Packet Contents
Little Colorado, Puerco, and Salt Rivers

ORIGINAL

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4. 1880? Map of Arizona showing wagon roads, etc. (LCR, Puerco, and Salt)
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23. Through the Grand Canyon / trip taken in 1911 (LCR)
24. In and Around the Grand Canyon / 1911 (LCR)

LCR=Little Colorado Puerco=Puerco River Salt=Upper Salt River

Note: Items 6 to 24 contain pictures, maps, charts, graphs, and tables as part of their narrative that are pertinent to discussions of river status.

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EASTERN ARIZONA COUNTIES ORGANIZATION
APACHE, GILA, GRAHAM, GREENLEE, & NAVAJO

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February 18, 1998

Attn: Jay Brashear, Chairman
and Members
Arizona Navigable Stream Adjudication Commission
1700 West Washington, #404
Phoenix, AZ 85007

Dear Commissioners:

Attached for your consideration is a collection of evidence relating to the navigability of the Little Colorado and Puerco Rivers. These data are organized in the following order:

1. Resolution
2. Charts and Graphs
3. Maps
4. Pictures
5. Textual Evidence (interspersed with illustrations).

Based on this evidence submitted, the following is apparent:

1. Dams existed at the time of statehood (and before) from the headwaters to St. Joseph (Joseph City).

2. Numerous water diversions for irrigation were in place, with appropriations and use of water from the Little Colorado River and its tributaries.

3. Transportation for log hauling, passengers, commercial freight, mail, and others was by horse and buggy, wagon, and railroad, with no evidence of navigation by either the Little Colorado or Puerco Rivers, with numerous land transportation routes along the side of the river.

4. The Little Colorado and Puerco Rivers, both of which are interstate rivers, were not recognized as navigable by the chief geographer of the United States.

5. Daily discharges for the Little Colorado River from St. Johns to Holbrook in the early 1900s was insufficient to support navigation.

6. Bridges and river crossings were in place at the time of statehood in St. Johns, Holbrook, etc.

7. Terrain shown pictorially of the upper Little Colorado River in 1904 reveal river terrain unsuitable for navigation either for persons, logs, or other commercial ventures.

8. Power generation utilizing river water occurred in the early 1900s (before statehood) in St. Johns, and grist mills ran in Springerville.

9. Captain Lorenzo Sitgreaves reported in 1851 that the Little Colorado (and Puerco) rivers were unnavigable, and left his survey of the river as a possible route to the sea after discovering Grand Falls.

10. The United States Geological Survey reported the Puerco River as an intermittent stream from 1909 to 1913.

11. C. Hart Merriam reported in 1890 that the characteristic of the Little Colorado River was to flow swiftly during a downpour, and disappear except for puddles within a day or two after the storm was over.

12. In our exhaustive search for evidence of irrigation and agricultural use, it is significant that there is no evidence of sufficient water along the Puerco River's Arizona stretch to warrant irrigation diversion.

13. Significant natural barriers existed at the time of statehood (and still exist), that impede and make impossible navigation of the Little Colorado River (e.g. Grand Falls, the Little Colorado River Gorge, sediment loading, and shifting sand.

14. In the extensive literature submitted, there is no mention of the Little Colorado or Puerco Rivers ever being navigable, or used for commercial transportation purposes.

With this summary, and the exhaustive attached evidence, we request that you initially classify the Little Colorado and Puerco Rivers as non-navigable along their entire lengths.

Sincerely:

Martin D. Moore, Director
Apache County Development

-and-

Executive Director
Eastern Arizona Counties Organization

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CLARENCE A. BIGELOW, MANAGER-CLERK
ST. JOHNS, AZ 85936

Resolution No. 97- 25
Navigable Stream Adjudication Commission Findings

A resolution finding the Little Colorado River and San Francisco River to be non-navigable and calling upon the Arizona Navigable Stream Adjudication Commission and the Arizona Legislature to adopt this finding.

WHEREAS, it is the desire of the Apache County Board of Supervisors to protect property, title, and water rights of Apache County and its citizens, and a non-navigable finding by the Arizona Navigable Stream Adjudication Commission and the Arizona Legislature may protect those rights; and

WHEREAS, the Arizona Navigable Stream Adjudication Commission is accepting comments and evidence regarding the navigability of the Little Colorado and San Francisco Rivers; and

WHEREAS, the Little Colorado and San Francisco Rivers are at least in part located within the geographic boundaries of Apache County; and

WHEREAS, the proponderance of the evidence compiled by Apache County clearly shows the Little Colorado to be non-navigable along its entire length at and before the time of statehood by virtue of its physcial and hydrologic characteristics, the presence of in-stream structures, evidence of regular land transportation routes along the banks, evidence of diversion from the river for irrigation and other purposes; and no evidence of commercial navigation for any purpose; and

WHEREAS, the proponderance of the evidence compiled by Apache County clearly shows the San Francisco River to be non-navigable along its Arizona stretches by virtue of physical and hydrologic features of the river in its Arizona reaches impeding navigation, bridges and crossings along in its lower reaches, lack of evidence of commercial navigation along its upper or lower reaches, evidence of in-stream structures in the upper and lower reaches impeding navigation, lack of sufficient streamflow, particularly in the upper reaches, to support navigation, evidence of transportation by land and not by river, and evidence of diversion for agriculture, mining, and other purposes.

THEREFORE BE IT RESOLVED, that the Apache County Board of Supervisors finds the entire length of the Little Colorado River, and its major tributaries, to be non-navigable before and at the time of statehood; and

THEREFORE BE IT RESOLVED, that the Apache County Board of Supervisors find the Arizona reaches of the San Francisco River to be non-navigable before and at the time of statehood; and

THEREFORE BE IT RESOLVED, that the Apache County Board of Supervisors requests that the Arizona Navigable Stream Adjudication Commission and the Arizona Legislature adopt these findings.

Adopted this 25th day of September, 1997.

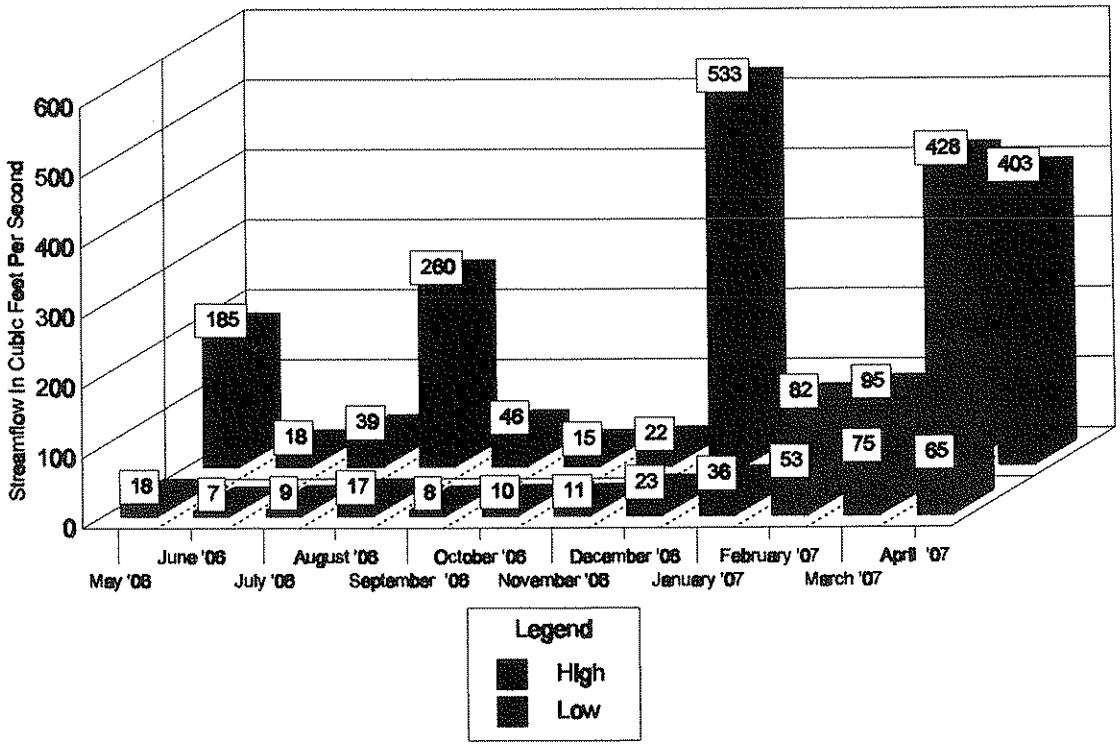
Joe Shirley, Jr., Chairman

ATTEST:

