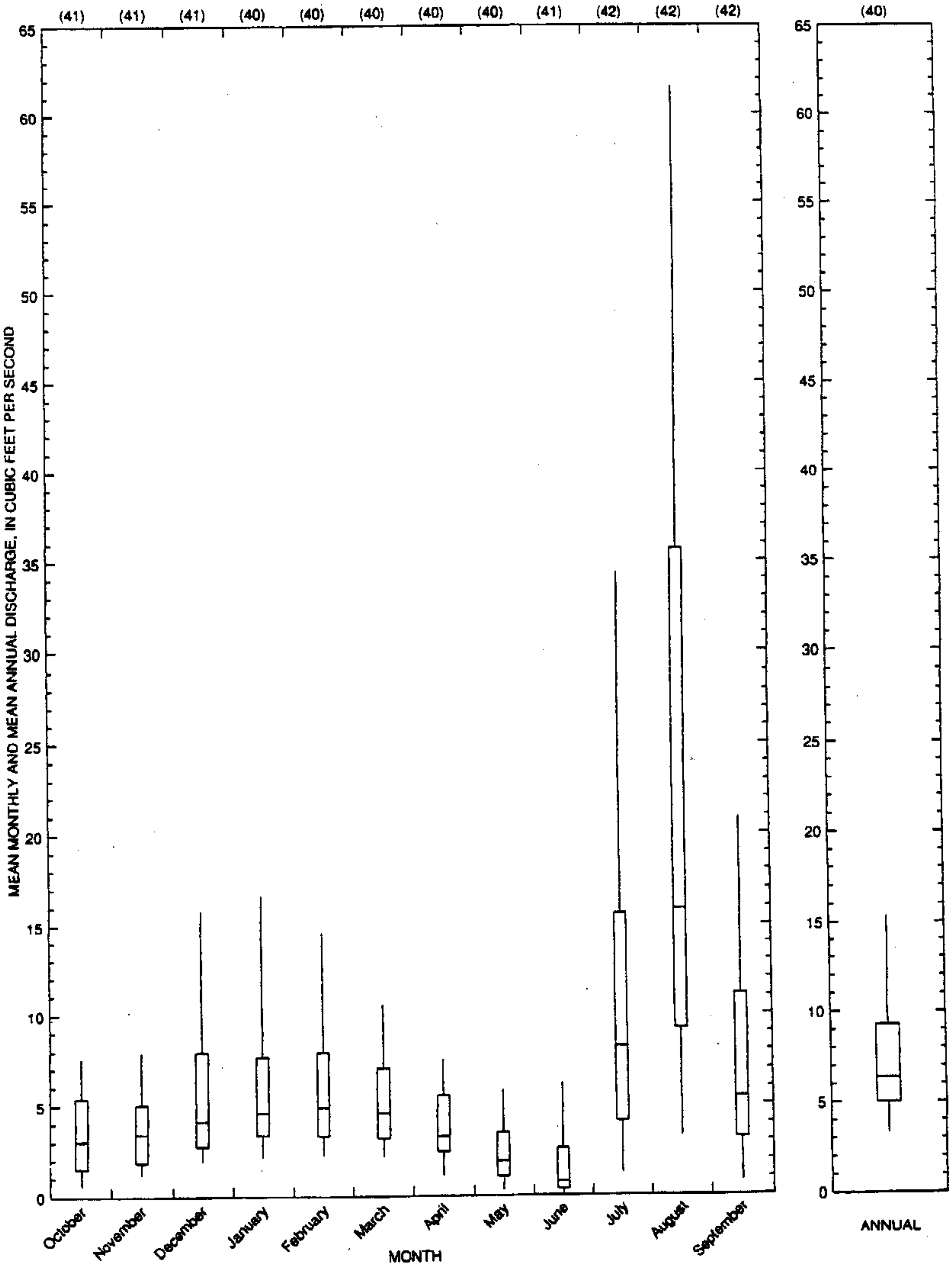
Reliability of values in column is uncertain, and potential errors are large.

09481500 SONOITA CREEK NEAR PATAGONIA, AZ--Continued





09481500 SONOITA CREEK NEAR PATAGONIA, AZ--Continued



PROJ: ASLD/Nav/Sonoita Creek
DETAIL: Estimated Hydraulic Parameters

Hydraulic Parameters were estimated using observed minimum and maximum stream widths and assuming a rectangular section and overall valley slope to perform a Manning's rating for both the minimum and maximum observed stream widths.
The sections were rated for flow exceedance values from USGS gage no: 9481500

Observed minimum stream width (typical) =	10	feet
Observed maximum stream width (typical) =	20	feet
Overall stream slope =	76.7	feet/mile
	0.0145	feet/feet
Assumed Manning's roughness coeff (n) =	0.04	