Clarence Bigelow, Clerk

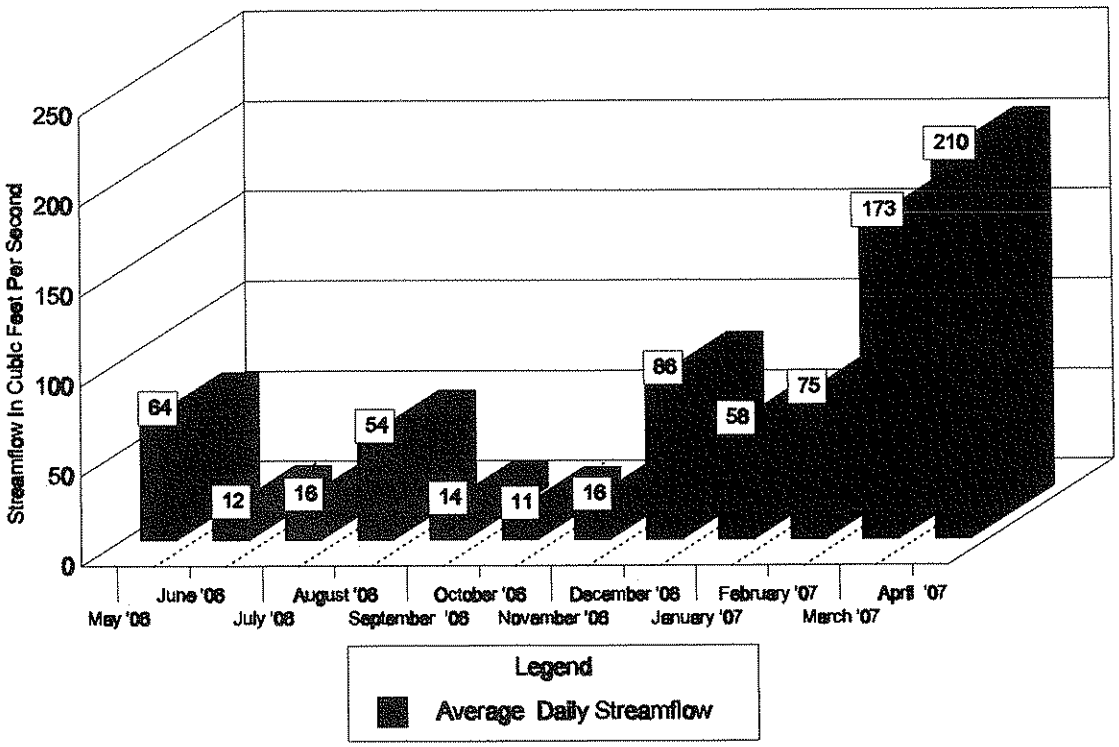
Daily Streamflow At St. Johns, Arizona

1906-1907



Source: *United States Geological Survey (1906/1907). Daily Mean Discharge Data: Little Colorado River at Saint Johns, Arizona, Station #09386000.*

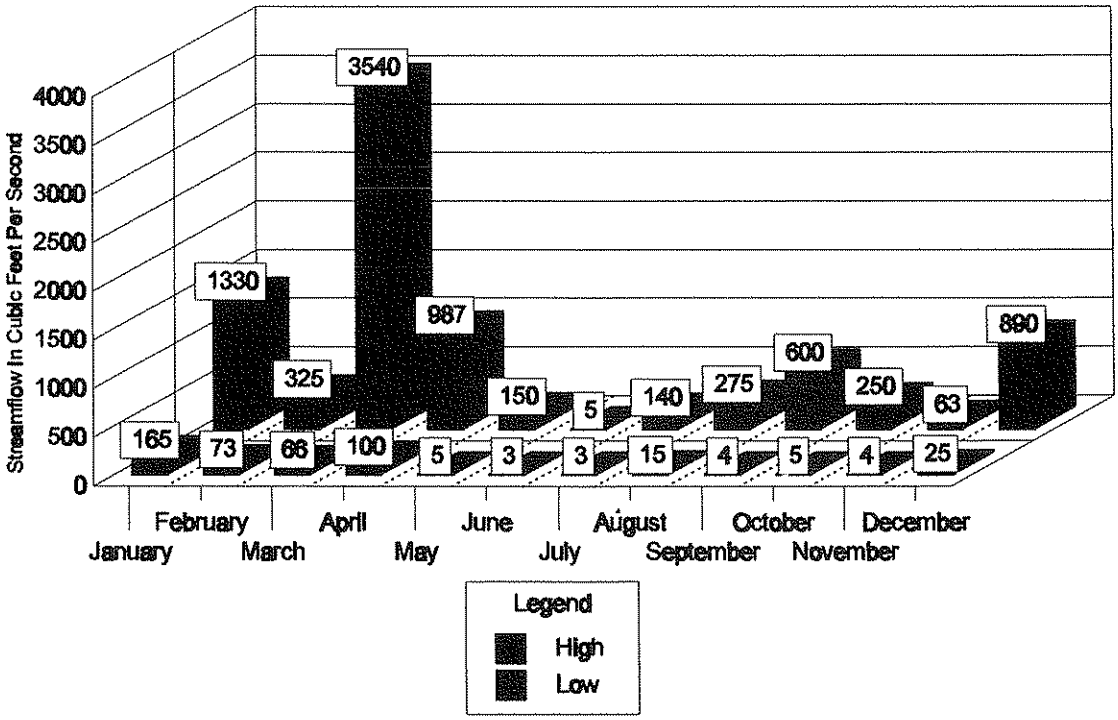
Daily Streamflow At St. Johns, Arizona
1906-1907



Source: *United States Geological Survey (1906/1907). Daily Mean Discharge Data: Little Colorado River at Saint Johns, Arizona, Station #09386000.*

Daily Streamflow At Holbrook, Arizona

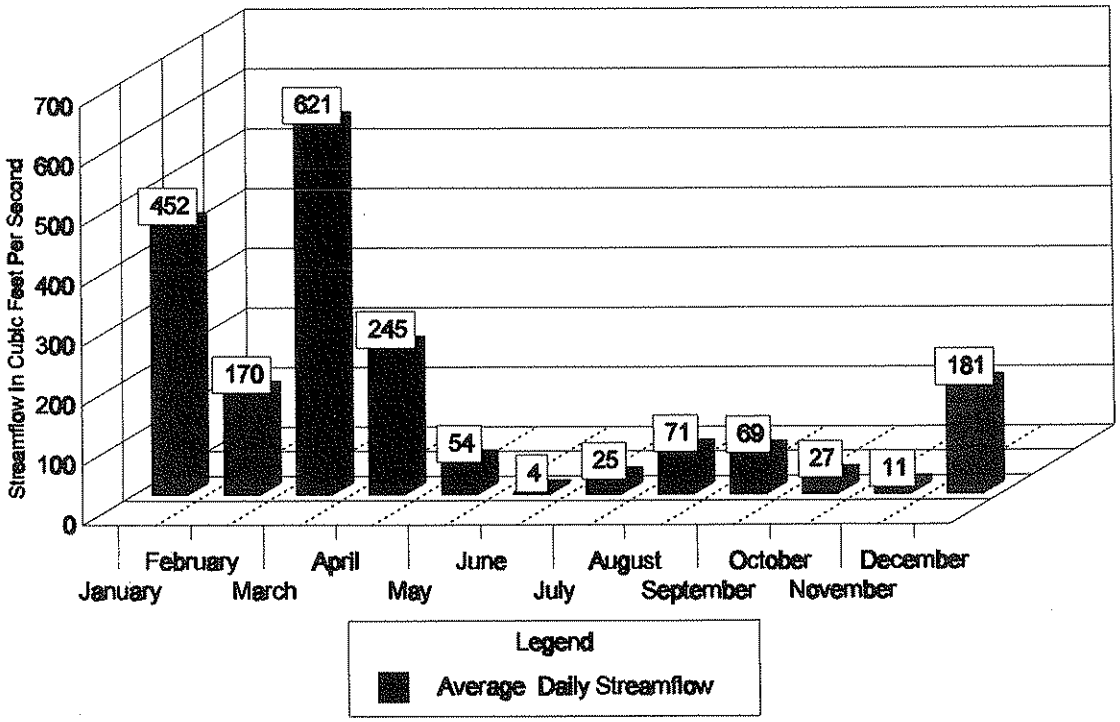
1906



Source: *United States Geological Survey (1906). Daily Mean Discharge Data: Little Colorado River at Holbrook, Arizona, Station #09397000.*

Streamflow At Holbrook, Arizona

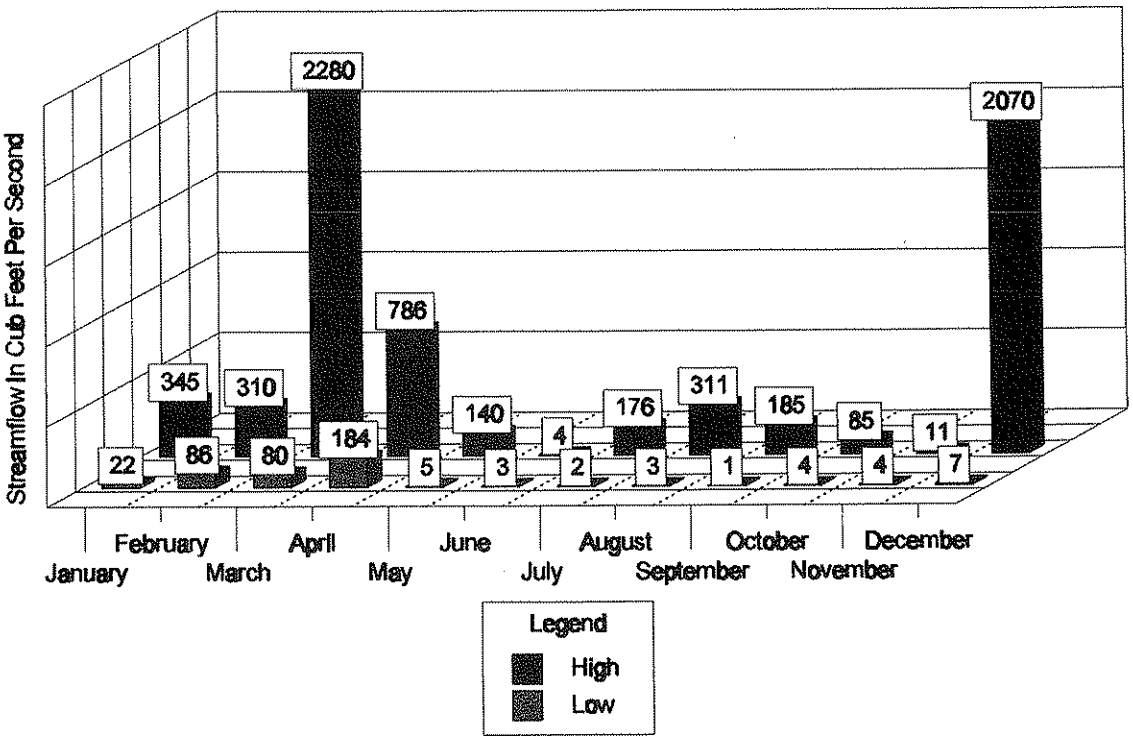
1906



Source: *United States Geological Survey (1906). Daily Mean Discharge Data: Little Colorado River at Holbrook, Arizona, Station #09397000.*

Daily Streamflow At Woodruff, Arizona

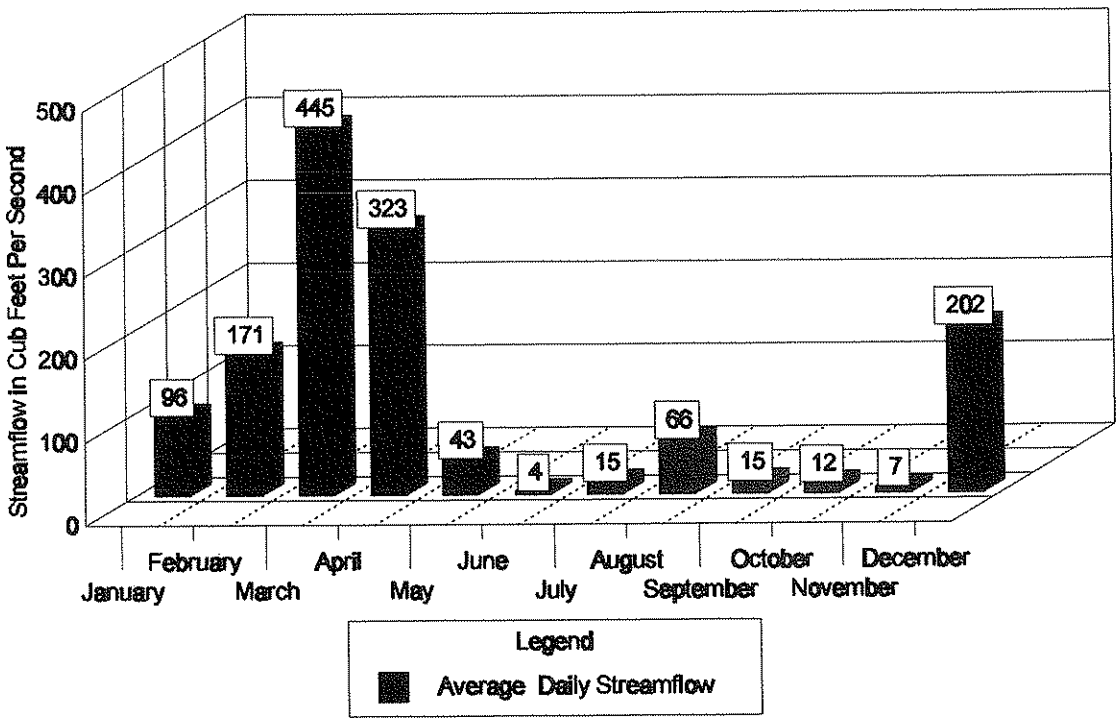
1906



Source: *United States Geological Survey (1906). Daily Mean Discharge Data: Little Colorado River at Woodruff, Arizona, Station #09394500.*

Streamflow At Woodruff, Arizona

1906



Source: *United States Geological Survey (1906). Daily Mean Discharge Data: Little Colorado River at Woodruff, Arizona, Station #09394500.*

Table 5.1

Dam Losses among Individual Settlements
in the Little Colorado River Basin

Settlement	1876 - 1900	1876 - 1923
Lower Valley Settlements:		
St. Joseph	13	14
Woodruff	10	13
Intermediate Settlements:		
St. Johns	2	5
Snowflake	3	6
Taylor	3	6
Eagar	0	1
Mountain Settlements:		
Showlow	1	1
Alpine	0	0

SOURCE: Leone (1979:91); Little Colorado Stake (n.d.); Eastern Arizona Stake (n.d.); St. Johns Stake (n.d.); Snowflake Stake (n.d.).

ASU Map Index Search - Document # 1279

DATABASE: Map Index

Record: 1 of 1

Call #: 4330.1880? R3

Location(s): HAYDEN ARIZONA

Title: Arizona

Author: Rand Mc Nally Company

Date: 1880?