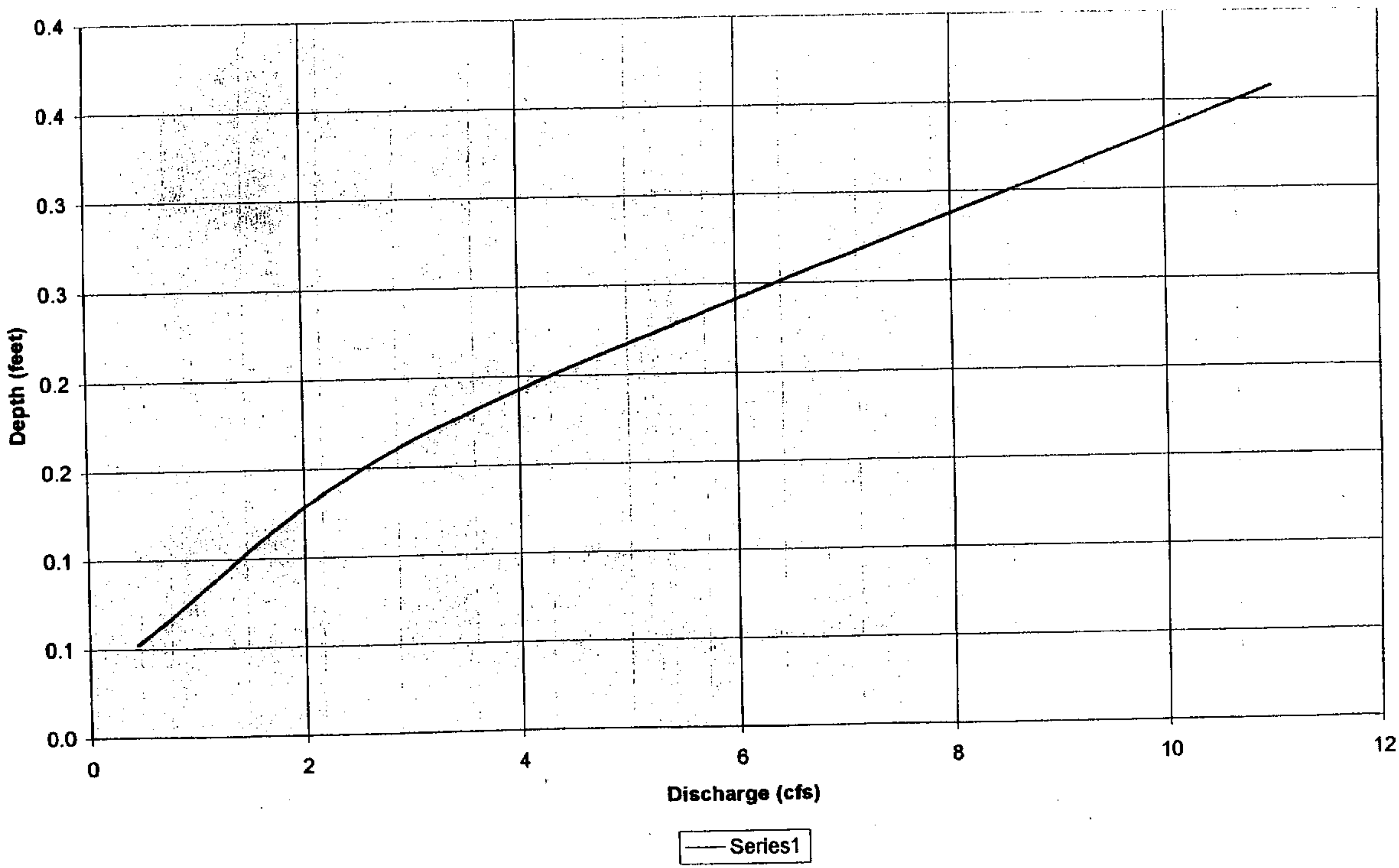
Estimated Hydraulic Parameters

Flow Exceedance (%)	Discharge (cfs)	Min. Width Depth (feet)	Hydraulic Parameters Velocity (ft/s)	Width (feet)
10	11	0.4	2.6	10
50	3.2	0.2	1.6	10
90	0.45	0.1	0.7	10

Flow Exceedance (%)	Discharge (cfs)	Max. Width Depth (feet)	Hydraulic Parameters Velocity (ft/s)	Width (feet)
10	11	0.3	1.9	20
50	3.2	0.1	1.2	20
90	0.45	0.0	0.5	20

Flow Exceedance (%)	Discharge (cfs)	Average Hydraulic Parameters Depth (feet)	Velocity (ft/s)	Width (feet)
10	11	0.4	2.2	15
50	3.2	0.2	1.4	15
90	0.45	0.1	0.6	15

Sonoita Creek Rating Curve



APPENDIX D-3

ANECDOTAL AND HISTORICAL REFERENCES

<u>**Sonoita Creek Anecdotal Citations list:**</u>

Mihalik, Paul, 1985, "Patagonia Profile", Padre Rio Publishers

This work is cited in the report. I've enclosed the portion of the book which I copied. Page 1 generally describes the valley as "lush".

Seibold, Frank M., 1983, "Patagonia Stories – Early History, The Cowboys, The Miners, The Legends",A&W Typesetters (publisher).

This work is cited in the report. I've enclosed the portion of the book which I copied. Pages 51 through 54 describe the 1937 flood event described on page 10 of the report.

Seibold, Frank M., 1979, "Tales from the Sonoita – Early History, The Cowboys, The Miners, The Legends",A&W Typesetters (publisher).

This work was not cited in the report. I took hand written notes on one passage where Mr. Siebold describes a 1920's cattle drive along the Sonoita Valley and states "The only river we ever crossed was the one time when Dobe Canyon was running about a foot of water after a sudeen shower in the mountains." "Dobe" canyon is probably a reference to Adobe Canyon which appears on the USGS quadrangle of the area. The passage suggests to me there was no flow in the Sonoita at the time of the drive (or at least none that a cattle driver would remark on).

Thornburg, Florence, 1958, "The Sonoita Valley", Arizona Highways Magazine article, August 1958 issue.

This work is cited in the report. I've enclosed the portion of the book which I copied. Page 2 of the article refers to the Sonoita Creek as "a year-long running stream started by springs activated by drainage from the Santa Rita Mountains and fed by waters from the Patagonia Mountains."

Patagonia Stories—

Early History,
The Cowboys,
The Miners,
The Legends

The Story of Patagonia
and
The People Who Made That Scene
1898-1982

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Table of Contents

Buck Blabon, who played Horatio at the Bridge, and his wife Hilda.

Don't Bomb My Bridge

The summer of 1937 was proving to be a wet one in southern Arizona. In the Patagonia area there was a hard rain almost every afternoon, and one or the other of the branch washes would come down big. The old Sonoita Creek was putting on a real show for the townspeople with all this high water, bringing logs and uprooted trees along in these floods. And sometimes a bobbing cow or some other animal. Some of the town's menfolk would stand on the deck of the railroad bridge, and with handmade lariats snare out enough driftwood for a winter's supply of fuel.

This was great fun for all who watched, whose only real worry was what could happen if all this flood water should reach their doorsteps.

Also the ranchers were happy with the lush growth of grasses that was spreading across their ranges. Their cattle were getting fat and their stock tanks had filled.

The one man who was having fits with all this summer runoff was Charlie Mapes, the railroad foreman. It was keeping him and his crew jumping to fix the washouts and to keep the roadbeds and bridges in repair.

So far none of the bridges had washed out but there was always that fear one might. Charlie knew that the old Santa Fe which had sold to Southern Pacific was built well. He was proud of this line. Charlie was a life-time railroad man who had come to Patagonia from a job with Southern Pacific in the New Mexico division. He was a quiet and unimpressive man, short of stature and usually wearing a slouch hat. He had a drooping mustache and smoked an old corncob pipe.

Charlie went about his work methodically, never seemed to get excited and was considered an easy man to work for. It was his job to keep this division of the S.P. railroad in repair and he did that job well.

Another man who was worried about these summer floods was R. C. Blabon, popularly known as Buck. Buck was, in a way, the city father and worried a good deal about the possibility of Patagonia being flooded. He had seen floodwaters lap over the dike into town on different occasions, not too much water but still the danger of a real flood was always present. Also Buck had noticed that a large sandbar was building up on the north bank of the creek which had narrowed the channel considerably and thus posed a flooding problem.