Notes: Library Has 3 Photo Copies. C.1 Negative. C.2,3 Positive

Relief Shown by Hachures Spot Heights

Scale: 1:1,393,920

Subject(s): Arizona Territory

Arizona - Mining Districts

Arizona - Mines

Mines Mineral Resources - United States - Arizona

Arizona - Railroads

Railroads - United States - Arizona

Arizona - History

Military Establishments - United States - Arizona

Arizona - Military Establishments

Arizona - Trails

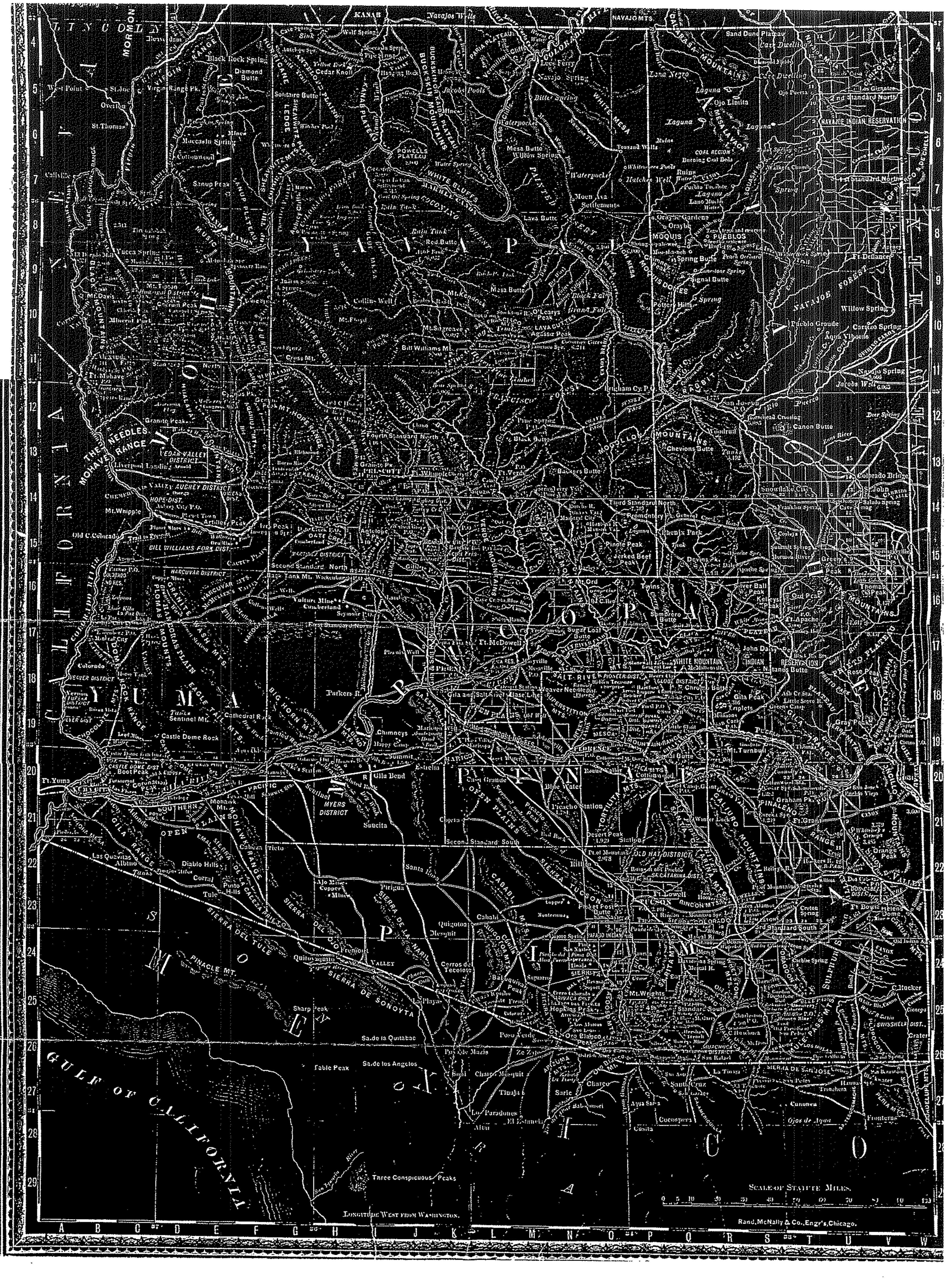
Trails - United States

History - United States - Arizona

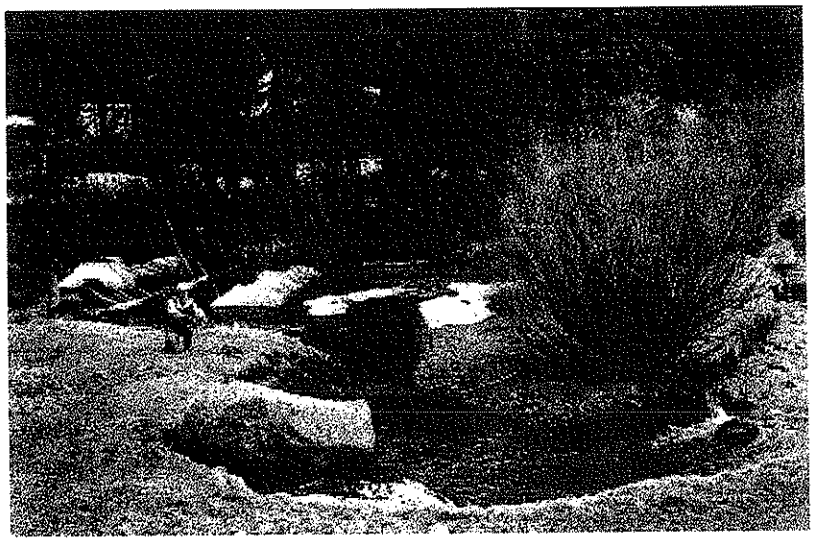
Arizona - Administrative Division

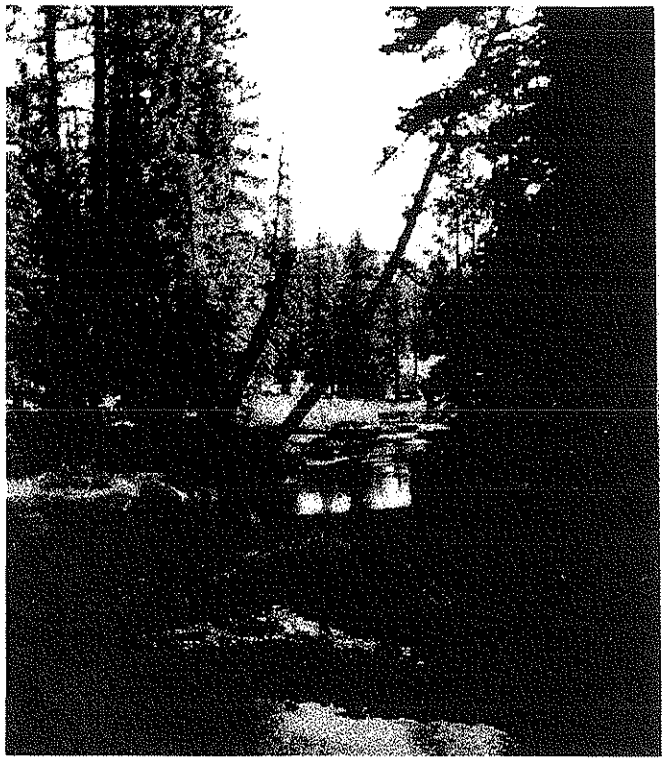
Arizona Territory - Mining Districts

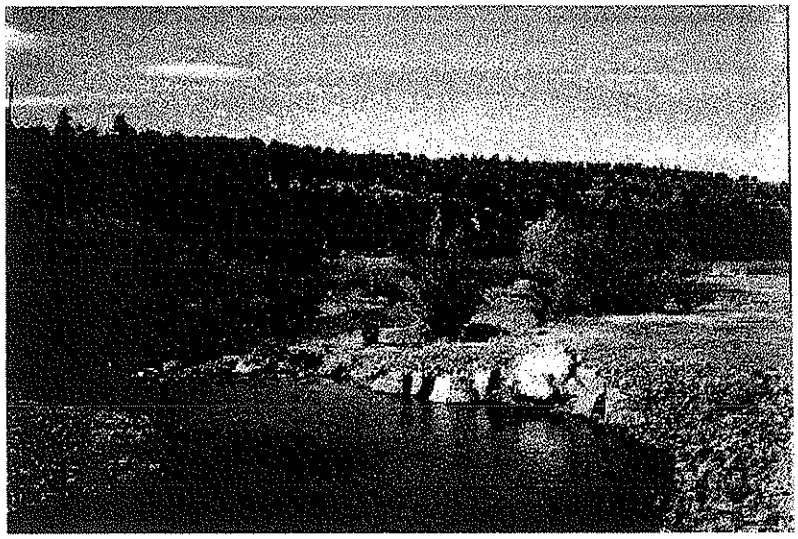
Arizona Territory - Roads

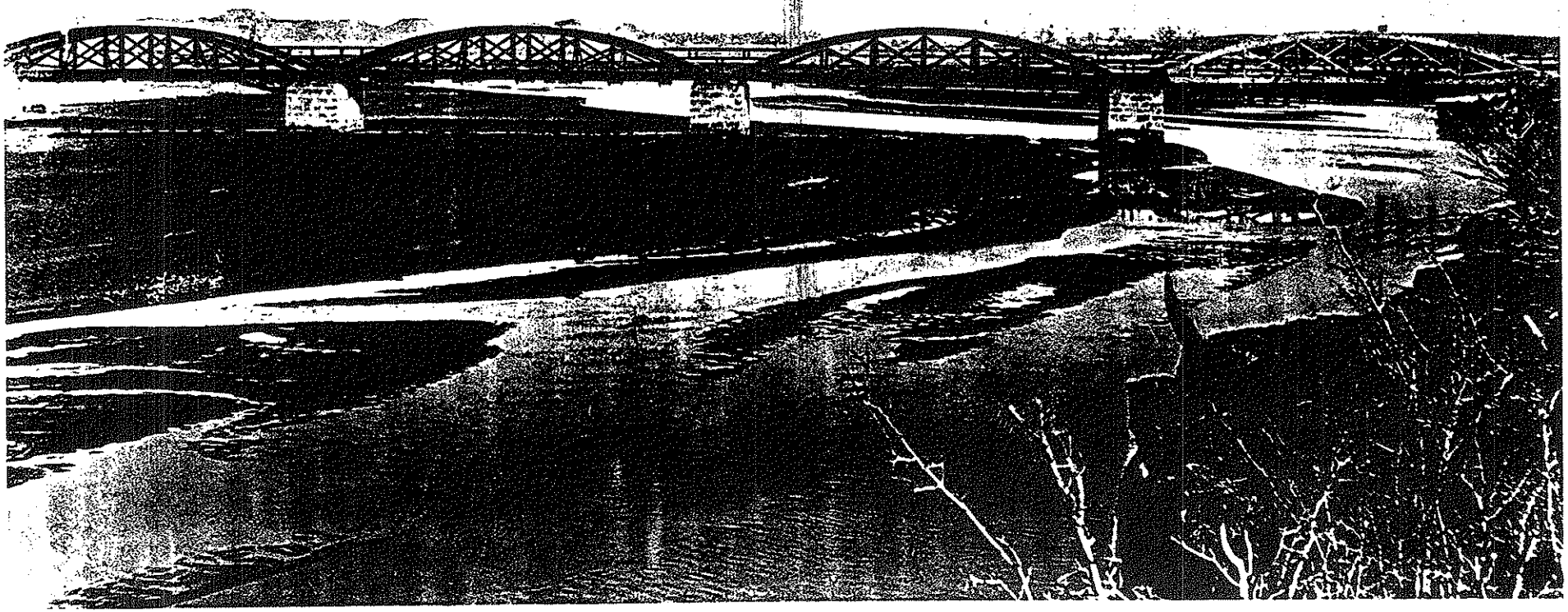


CALIFORNIA
NEVADA
MOHAVE
YAVAPAI
YUMA
MARICOPA
PIMA
APACHE
MEXICO
SONORA
GULF OF CALIFORNIA
Longitude West from Washington.
Scale of Statute Miles.
Rand, McNally & Co., Engr's, Chicago.









Arizona Southwest Index Search - Document # 12749

DATABASE: Arizona Southwest Index

Record: 1 of 1

Call #:	CP SPC 84-1
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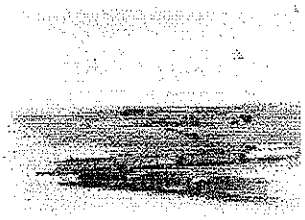
Publisher:	Holbrook, Ariz. Collection
Pub. Date:	1910
Notes:	Unid. Photographer 3.5x5.5 Silver Gelatin Photoprint Postcard
Collection(s):	CP Photographs
Subject(s):	Military-Service


TROOP C & E CROSSING LITTLE COLO. RIVER HOLBROOK ARIZ



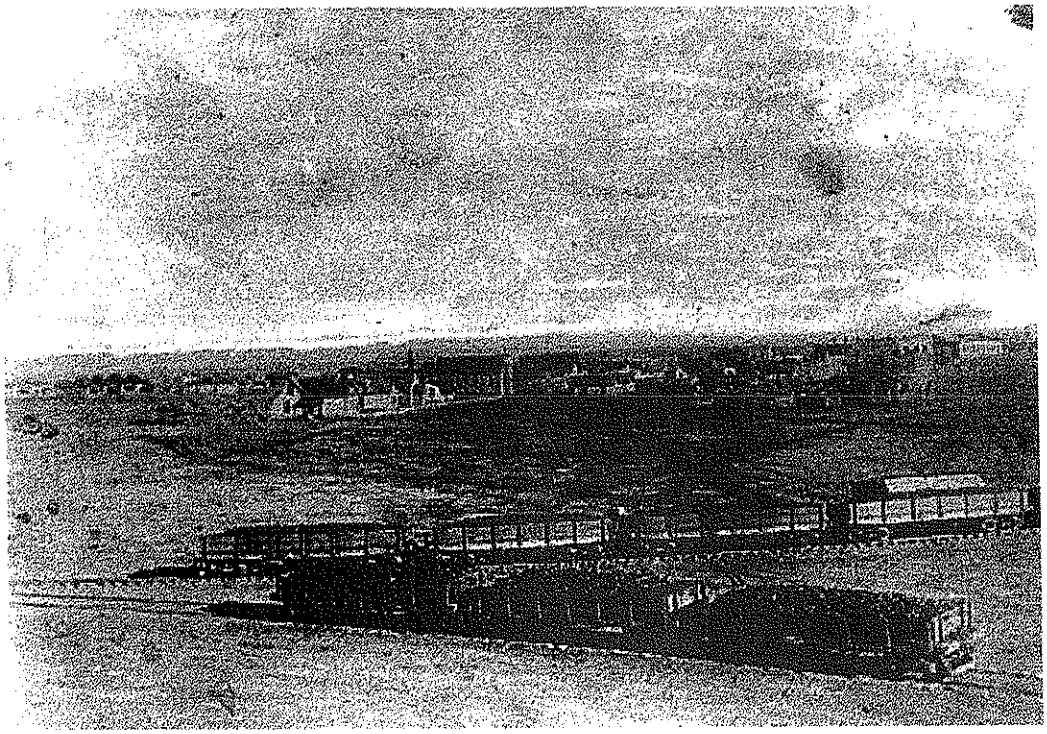
Bird's eye view of Winslow looking east.

Local call number
NAU.PH.3
Creator
Unidentified
Title
Bird's eye view of Winslow looking east.
Physical description
Black-and-white photograph, 17x24 cm
Use
Reproduction requires permission of the repository.
Original creation date
c. 1890
Subjects
Cities and towns - Winslow (Ariz.)
Railroads - freight
Places
Winslow (Ariz.)
Repository
Cline Library
Special Collections and Archives Department
Northern Arizona University
Collection name
N.A.U. General Photograph

Cline Library
Special Collections and Archives Department
Northern Arizona University

Contact: SPCOL@a1.ucc.nau.edu

Revised: February 03, 1997



Bird's eye view of Winslow looking east.

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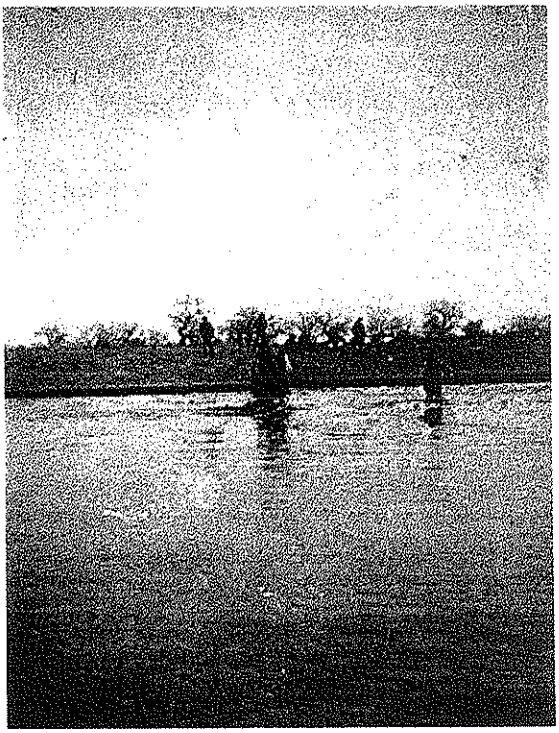

Little Colorado River at Tolchaco, 1902 or '03.

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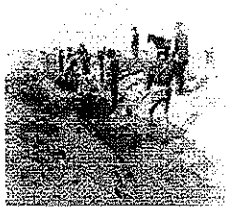
Contact: SPCOL@a1.ucc.nau.edu

Revised: February 03,1997



Digging irrigation ditch at Tolchaco, 1903.

Local call number
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Creator
Philip Johnston
Title
Digging irrigation ditch at Tolchaco, 1903.
Physical description
Black-and-white photograph, 11 x 8 cm.
Use
Reproduction requires permission of the repository.
Original creation date
1903
Subjects
Irrigation canals and flumes
Navajo Indians
Places
Navajo Indian Reservation (Ariz.)
Tolchaco (Ariz.)
Repository
Cline Library
Special Collections and Archives Department
Northern Arizona University
Collection name
Philip Johnston

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Contact: SPCOL@a1.ucc.nau.edu

Revised: February 03, 1997

Digging irrigation ditch at Tolchaco, 1903.

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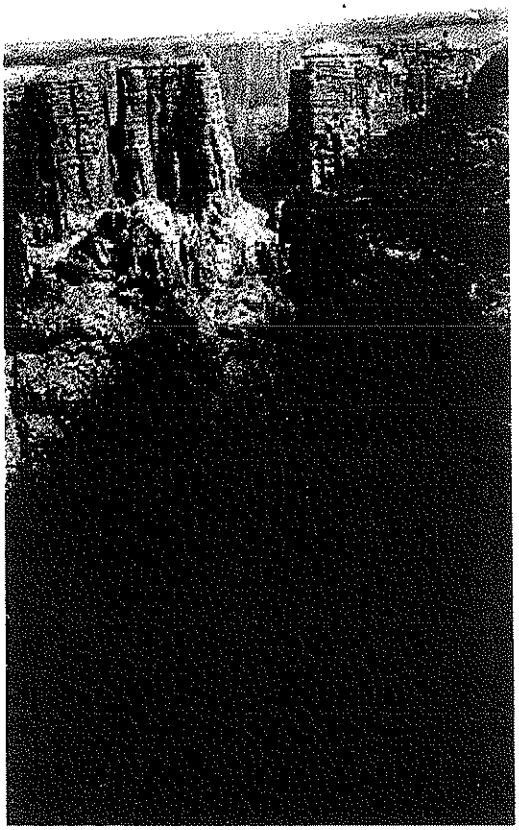
Revised: February 03,1997



View of Little Colorado River gorge.

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Revised: February 03,1997

Report of an EXPEDITION down the ZUNI and the COLORADO RIVERS in 1851

Captain Lorenzo Sitgreaves
U.S. Army Topographic Engineers

U.S. Senate
Executive Document 59
32nd Congress, 2nd Session
1853

A

RIO GRANDE CLASSIC

first published in 1853

Library of Congress Card Catalog
62-20280

The Rio Grande Press, INC.
1734 East 71st Place, Chicago 49, Illinois

32d CONGRESS, 2d Session. } SENATE. { EXECUTIVE, No. 59.

REPORT OF AN EXPEDITION

DOWN THE

ZUNI AND COLORADO RIVERS,

BY

CAPTAIN L. SITGREAVES,
CORPS TOPOGRAPHICAL ENGINEERS.

ACCOMPANIED BY MAPS, SKETCHES, VIEWS, AND ILLUSTRATIONS.

WASHINGTON:
ROBERT ARMSTRONG, PUBLIC PRINTER.
1853.

REPORT

OF

THE SECRETARY OF WAR,

COMMUNICATING,

In compliance with a resolution of the Senate, the Report of an Expedition down the Zuñi and Colorado rivers, by Captain Sitgreaves.

FEBRUARY 15, 1853.—Referred to the Committee on Military Affairs.
MARCH 3, 1853.—Ordered to be printed; and that 2,000 extra copies be printed, 200 of which for Captain Sitgreaves.

WAR DEPARTMENT,
Washington, Feb. 12, 1853.

SIR: In compliance with the Senate resolution of the 28th July last, I have the honor to transmit herewith the Report "of the Expedition down the Zuñi and the Colorado, under the command of Captain Sitgreaves, of the Corps of Topographical Engineers, and of the maps belonging thereto; also, the sketches and views and illustrations of Indian customs."

Very respectfully, your obedient servant,

C. M. CONRAD,
Secretary of War.

Hon. D. R. ATCHISON,
President of the Senate.