So Buck and two of his friends had decided to prepare for that eventuality. They had fashioned a bomb from several sticks of dynamite together, with cap and fuse in place. Buck kept this bomb in readiness in case it ever became necessary to bomb the bridge during highwater. Buck was determined that Patagonia should never be flooded.

August 8th dawned bright and hot in the Patagonia area, the sort of day that usually promised rain. By one o'clock small thunder caps were beginning to form, and darken and grow in size. By two o'clock these small thunderheads had merged into one continuous bank of clouds which spread from the Mowry flats, in the Harshaw drainage, to the south, to Gardiner Canyon on the north end of this huge perimeter, which outlined the arc of the Sonoita basin.

Misty strings of rain were beginning to fall in the center of this great arc and gradually increase in density to form a solid curtain that darkened the whole area. Vivid streaks of lightening flashed intermittently creating an eerie background to this whole scene. The old-timers of Patagonia nodded their heads knowingly, "There'll be high water today. Look at that bank of clouds. Watch out, Patagonia!"

Half of the residents of Patagonia lined the banks of the Sonoita when the first crest of churning flood water arrived. Black with mud and debris, this rolling wave hit the railroad bridge and swirled over the guardrails leaving a mat of tangled brush and weeds.

Charlie Mapes was the railroad foreman who defended the bridge in the big flood.

Buck Blabon and his friends stood slightly apart from the rest, watching to note whether a second rise of water would come. In his right hand Buck held the homemade bomb. On his face was a grim look of determination and concern. On the other side of the gathered townspeople Charlie Mapes stood with his feet firmly planted. The cool breeze which had sprung up whipped the baggy pant legs of the old worn coveralls around the railroad foreman's thin legs.

As they all watched the swirling waters, a great log caught against the pier with one end stuck under the deck of the bridge. Brush and other debris were beginning to build up behind it. Here was real trouble!

Buck Blabon watched these developments closely. "If that log don't move pretty quick, we'll have to bomb the bridge."

Charlie Mapes heard this and then he moved a couple steps closer to the bombing crew. Strong and quiet, the old man spoke words clearly and understandable to all. "I'm in charge of this end of the S.P. and I'll tell you when it's time to blow this bridge."

Here at last a real confrontation between two determined men, each strong in his own way, each guarding a segment of society. Buck Blabon, tall and broad-shouldered, towered over the smaller railroad foreman. He addressed Mapes.

"Charlie, we can't just stand here and watch this flood go through Patagonia. And that's exactly what's going to happen if that log jam don't break."

"I'm in charge of that bridge, Buck," reminded Mapes, "and I'll tell you when to blow it."

At last the log turned slowly, with the swirling water and began to move under the bridge. Now with the log moving, the impasse that the log jam had created between two strong men resolved itself. The tension which had mounted so high through the crowd was slowly easing.

Who would have prevailed in this tight situation is anybody's guess. Happily for Patagonia and all concerned, when the flood crisis was over life returned to normal and Charlie Mapes and Buck Blabon, who were never really mad at each other in the first place, remained the good friends they had always been.

George Tatum's Investments

George Tatum had finally reached that enviable goal which so many cowmen strive for, and not all manage to reach. He had finally paid off his outfit. Now it was all his and Emmie's, all 20,000 acres of it, the three sections of deeded land, several more sections of state leases and a real good chunk of forest reserve lease. All this together with some 700 head of assorted livestock, which included the mother cows and their calves, a small bunch of registered bulls and 16 head of real top cow horses. No more mortgages, no more interest payments, not so many end-of-the-month bills, all of which had caused them both so many sleepless nights. It was a real relief for him to know that it was finally all theirs to work and enjoy. But it was taking a little bit of getting used to, to realize that those tough old days of scrimping were in the past. He and Emmie had worked many long years on this place to make it what it was. Now they could sit back and enjoy life, or could they? They could see their way to buying that new pickup with the fancy cushions that Emmie had seen in Nogales. Or some new clothes, which George didn't have much interest in and figured he didn't need anyway. Emmie, being a woman, naturally showed more interest in the new clothes and the new styles but was finding it hard to spend good money on frilly things. Most of their surplus income was being spent on wells, new windmills, and stock tanks, those things that improved a cow spread.

cattle. In 1900 an interesting note on Joe Wise's operations: when the title of the Baca Float Grant was finally settled, the court recognized Joe Wise's claim as a legitimate squatter and made a settlement of several thousand dollars to him.

Directly north and out of the Baca Flat Grant, Charlie Chapman and his brother Al had started a ranch and were running four or five hundred head of cattle. The Chapman brothers had based their operation on several patented mining claims in the Josephine canyon area.

Two American ranchers who had established ranches in the Nogales area were Jim Harrison whose operations were headquarters on the Yerba Buena and the Buena Vista Land Grants and the Sorrels brothers who consisted of Ray and his brother Bert and a brother Roy. Their operations were on the west side of the Baca Float Grant and a small part of the Sonoita Grant and the balance of their grazing land was Forest Service land. Both the Harrisons and the Sorrells brothers were running several thousand head of cattle. The Sorrells at this time gave two main brands the T4 and the Double Rail N.

Vail and Ashburn's Rail X ranch took up the greater part of the center of Santa Cruz county reaching from the edge of Patagonia, taking in the entire drainage of the Temporal Canyon and the east side of the Santa Rita mountains as far north as Gardner Canyon.

Ashburn's Rail X Ranch also controlled most of the Sonoita and Elgin Basin as far east as the Whetstone mountains. Also previous to the 1920s Ashburn's Rail X cows were using a good part of the Canelo range.

In Red Rock Canyon, Julius Kunde who branded reverse k 7 and Frank Seibold who branded YL and later T Rail brand were running separate herds of improved Mexican cattle.

Both of these ranchers along with Richard Farrell were only a few of the ranchers in Santa Cruz county whose ranching operations were based on deeded homestead land. Richard Farrell branded the OIL brand on the left ribs.