BUREAU OF TOPOGRAPHICAL ENGINEERS,
Washington, Feb. 7, 1853.

SIR: I have the honor to submit the Report of the Expedition down the Zuñi and the Colorado, under Captain Sitgreaves, of the Corps of Topographical Engineers, called for by a resolution of the Senate of July last.

Respectfully, sir, your obedient servant,
J. J. ABERT,
Colonel Corps Top. Engineers.

Hon. C. M. CONRAD,
Secretary of War.

WASHINGTON, *February* 7, 1853.

SIR: I have the honor to submit the accompanying map of the route explored by me from the pueblo of Zuñi, New Mexico, to Camp Yuma, on the Colorado of the West, under instructions from you, of which the following is an extract:

"The river Zuñi is represented on good authority to empty into the Colorado, and it has been partially explored by Lieutenant Simpson to the pueblo of Zuñi. You will therefore go to that place, which will be, in fact, the commencing point of your exploring labors. From the pueblo of Zuñi you will pursue the Zuñi to its junction with the Colorado, determining its course and character, particularly in reference to its navigable properties, and to the character of its adjacent land and productions. The junction of the Zuñi and Colorado will be accurately determined. You will then pursue the Colorado to its junction with the Gulf of California, taking those observations which will enable you accurately to delineate its course."

The party was organized at Santa Fé, and consisted of Lieutenant J. G. Parke, Topographical Engineers; S. W. Woodhouse, M. D., physician and naturalist; Mr. R. H. Kern, draughtsman; Mr. Antoine Leroux, guide; five Americans and ten Mexicans as packers and *arrieros*.

As many mules as could be procured in time, suitable for the purpose, were purchased; but these not being sufficient, the assistant quartermaster at Santa Fé furnished me, on my requisition, with forty additional ones, with pack-saddles, &c. A portion of the provisions for the party were obtained from the assistant commissary of subsistence at the same place.

The commanding officer in New Mexico being about to make an

expedition against the Navajos, directed me to await his departure, so as to take advantage of the protection afforded by his command as far as our routes coincided, or until he could detach a proper escort for my party. The troops assembled at Santo Domingo, on the Rio Grande, and took up their march thence on the 1st August. On the 1st September we arrived at the pueblo of Zuñi, the point at which my exploration was to commence.

Colonel Sumner had detailed for the escort Brevet Major H. L. Kendrick, 2d Artillery, with thirty men of his company, but they were not detached until after they had accompanied him to Cañon Bonito, three days' journey farther into the Navajo country. I was thus compelled to wait at Zuñi until the 24th September, consuming in the mean time part of the limited supplies provided for the expedition. The mules likewise suffered from the delay, for there was scarcely any grazing in the immediate vicinity of the pueblo, and I did not deem it prudent to send them to a distance, as small parties of Navajos had been seen lurking in the neighborhood. The mules of Major Kendrick's command were still more unfit to undertake a difficult march, many of them having been taken out of wagons after a journey of several weeks' duration.

I can add very little to the information afforded by the map, almost the entire country traversed being barren, and without general interest. Observations with the sextant were made as often as occasion served; and the latitude and longitude of as many points determined as are necessary to establish the line of march with sufficient accuracy. Collections were made of such objects of natural history as could be transported with our limited facilities. Their description will be found in the reports hereto appended.

The expedition set out from Zuñi the 24th September. The incidents of the journey are detailed in the following extracts from my journal:

September 24, *Camp No.* 1.—Our first day's march was only six miles. It was made thus short to enable us to correct any defects that might be discovered in the arrangement of the packs.

The Zuñi is a mere rivulet, and not entitled to the name of river; in most parts of our country it would not be dignified with that of creek. The corn-fields of the Zuñi Indians extended at intervals for several miles down the stream, their crops and orchards being planted on the edge of the valley, or in the fertile gorges of the mountains. The only cultivation in the immediate vicinity of the pueblo consisted of small vegetable gardens, tended by the women and watered by hand, in which

were grown chiefly onions, beans, and chile.* Their orchards produce good peaches, with which we were abundantly supplied during our stay at the village.

September 25, *Camp No.* 2.—A well-beaten trail, following the general direction of the stream, enabled us to avoid the inconvenience of travelling over ground rendered soft and miry by the recent rains. We encamped on the banks of the creek, near some abrupt rocks, from beneath which gushes out a fine spring. Fragments of pack-saddles and broken boxes gave evidence of a former encampment of white men, probably of the party of Lieutenant Thom, who escorted Mr. Collier to California in 1849.

September 26, *Camp No.* 3.—The valley is here shut in by abrupt walls of gray sandstone, occasionally mixed with basalt, having frequent springs running out from under them; but farther down it expands to several miles in width, other valleys opening into it. The faces of the sandstone rocks, wherever they presented a smooth surface, were covered with Indian hieroglyphics, or pictures, carved or painted upon them.

The bed of the stream becoming dry, we crossed the point of a precipitous basaltic ridge, and, keeping on the slope of the hills bounding the valley to the north, encamped on a little channel filled with muddy rain-water in the middle of a miry plain. The soil on the hills was sandy, and in the plain, of sand mixed with clay; in both cases yielding to the foot.

September 27, *Camp No.* 4.—Just after leaving camp a small party of Indians came in sight, who proved to be Coyoteros, (Apaches,) driving some asses to Zuñi for the purpose of trade. One among them was evidently a Mexican, captured probably in childhood, for he spoke but few words of Spanish.

The well-marked trail we had hitherto followed brought us at length to the Little Colorado, which it crosses, continuing on south to the Salt River, a tributary of the Gila.

At this point the Little Colorado is an insignificant stream, divided into several small channels, flowing through a narrow valley destitute of timber, but covered with a thick growth of rank unnutritious grass. The hills bounding it on either side are of gradual slope, with here and

* Since the establishment of the military post at Cañon Bonito, and the consequent pacification of the Navajos, the amount of cultivation has greatly increased. During the past season the Zuñi Indians had some ten thousand acres in corn, and the Moquis a still greater quantity.

there a rocky point, of a conglomerate of gray sandstone and pebbles jutting out into the bottom.

September 28, *Camp No.* 5.—Proceeding down the valley, it widens out into a broad plain, which the recent profuse rains had made soft and muddy. To avoid this we turned off from the river, and made our way across the high land, but gained little by the exchange, for the soil was so light and thinly covered with grass that the mules sank to their fetlocks at every step. The ground was strewed with pebbles of agate, jasper, and chalcedony, and masses of what appeared to have been stumps of trees petrified into jasper, beautifully striped with bright shades of red, (the predominating color,) blue, white, and yellow. The rocks were gray sandstone, sometimes of a slaty structure.

September 30, *Camp No.* 7.—The river here runs through a deep and rocky cañon, which we skirted, and crossed below it to the south bank, finding the ground much broken by ravines, which were only visible when we came directly upon them. The surrounding scenery resembled that of the northwestern prairies, the country being bare of trees and the horizon unbroken, except in one direction, where a high conical peak, that had served us several days as a landmark, varied the uniformity of its outline.

October 1, *Camp No.* 8.—The river, winding to the north, gave us a straight course across the high land, soft and sandy, as usual, and frequently intersected by deep ravines, until we again encountered it, flowing now between bluff sandy banks fringed with cotton-wood trees, and presenting at length the appearance of a river, but still with little water in its bed. I remarked cropping out of the side of a bluff a seam of fibrous gypsum three or four inches thick. In the course of the day's march the San Francisco mountains became visible to the west, and to the north several singular volcanic peaks.

October 2, *Camp No.* 9.—The river here receives a tributary known among trappers as Chevelon's Fork, from one of that name who died upon its banks from eating some poisonous root. Their confluence produces an intricate labyrinth of sloughs, in which we became involved, and were forced to encamp, not finding an outlet until late in the day. In several places veins of fibrous gypsum were seen, looking like the ice-crystals that burst open the ground in spring.

October 3, *Camp No.* 10.—Our course was here interrupted by a deep bayou thickly overgrown with rushes, and which, on attempting to turn it, was found to lead to a rocky ravine or cañon utterly impassable. We retraced our steps, therefore, and with much difficulty

recrossed the river, which, making a bend to the north, winds through a broad plain resembling the bed of a great lagoon from which the water had just subsided, leaving it slimy and intersected with fissures and channels that often impeded our progress. Here and there only a bush of the wild sage dotted its surface, and the surrounding hills appeared equally destitute of vegetation.

October 5, *Camp No.* 12.—The country on the north bank presenting the same appearance of desolation as far as the eye could discern, we again crossed the river, and, passing on to higher ground, encamped on a bayou near the edge of the valley. The grass upon the hills was invariably better and more abundant than on the river bottom, but the absence of wood and water in such places generally obliged us to make our camps near the river. The mules, particularly those of Major Kendrick's command, already began to show signs of fatigue, and their backs to become galled by the saddles.

The army pack-saddle is of excellent materials and workmanship, but is defective in form. Its shape should approach more nearly to that of the riding-saddle, so as to provide against a change in the condition of the animal. A saddle may answer very well for a horse or mule in good condition, which will injure the back when the animal becomes lean or changes from a grain to an exclusive grass diet. Lieutenant Colonel Johnston informed me that he was in the habit of using with good results the common Texas tree, provided with the necessary rings and straps. A good pack-saddle is still a desideratum in the service.