In San Rafael Valley Colin Cameron had acquired the San Rafael De Zanja Grant. At one time Cameron was running around 20,000 head of cows. His cattle ranged the entire San Rafael Valley, part of Red Rock Canyon and all of Harshaw

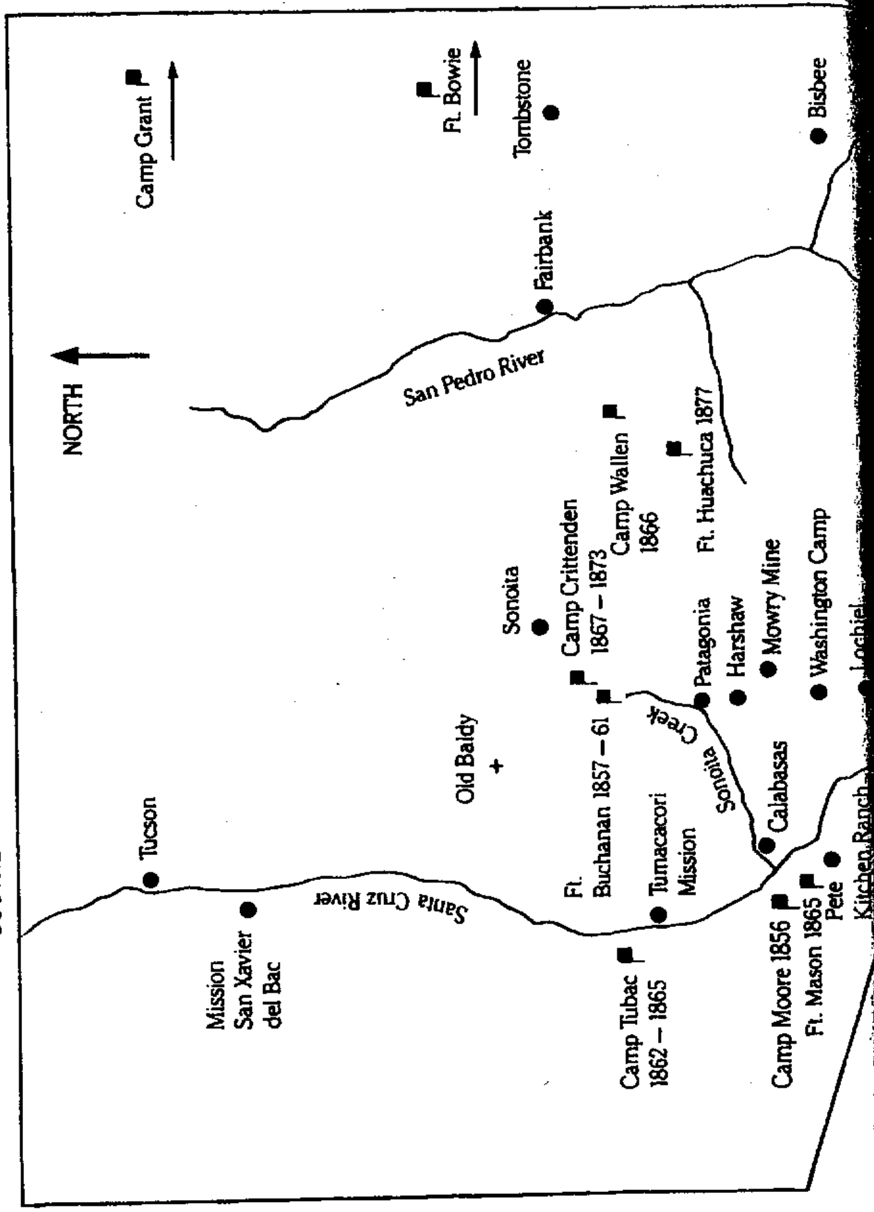
Canyon and also part of the Canelo range. While the San Rafael Grant remained intact to its present day boundaries consisting of 26,000 acres, Colin Cameron had resorted to all sorts of tactics to enlarge his holdings and at one time claimed, in his own imagination, that the Grant extended twelve miles square. Meanwhile, Colin Cameron had stirred up much bad feelings among his neighbors, who were beginning to wonder if they could hold out against this wily Scotsman. While I don't believe that Colin Cameron had any poetic imagery or imagination, he was still feeling as one early day Texan stated it, "Say, mister, as far as you can see belongs to me." At a later date, a rancher friend of mine, Clyde McPherson expressed his own sense of largeness and sense of well-being by the simple statement, "I got money in the bank and cattle on the range." It seems now that Mr. Colin Cameron was simply a land hog. Later when the courts finally settled the claims and boundaries of the San Rafael De Zanjo Grant, they cut it back to its original holdings of 26,000 acres. This now is what Florence Sharp and her son Robert hold in the immense San Rafael Valley. The stories told of Cameron and his operations are legion and would fill a storybook. One dry year in the late 80s Cameron ordered Julius Kunde, who was then his foreman, to roundup all his steers and dry cows and get ready to ship them to pastures in Montana which Cameron had leased for the summer months. The shipment of Cameron's cows and steers to Montana was an interesting operation. They had arranged for 32 cattle cars to move the cows and steers and another two cars to move the saddle horses and then they leased a flat car to move their chuck wagon and camp outfit. What an interesting sight that must have been! The story goes that Cameron's cowboys really enjoyed this vacation trip to Montana.

The story goes that Cameron's RO outfit also possessed a large remuda of beautiful and breedy horses that also had an unusual number of buckers. The story also goes that his foreman Julius Kunde met Will Roth when Roth was a young man walking afoot across the valley. He stopped and asked Julius Kunde for a job on the ranch. After looking Roth over Mr. Kunde answered him thus, "Well kid, I would give you a job but I don't think you could ride our horses." Will Roth

PATAGONIA PROFILE

A history and guide to Patagonia, Arizona
by
Paul A. Mihalik, Lt. Colonel USAF, Ret.