October 7, *Camp No.* 13.—Many precipitous cañons were passed, enclosing within their walls of yellow sandstone clumps of small cotton-wood trees. Ridges of lava and a black dust, the detritus of the lava, overing the ground in many places, indicated our approach to a volcanic region. Near our camp, on the bank of the river, were the ruins of several stone houses, which the guide, Mr. Leroux, said resembled those of the Moqui Indians.

October 8, *Camp No.* 14.—About a mile below the last camp the river falls over a succession of horizontal ledges of sandstone, forming a beautiful cascade of one hundred to one hundred and twenty feet in vertical height, and continues on its course through a cañon of that depth, the general level of the banks remaining the same.

Having been informed by my guide and other experienced trappers that this cañon extends down the river to its junction with the Colorado, and the great cañon through which the latter flows, I regarded the attempt to follow the river to its mouth as too hazardous, consider-

ing the condition of the animals and the state of the supplies, and therefore, by the advice of the guide, turned off towards the mountains, with the purpose of striking the Colorado below the great cañon, and then exploring it upward as far as might be found practicable. Leaving the river then, we passed along the base of high table lands, the lava-sand lying several inches deep upon the ground, filling up the hollows, and forming ridges across the plain; and, ascending the plateau, found it also covered with the lava detritus, and all the prominent points occupied by the ruins of stone houses of considerable size, and in some instances of three stories in height. They are evidently the remains of a large town, as they occurred at intervals for an extent of eight or nine miles, and the ground was thickly strewed with fragments of pottery in all directions. The fact that no vestige of water could be discovered in the vicinity sufficiently accounts for their present depopulation. The encroachment of the lava-sand blown down from the adjacent mountains may have gradually filled up the springs and water-courses; it is certain, at any rate, that the heaviest rains would now be rapidly absorbed by it, and after a day or two leave no trace of water upon the surface.

The houses resemble in all respects (except that *adobes* do not appear to have been at all used in their construction) those of the existing pueblos of New Mexico; and the pottery, of a great variety of fabric and pattern, is similar to that now in use among them.

October 9, *Camp No.* 15.—Pursuing our way still farther into the mountains, the ruins became of rarer occurrence, or else were concealed by the cedars with which the hills were covered. A small pool of water was discovered under an overhanging rock, out of which the men as they came up filled their canteens; and, as the water was not thereby sensibly diminished, it was supposed to have its source in some concealed reservoir, and that it would be possible in the course of the day to water all the animals. We should then, moreover, have been able to hold a more direct course, having diverged towards the mountains in the expectation of finding water. The camp was scarcely pitched, however, when it was reported that the spring was rapidly becoming exhausted, and Mr. Leroux was therefore sent, with the mules and half of the men, in search of water, the rest remaining in camp to protect the supplies. He did not return until late in the night, and reported that he had come upon a large encampment of Yampai or Tonto Indians on the edge of a deep ravine, through which ran a stream, which he supposed to be the headwaters of the San Francisco, a tribu-

tary of Salt River. The women and children, engaged in gathering *piñones*, (pine-nuts,) fled at his approach; while the men held themselves aloof, and refused to parley with him or meet his friendly advances. He was compelled, therefore, to return as he went, not venturing to drive the mules into the ravine, and thus give the Indians an opportunity of attacking him at disadvantage. I regretted that he had suffered his men to take from the lodges sundry articles of value to the Indians. Among these were some admirably made baskets, of so close a texture as to hold water; a wicker-jar, coated with pine-tree gum; a large quantity of piñones and grass-seed; some bread, made of the mezquit bean; a cake of *mezcal*, (a preparation of the maguey;) and pieces of a substance that had all the appearance of chalk; but as it did not effervesce with acids, was probably an exceedingly pure variety of kaolin.

October 10, *Camp No.* 15.—The mules, having now been two days without water, were, as the last resource, sent back to the river, taking with them some kegs and India-rubber water-bags with which I had fortunately provided myself. They returned in the evening, less three of their number lost by the way, but bringing back an abundant supply of water. In the course of the preceding night, by watching by the spring and dipping up the water by the spoonful as it trickled out, enough had been obtained to furnish each person with a cup of coffee.

October 11, *Camp No.* 16.—As we ascended the mountain the cedar gave place to the nut-bearing pine; and this, when near the summit, to a pine of larger growth with long leaves. Herds of antelope were seen in all directions, but they kept to the open country, and were shy and difficult to approach.

October 12, *Camp No.* 17.—The ascent of the mountain was continued, with the greatest anxiety as to the result of the day's journey; for the mules had drunk but once in more than four days, and the country showed no indications of water in any direction. There was much beauty in some of the glades and mountain glens we passed. The ground was covered with fresh grass and well timbered with tall pines, mingled, after attaining a certain altitude, with aspens of a brilliant yellow.

Crossing the summit we descended gradually to the brow of a precipice overlooking a green vale of five or six miles in extent, but with no appearance of water, and commenced the descent, picking our way with difficulty among the loose rocks, in the belief that there we should be compelled to abandon most of our animals. When half-way down, a

shot from one of the Mexicans on the flank inspired us with hope, for it was the signal fixed upon to notify the discovery of water; but still I observed nothing to warrant it; and it was not until we had reached the bottom of the cliff that I discerned a narrow thread of grass and weeds, greener and ranker than the surrounding growth, winding out from a little nook, and losing itself in the plain. It proved to be a spring of delicious water; and thus providentially terminated our fears and anxieties for the time.

October 13, *Camp No.* 17.—It was necessary to halt here for a day or two to rest the mules and have them reshod. The feet of the sheep, too, had become sore and worn out; and at the suggestion of a Mexican, my *mayordomo*, the cracks in them were filled, by means of a hot iron, with resin and pine-tree gum, by which operation the animals appeared much relieved. Mr. Leroux reconnoitred the route ahead, and found water in several places ten or twelve miles distant. He again surprised a few lodges of Indians, who fled, leaving their effects behind them. This time he did not permit his men to pilfer, but, on the contrary, left at the lodges a small present of tobacco, handkerchiefs, and knives, for the purpose of conciliating the Indians, and inducing them to hold some intercourse with us, by which means we hoped to obtain useful information in regard to the route. The only provisions found in the lodges were piñones and the grass-seed before mentioned.

The box chronometer had been carried in a pannier, carefully packed in wool, and placed on the steadiest mule of the *atajo*, which was always led by the halter; but it was nevertheless found to have stopped, from the roughness of the last day's journey. Independent observations were therefore made for the longitude, the pocket chronometer not having sufficient regularity to be depended on.

During the night we were alarmed by a stampede of the mules. Fortunately they ran into a gorge near the camp, from which there was but the one outlet, and we succeeded in quieting them. The cause of their fright was made apparent by the roaring of a panther, or other large animal, in uncomfortable proximity to the herd.

October 15, *Camp No.* 18.—Our route lay across plains of gentle slope. Mingled with the pines were a few small post-oaks; and in a green glade was found some white clover of a different variety from that common in the States. Flowers and birds were more numerous than upon the northern slopes of the mountain, but no fragments of pottery or other signs of habitation were seen. Our camp was upon the dry bed of a lagoon, a mile in extent, having some small pools of water

hidden among the tall grass, from which our arrival put up a large flight of water-fowl, crows, and smaller birds. When approaching the mountains I had been struck with a singular incandescent appearance which some of the higher slopes presented when the sun was near the horizon. This I found to be caused by a bright, yellow-colored grass, having the extremities of the blades tipped with red by the action of the frost. It looked fresh, but the animals preferred the shorter kind, which grew upon the ridges and among the pines.

October 16, *Camp No.* 18.—We were detained at this camp by the illness of one of the party, a Mexican, from a blow on the head received some days previously. He died on the 25th, and was buried at the foot of a large pine tree, marked with a cross. The delay afforded our jaded animals the rest they so much needed, but also consumed a portion of the supplies of which we were afterwards in great want. The bacon had lost much in weight from the effect of the hot sun, and the issues at this place nearly exhausted the supply. About twenty sheep, in poor condition, remained, and formed our sole dependence, with the exception of some meat-biscuit, the excellence of which had not then been tested. It is an admirable preparation, and should form a large proportion of the supplies for all similar expeditions. Although antelope and black-tailed deer were abundant, and the fresh tracks of bears were occasionally seen, our hunters, some of them experienced and expert, had not been successful in supplying us with game. The daily variation of the temperature was remarkable, the average range in twenty-four hours being about 55° Fahrenheit, or from 10° to 65°. Near the summit of one of the adjacent hills were the traces of old excavations, made apparently in search of the precious metals, but the surrounding formation gave no indications of their existence. Similar remains were observed near Camp No. 16.

October 21, *Camp No.* 19.—Occasional patches of white clover were again met with, and the singular cedar first seen when crossing the Zuñi mountains. The trunk is large and low, with wide-spreading branches, and the bark, several inches thick, is corrugated like that of the oak. The camp overlooked a wild and picturesque cañon. Tall pines, oaks, and the low, spreading cedar were mingled so as to produce a park-like effect, heightened by glimpses through the vistas of the sheep and mules grazing on the rich grama grass that grew up among and concealed the sharp, black fragments of trap that covered the ground.