PATAGONIA, ARIZONA — 1985

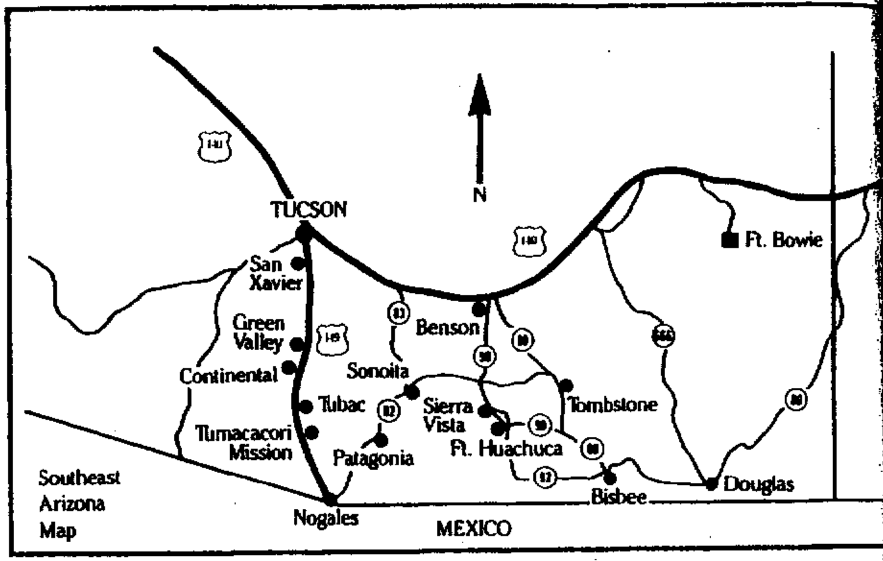


SOUTHERN ARIZONA MAP OF ARMY POSTS AND OLD MISSIONS

CHAPTER ONE
CRITTENDEN — THEN PATAGONIA

Many old-timers in the Patagonia area remember certain specific aspects and facts about the early period of Patagonia, Arizona but it is difficult to find consistency among them. Research material is in short supply and memories are not as sharp as they were even a few years back. We do know this for certain—before Patagonia existed the town of Crittenden was founded three miles Northeast from Patagonia on what is now State Highway 82. And before the area was called Crittenden, the New Mexico and Arizona Rail Road Company gave the name CASA BLANCA to that place of early settlers and miners.

Before the railroad came through the Sonoita Valley this beautiful farming and ranching land was part of a Spanish land grant having been part of the Spanish conquest on this continent. When one looks at the valley and nearby mountains it is easy to imagine the activities of the early Spanish explorers and missionaries who passed through this region. The land remains much the same as when the Jesuit father Eusebio Francisco Kino traveled the area in his quest for peace with the Pima Indians in 1697. Father Kino is known as the pioneer padre of the Pimeria Alta, the land of the Upper Pima Indians, and Arizona's first pioneer, explorer, and cartographer. In this Sonoita Valley the Apaches thrived in the lushness of their enchanted land, and it is known that in the time of Padre Kino a rancheria named Los Reyes de Sonoidag existed in today's Patagonia area.



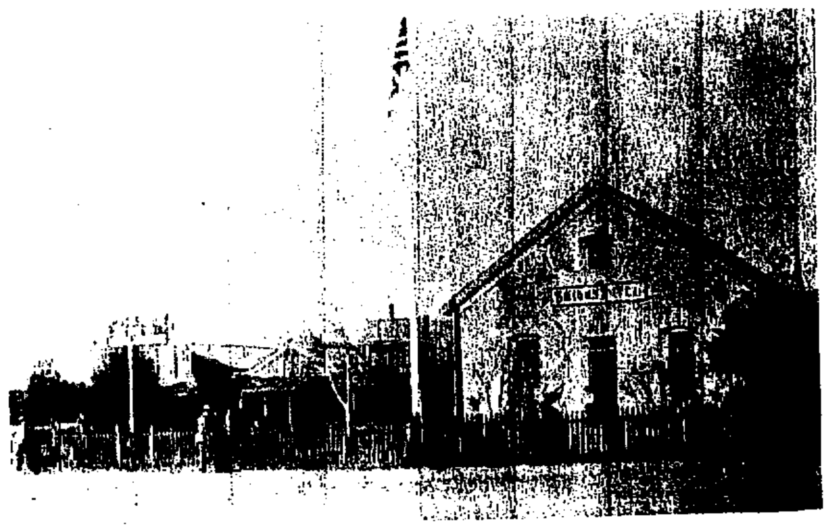
Southeast Arizona Map

A Pennsylvanian, Rollin R. Richardson, came to the Sonoita valley in the year 1882. He had been in the Civil War and was once in the oil business in his native state. He acquired ownership of most of the land making up the original Spanish land grant, stretching from what is now Patagonia to within a mile or two of Sonoita. He ranched extensively but later, in 1890, because of losses to the drought, he sold out much of his ranchland to Vail, Gates, and Ashburn. The area around Casa Blanca slowly became a town, especially when the New Mexico and Arizona Railroad laid track that connected Nogales with Benson. Richardson held on to land which later would become the location of Patagonia.

One of the pioneers who contributed to that growth was a Norwegian who had fought in the Indian Wars and had lived in Tombstone and Harshaw. His name was John Smith. He obtained a lease from the railroad for use of land on which to build a hotel. Smith's Hotel was completed in 1885, the same year he planted a


John and Helene Smith of Crittenden.

Smith's Hotel, 1885.



'Judge' E. Vanderlip.
Sold homestead to John Smith.

Yellowstone Club Bar, left. Crittenden.

Helen B. May at Crittenden cemetary and owner of old historical photos.

cabbage rose bush which still grows along the northeast wall. Smith also operated a restaurant and some shops, and acquired land from an old homesteader, 'Judge' E. Vanderlip.

Smith's Hotel was damaged by an earthquake in 1887. The top part of the structure was taken down, changing it from a sharply peaked roof structure to its appearance today. His granddaughter, Mrs. Vivian Davis, still lives on the land which has been family property since 1960 when the Railroad sold the hotel site. It is Mrs. Davis who graciously loaned her collection of historical photographs for use in this publication. It was her mother, Mrs. Helen B. May, deceased, who had the sense of history that prompted her to collect and preserve the important photos. There is no record of the names of the original photographers.

In 1896, Richardson decided to move to his property which was to become the town of Patagonia in 1899. He first attempted to name it ROLLIN after himself. The people rejected the name ROLLIN and through their persistance and use of people power, named the town

Lime kiln south of Ft. Crittenden marker, Route 82.

post office PATAGONIA after the Patagonia Mountains. The people, following his lead, gradually moved, leaving Casa Blanca to its fate. On July 1, 1897, the Southern Pacific Railroad took over the management of the rail operation which connected Nogales to Benson. This new manager of the railroad renamed the Casa Blanca site to Crittenden,and so it remained until it no longer had a post office in 1899. Soon Patagonia was shipping cattle and ore and the town began to grow.

Ft. Buchanan and Camp Crittenden.

Two old Army posts are located in the area roughly nine miles up the highway from Patagonia towards Sonoita. 'Ghosts' of the Army posts would be more accurate because they have been abandoned a long time. In 1857, due to Apache Indian activity through the Sonoita Creek valley, Ft. Buchanan was established for the protection of settlers. A major war trail along Sonoita Creek to Calabasas at the junction with the Santa Cruz River north of Nogales, Sonora made the entire region subject to the whims and anger of the Apache. The location of Ft. Buchanan acted as a buffer against the

Indian raids of settlers and mines of the Santa Cruz-Sonoita Creek area.

A fine account of the history of Ft. Buchanan and Ft. Crittenden is given in the Fall 1965 issue 12, of *THE SMOKE SIGNAL* published by the Tucson Corral of the Westerners, Tucson, Arizona. A copy is usually available for a small fee at the Ft. Huachuca Museum, Ft. Huachuca, Arizona.

A story that is thought to be true is included in that fine publication referenced above and reads, "word of the fort's contemplated abandonment had gotten abroad (abandonment of Ft. Buchanan took place on July 21, 1861), and hardly had the soldiers passed beyond the limits of the post when Papago Indians swarmed from the surrounding hills, anxious to be first in a search for what the soldiers left behind. Suddenly they saw the Indian girl. An old man led the crowd toward her; reaching down he ripped away the rebozo that covered the baby. Then he turned and harangued the crowd, reminding them of the old law of the tribe by which a woman guilty of adultery must be stoned to death. Taking the girl roughly by the arm, he led her to the parade ground. Following him came the Indian men, women, and children, picking up stones as they came.

Off to the East the dust could still be seen in the air above the marching soldiers. No help from them now. To her pleading, the old man turned only a deaf ear and a stony face. As he stepped away, the first stone was thrown. She started to run—a few steps and a stone struck her on the head. Stunned, she stood there, clutching her baby. More stones rained upon her and she sank to her knees: the baby fell from her arms: blood trickled from her wounds into the dust. Soon she and her baby were lifeless under a veritable mound of stones—a tragic ending, indeed, to life on this post." — Bucky O'Neil. (from his story "Requiem of the Drums", 1901).

When the fort was abandoned, the Apaches began a violent storm of murder and robbery in the Sonoita and Santa Cruz valleys. That ended the wheat and corn crops that were raised along the fertile soil of the Sonoita by Texas and Missouri settlers in this valley.

Camp Crittenden, about 8 miles east of town, was established after the Civil War on August 10, 1867—only 300 or 400 yards from the old site of Ft. Buchanan which was burned to the ground by the departing soldiers described above in O'Neil's story.

It was from Ft. Lowell in Tucson, and a stop at Camp Crittenden that Lt. Howard B. Cushing departed with 21 men on May 5, 1871 on a search for Apaches and was killed in ambush in the Whetstone Mountains, located 12 miles east of Sonoita, Arizona. Lt. Cushing was known as a hero of the Civil War, along with two famous brothers, one in the artillery at Gettysburg and one in the navy.

Later, between September 1, 1871 and September 4, 1872, forty-one citizens were killed and sixteen wounded in 154 cases of Indian actions in Arizona although Apache raids dropped off in the Sonoita Valley by September 1872.

However, still one more incident in 1872 resulted in the death of two men who were escorting army wagons from Camp Crittenden to Tucson. One man was killed immediately and the other was tied to a tree and tortured to death with firebrands that left one hundred wounds on his body. The Apaches really did hate the encroachment of the white man into their beloved enchanted land, the name given by the Indians long ago to the area of the Sonoita Valley.

Camp Crittenden (not officially a fort) was evacuated in 1873. The army decided to re-locate to Ft. Huachuca on the slope of the Huachuca mountains, a few years later.

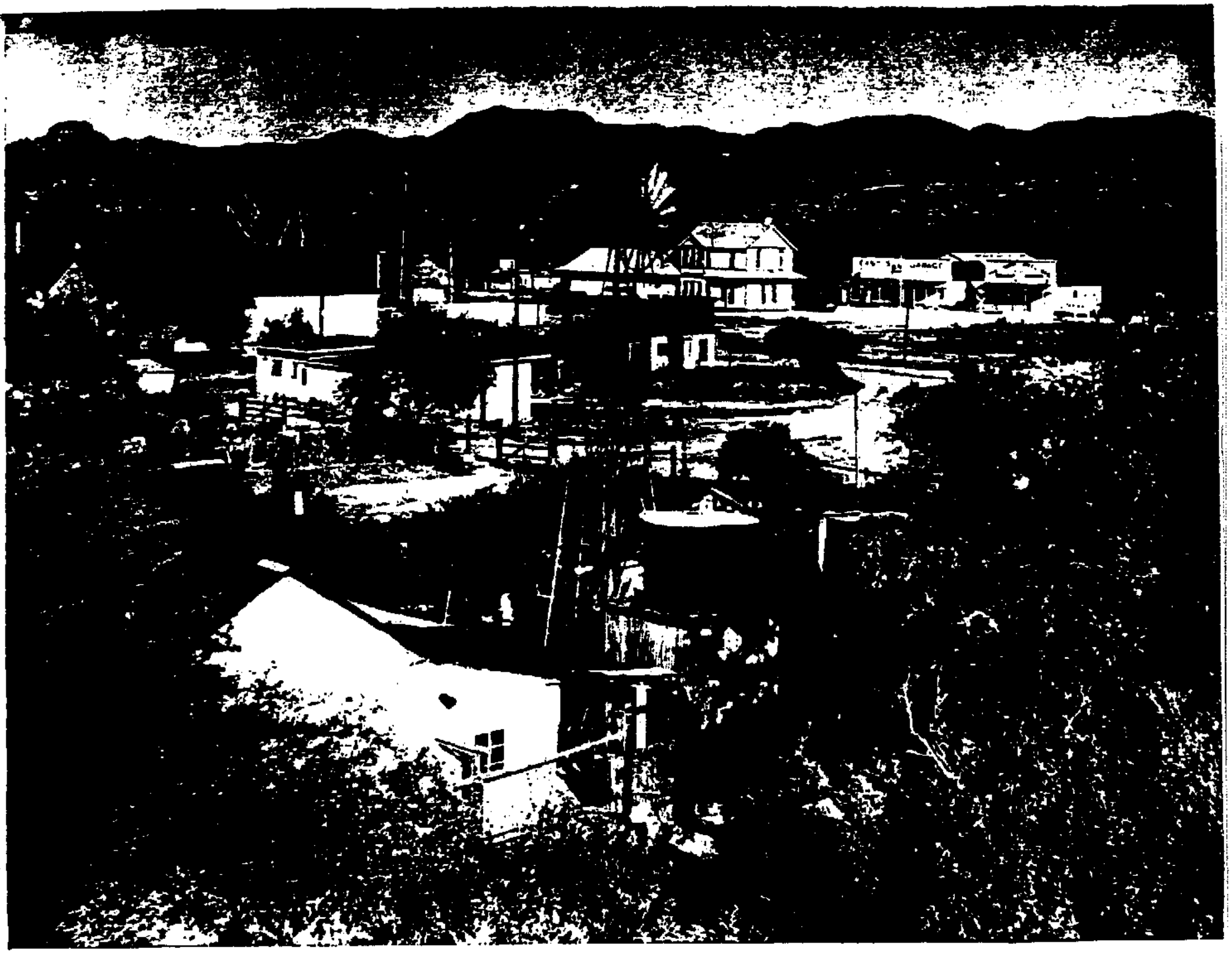
CHAPTER TWO
PATAGONIA

A Unique Place

Patagonia is unique in its natural beauty and climate. Because of its 4,050 ft. elevation it averages ten degrees cooler than Tucson during the summer day and much cooler at night because the high desert loses heat quickly on clear nights. July is warmest, high temperature averaging 95 to 97.

In the winter snow might fall once or twice a year in the early morning hours but only one or two inches and is usually melted off in two hours. In 1978 a freak 12 inch snow fell as seen in the winter photo, the first such heavy snow in about 30 years.

A 'wet' season arrives in late June called the monsoon and is highly welcome by all, especially the ranchers. For July and August the humidity rises slightly but the slight discomfort is hardly noticed and the trade-off of green mountains and grazing land is more than worth it. Rains also fall in the months of February and March but not enough to ruin your outdoor plans. Average annual rainfall is approximately 16 inches. The relatively low humidity all year makes the warm temperatures quite tolerable, and fall and winter are about perfect.



WESTERN WAYS

View of Patagonia, one of Arizona's most interesting ranch towns

The Sonoita Valley

BY FLORENCE THORNBURG

Sonoita Valley, near Patagonia in Southern Arizona, is unique in that it has an extensive wooded area in a normally arid region. Sonoita Creek, which flows through the valley, rises from springs located some eight or ten miles above Patagonia, to the northeast. The valley, which ranges from a half mile to a mile in width, starts here. Above this we find a higher plateau of level grass lands around the little town of Sonoita. The total length of this narrow valley lying between the Santa Rita Mountains to the north and the Patagonia Mountains

west. Here the stream flows into the Santa Cruz River.

This valley has a fascinating history dating back to Spanish rule. Going back to the 17th and 18th centuries we find Spain wanted to protect a land route between Mexico and California across what is now Arizona. And the rulers proposed to do this by a Mission system across this great new region rather than with military might. Followers of southwestern history know that missions and *visitas* were founded under the leadership of Father Eusebio Francisco Kino. A *visita*, which was not a resident mission but received only occasional visitation by the Padres, was established in Sonoita ...

diary and was referred to as Los Reyes de Sonoitac. In some reports it has been written as Sonoidag. And the name was changed at least three times. In the Reyes report of 1772 another saint's name was used and the *visita* was referred to as San Ignacio de Sonoitac. Finally it was called San Jose de Sonoitac. English-speaking people have corrupted the name, probably because we fail to get the "ack" sound by placing the tongue in the roof of the mouth, so the name has been shortened to Sonoita. The *visita* was abandoned before 1784 but the name was still used for the area.

Several missions were established in the valley to the west along the Santa Cruz River. Guevavi, or Guebavi as it was sometimes written, near Calabasas was the oldest but now little is left to show its location. Tumacacori, farther north is a National Monument and San Xavier del Bac near Tucson has been restored and is used for worship.

The center of interest in Sonoita Valley is the year-long running stream starting from springs activated by drainage from the Santa Rita Mountains and fed by waters from the Patagonia Mountains. This is a stream which gurgles in early spring, hangs on tenaciously during the dry months which precede summer rains and sometimes in summer carries flood waters, particularly from heavy rains in the canyons which drain the Patagonias. Usually no serious damage results from these floods but sometimes the little stream can become a giant. Near the banks in shallow water the stream is green with water cress which people eagerly gather in spring. Trees arch gracefully over the water for most of its length. Underground water nurtures huge cottonwood, sycamore and ash trees along its banks. There are also hackberry, willow, walnut, mulberry and mesquite trees. Elderberries, which I remember as shrubs in the mid-west, grow tree size here, some with trunks two feet in diameter and bearing fruit to be enjoyed by people and wildlife. The soapberry with its translucent amber fruit which is not edible, is also found. There are a few hedge or Osage orange trees probably carried in by flood waters or at least by some outside agent, which is also true of the mulberry. Live oaks cover the adjacent hillsides and grow to be ornamental trees in the canyons draining towards the stream.

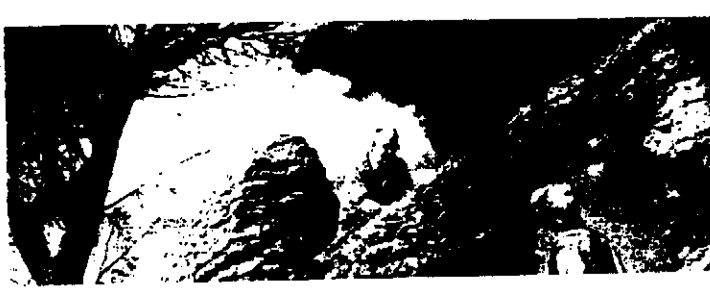
The Indian tribes knew this area well. In 1700 it was estimated there were 500 natives living here, some driven from other areas through fear of the Apaches. To them it was a paradise with an abundance of water and game, with warm hill slopes and sheltered canyons for cool days, water and dense shade when the sun was overhead in summer. Their resentment of settlers coming in with herds of cattle is understandable. The present name, Patagonia, is derived from *patagon*, the word used by the Spaniards to describe the Indians of the region, meaning big people or by some interpretations big foot-prints or big feet.

The first land owner in the Sonoita Valley was Don Leon Herreras, a *ranchero* of Tubac who in the year 1821 was looking for new grazing lands for his herds of stock. Don Herreras had benefited by the far-sighted vision of Father Kino, the man who introduced domestic animals from Europe in support of his newly founded parishes. Fruit and grain were also introduced by Father Kino and it is very probable that Herreras planted these along the Sonoita since the land was fertile. We do know fruit trees flourished and grains were grown along the Santa Cruz River to the west in early mission days.

In asking for new lands Herreras petitioned the Commissary General of the Treasury, of the State of the West for two *sitios* of land near Sonoitac, said to be eight leagues distance from Tubac. A league in English-speaking countries being estimated at three miles would make Sonoitac about 25 miles distant from Tubac. The State of the West comprised at that time the present states of Sinoloa, Sonora and southern Arizona. Mexico became independent from Spain in this same year that Herreras was appealing for land, 1821. But the laws concerning grants of land remained about the same under the Mexican regime as they had under Spanish rule, the change just delayed the title. Land granted to one stockman was usually limited to not more than four square leagues. Don Herreras asked for two *sitios* of land and in June 1821 was granted one and three fourths *sitios* or about 7592 acres. A *sitio* equalled a square league containing roughly about 4338 acres. The land was valued at $60 per square league by appraisers since there was running water. Old records tell us that Herreras paid $105 plus the customary 18% tax for land fee, plus 2% for the general fund and a three peso fee to the royal treasury, which should remind us government taxes aren't a new thing. Don Herreras did not become owner in fact until four years later when title was issued to him in May 1825 by Juan Miguel Riesgo, Commissary General of Mexico for the State of the West.

For some thirty years after 1790 there was comparative peace in the valley. But in 1821 the Apaches began raiding the ranches and missions in the area and this made living on isolated ranches hazardous. Twice the Herreras family was driven from their *hacienda* on the Sonoita. How long they remained away each time is not known. For most of the land grants a proviso in the title stated that should the owner abandon the lands for a period of three years or more they would revert to the public domain but for some reason this proviso in the Herreras title read one year. A *presidio* was established in Tubac, the oldest Spanish settlement in Arizona, in 1752, and it may be assumed that the *rancheros* with

Ruins of Old Guevavi Mission



Along Sonoita Creek

their families fled there at times for protection from the raiding Apaches or to Calabasas six miles to the west where a garrison of American troopers was stationed later. Still later, in 1856, Fort Buchanan was established east of Patagonia but was abandoned in 1861. Then Camp Crittenden was set up in 1867. A roadside sign marks the site of the camp in the upper Sonoita Valley.

About 100 years ago, the Herreras heirs sold their interest in the lands to Joaquin Elias. A later owner was Matias Alsna whose claim wasn't approved for some years. In fact it took a Supreme Court ruling to settle his claim. The amount of land confirmed at that time was 5123 acres, or 2469 acres less than that granted originally to Don Herreras. Present owners of the Spanish Land Grant are Mr. and Mrs. Peter Lewis, with the exception of the Circle Z land which is owned by Fred Fendig.

Not all of the grant lies along the stream but it stretches back into the grassy hills. State Highway 82 drops down to Sonoita Creek about 15 miles northeast of Nogales. Coming from Nogales in spring we travel between grassy hill slopes until within about five miles of Patagonia where the road crowds into a canyon along the stream. Here we enter a new world, a green forest of new leaves of cottonwoods, ash, sycamore, walnut and other trees and shrubs which make a veritable park of the valley floor. A recent change in the road has marred this beauty somewhat and a scar will remain until nature has time to cover man's effects. The stream west from Patagonia for three miles is paralleled on both sides by roads. And here a road branches from Highway 82, crosses the stream by fording and extends north for some miles towards the Santa Rita Mountains. This road gives access to several ranches and mines to the north but is a dead-end road.

Patagonia is a quiet town, with striking views of mountains on two sides, at an elevation of 4050 feet. This is an altitude which makes for pleasant year round living in Arizona. Average rainfall is 17.3 inches. Summer rains begin about July 1st and these rains act as a check on high summer temperatures. A little snow may fall in winter but soon melts in a warm sun. No long range temperature records have been kept at Patagonia but according to records compiled since 1899 at Nogales, 18 miles to the southwest at 3800 feet elevation, the mean maximum temperature there is 79.4 degrees with the mean minimum 45.2 degrees. A high of 104 degrees may be reached in June, the hottest month, with an occasional low of 18 degrees in January.

The town of Patagonia has had its ups and downs, fluctuating with the mining activities surrounding it. Some $20,000,000 in ores have been taken from mines in the area in the past. Oldtimers claim that 100 years ago there were 350 mining claims within a fifteen mile radius of Patagonia. This was only a few years after the United States acquired this area from Mexico as part of the Gadsden purchase. Until recently two mines of The American Smelting and Refining Company, the Flux Mine and Mill, and the power plant at the Trench Mine were active, employing 125 men. But these were closed down in November 1957.

With a population of around 850 people, Patagonia is the center of rich grazing lands and there are many are two guest ranches in the valley, Rail X owned and operated by Mr. and Mrs. Walter Kolbe and Circle Z with Fred Fendig owner. The grade school sits on a hilltop overlooking the town while the newer high school building is at the east edge of town, near the Ranger Station of the Coronado National Forest. The Woman's Club sponsors a Library and their club house is used for community purposes. Three churches serve people of different faiths. Alert leaders guide the active 4 H club groups of boys and girls. The high light of the year for them being the annual 4 H Fair and sale where they realize profits from their labors in various projects. The scenery has appealed to Hollywood and scenes for some eight or ten movies have been filmed in the area. The present town council, with Edward G. Loftus as Mayor, boasts "there has never been a municipal tax levy, and none is contemplated."

At one time a railroad ran the length of the valley connecting the towns of Benson to the northeast with Nogales, via Patagonia and Calabasas. It crossed and recrossed the stream many times. A storm in 1929 washed out bridges and so the line was abandoned below Patagonia. Now the train whistle competes with the hum of the highway traffic only twice a week when a short train pulls into town from the east then returns the way it came. Mail by truck, and a bus line serve the community twice daily. The road from Patagonia over the Patagonia Mountains makes a scenic and interesting drive. Some of the old mine camps such as Harshaw, Washington Camp and Duquesne may be visited and at the other end is Lochiel, Port of Entry to Mexico. You may return by way of San Raphael Valley to complete the drive.

The raised abandoned right-of-way of the railroad is still a pleasant place for walking through the woods and along the stream, especially for those interested in Nature. There are no bridges, only the concrete abutments are left standing but they make good places to sit and watch the stream slide smoothly by or to watch for wildlife. In early morning or evening white-tailed deer, fox, coati mundi, or chulas as they are more often called may be seen. There are squirrels, jack rabbits, perhaps a bob-cat and in evenings the big Hooded and Hog-nosed skunks which won't hurt you at all. Mammalogists are quite interested in the Hooded since it isn't found far from the Mexican border.

The most accessible part of the woods, although privately owned has been used for many years as a public park by people of Southern Arizona. Populations are increasing so rapidly here that weekends and holidays find crowded conditions in these woods. During summer months there are literally swarms of people picnicking in the area extending three miles west from Patagonia and especially in the place popularly known as Blue Haven. Many car licenses are from Maricopa, Pima and Santa Cruz Counties, also many from Sonora, Mexico, across the border. And quite a few from more distant places have heard of this nice woodsy place with a running stream. Because of grazing and over-use by picnickers and litterbugs no new trees can get started and old ones die each year. The setting aside of a section of the woods which is so easily accessible, to insure proper supervision seems imperative if we are to have it to enjoy in the future. Rarely in desert country do you