A Mexican who left camp on the 19th to hunt for game, had not returned when we set out; and as our frequent search for him had been unsuccessful, it was feared that he had fallen into the hands of the Yampais. At sunset, however, on driving the animals to water in the cañon, he was discovered sitting on a rock, picking a rib of venison. He had lost himself and become bewildered, wandering about for three days without water or food; for, although he had killed a deer, he had not ventured to eat for fear of rendering his thirst insupportable, until he found himself at the spring near Camp 17, from which place he had been guided by the trail of the party until he overtook us.

October 23, *Camp No.* 21.—Keeping along the side of the mountain in the hope of meeting with water, we got into a succession of deep and steep ravines; but, finding them dry, bore more to the south, and descended into the bed of a small stream, called by trappers Bill Williams's Fork, in which were a few pools containing sufficient water for the supply of the party. As we descended the pines became of smaller growth, with here and there cedars, scrub-oaks, locusts, and the *Fallugia paradoxa*, described in Major Emory's report.

October 24, *Camp No.* 22.—Leaving behind us the mountains and the stream, whose course was too much to the southward, we struck out west across the plain. The ground was much broken by precipitous ravines, in one of which were seen masses of porphyry and quartz, the only exceptions to the usual trap we had met since reaching the mountains.

October 25, *Camp No.* 23.—In the course of the day we passed a few groves of the common cedar, the only tree to be seen. The grass, of good quality, was parched with the continued drought, and the soil, loose and dry as ashes, gave little hope of finding water.

October 26, *Camp No.* 24.—At daylight it was discovered that a dozen mules were missing. Their tracks showed that they had gone back upon our trail, and some men were despatched to recover them; while the rest of the party pursued their journey across a rocky ridge thickly overgrown with cedars, whose low branches, frequently sweeping off a pack, rendered the march slow and laborious. When we stopped to rest in the middle of the day the animals, overcome with thirst and fatigue, refused to graze, and huddled together under the shade of the trees. Before resuming the march, a gourd of water and some bread were left for the men who had been sent back in search of the missing mules; and, after a march of seven miles farther, we encamped the third night without water.

October 27, *Camp No.* 25.—A few hours after setting out, fresh

signs of Indians began to make their appearance, and increased as we advanced, in frequency and numbers, until we came upon a well-marked and newly-made trail, leading to the northward of our course, but into which we turned in the hope of its leading us to water. Having pursued it in silence a few miles, we surprised a party of ten or twelve of the most wretched looking Indians I have ever seen, naked, and apparently almost starved. They all fled, except an old man and a woman, whom we attempted to conciliate with some presents; but were not successful in allaying their fears, although the man finally undertook to direct us to water. The mules were therefore unpacked and sent off under his guidance. He conducted them to two small springs in a rocky gorge, some ten miles distant; but, in their eagerness to drink, the ground was soon trampled into a mere mass of mud, so that very few were enabled to quench their thirst. The Indian watched his opportunity, when not observed, to slip from his mule and escape among the rocks; but as he had performed the only service we required of him, no attempt was made to retake him.

October 28, *Camp No.* 26.—As there was no other alternative, the camp was removed to the vicinity of the springs and the men set to work at clearing them out. By this means, and leading two or three at a time to water, in the course of this and the following day a small quantity was obtained for each animal, barely enough to keep them alive, but not enough to allay their thirst, as their refusal to eat and plaintive cries too clearly proved.

The continued absence of the men who had been sent back on the 26th upon the tracks of the missing mules created great fears for their safety, or lest they had returned to Zuñi; and their arrival there, it was apprehended, would give rise to unfavorable rumors in regard to the party. Our anxiety was relieved, however, by their reappearance in camp. They had succeeded in finding the mules and bringing them within a day's march of camp, when half the number had again made their escape. During their absence of four days the men had suffered much from hunger and thirst, having taken but one day's rations with them, and being without water, except a small gourd full that one of them had been provident enough to conceal before setting out. The bread and water we had left for them, though placed conspicuously in the middle of our trail, had not been discovered by them, and was probably carried off by the Indians.

A party sent out to reconnoitre brought back the gratifying intelligence that twelve miles in advance was a small stream of running water

and an abundance of tolerable grass. A band of Yampais were found encamped upon it, from whom Mr. Leroux learned that the numerous trails we had observed for the last two or three days united and led to the country of the Mohaves, and that their camp was but one day's journey from the river.

October 30, *Camp No.* 27.—This rivulet, which I have called the Yampai, has its source in three small springs; it is repeatedly lost in the ground within a distance of half a mile; after which it disappears entirely. A few willow and cotton-wood trees grow upon its banks, and green grass was here seen for the first time since leaving the San Francisco mountains. Here, too, we enjoyed the luxury of a bath and clean clothes—a luxury not fully appreciable by those who have not gone a week without water to wash even their faces and hands.

November 1, *Camp No.* 28.—In the morning one of the sentinels discovered an Indian lurking about the mules, and brought him into camp. He called himself a "*Cojnino*," was well clothed in shirt, leggins, and moccasins of buckskin, and his hair bound up behind into a queue, after the manner of the Pueblo Indians. A long hair-rope wound around his waist gave unmistakable evidence of his designs upon our mules. After a short time several others made their appearance upon a neighboring hill, and were induced by signs to approach the camp; but, when within two hundred yards, the first one sprang up and darted from the midst of a dozen men who were standing around him, wielding an arrow drawn from his quiver to prevent their approach, and calling out loudly to his companions, who immediately turned and fled, discharging their arrows into the herd and killing three of the mules. The men were then ordered to fire upon them, which they did without any apparent effect, although traces of blood upon the rocks showed afterwards that one at least had been wounded.

November 2, *Camp No.* 29.—We kept down the valley of the Yampai some twelve miles, when, finding that its course was out of our most direct route, we diverged from it across a wide barren plain, and encamped without water, grass, or wood, the only fuel being the withered cacti with which the plain abounded.

A naked escarpment on the side of the creek showed a stratum of granite, containing a great deal of feldspar, underlying the trap, and a whitish feldspathic rock enclosing nodules of chalcedony. The rest of the country only exhibited the usual volcanic formation.

November 3, *Camp No.* 30.—Directly in our front was a bold range of mountains, from the top of which we were sanguine of seeing the

Colorado. We entered a rugged and difficult pass, between cliffs and pinnacles of gneiss, and attained the summit after a long and fatiguing ascent and the loss of several mules that gave out by the way, to be again disappointed in beholding, instead of the river, another extensive and desolate plain, and beyond it a similar formidable looking mountain range.

While halting to rest the mules and endeavor to bring up those that were left on the road, Mr. Leroux turned off to ascend a higher peak, affording a more extended view of the country ahead; and, passing by a cluster of rocks, received the discharge of a flight of arrows from a concealed party of Indians. Three of the arrows took effect, inflicting severe wounds in the head and wrist, which caused him much suffering and disabled him for the rest of the journey. The Indians were driven from rock to rock, but always contrived to keep out of rifle range; and, after the pursuit was abandoned as fruitless, they returned as near as their safety would permit, watching our movements and making gestures of rage and defiance. When the march was resumed they followed for a short distance, approaching near enough to discharge some arrows, without effect, at the rear of the party. They were similarly clad and appeared to be of the same tribe as those last seen; some of the men, indeed, thought they recognised the one who had been in our camp two days before.

November 4, *Camp No.* 31.—Many trees of the Spanish bayonet, scattered over the plain, varied the scene somewhat, but gave no relief to its aspect of barrenness; and another night passed without grass or water, added to the sufferings of the nearly exhausted animals.

November 5, *Camp No.* 32.—The approach to the mountains, before alluded to, was by a gradual ascent, so that when we arrived at their base, there did not remain much to be overcome. The pass was nevertheless exceedingly rough, and bordered by overhanging crags, which it was deemed prudent to occupy before advancing with the *atajo*. We passed through, however, unmolested, and were at length cheered by the view of the Colorado, winding far below through a broad valley, its course for many miles being apparent from the large trees upon its banks. The smoke of numerous fires in the valley gave evidence of a large Indian population, and the sight brought a spontaneous cheer from the men, who believed that this was to be the end of their privations and of the labors and anxieties of the journey.

The barometer showed us to be about 3,200 feet above the river. The descent to it was rapid and continuous, the slope of the mountain reaching almost to its banks.

A small travelling party of miserable looking Indians was met ascending the mountain; one of whom being too much frightened, or too heavily laden to escape, was interrogated by signs; but no information could be obtained from his real or affected stupidity.

At this point the river was two hundred and sixty-six yards wide, with six feet of water in the deepest part; the banks bluff and sandy, about twelve feet high, and the current rapid; but a dense growth of willows and weeds prevented me from measuring its velocity with any degree of accuracy. The presence of water seemed to afford the only relief from our former privations; for the soil, an almost impalpable sand, bore nothing but dry weeds and bushes, and the whole scene presented the most perfect picture of desolation I have ever beheld, as if some sirocco had passed over the land, withering and scorching every thing to crispness.

From this point I had designed to explore the river upward to the great cañon, and determine accurately the mouth of the Rio Virgen, one of its largest tributaries; but the exhausted condition of the animals and scanty supply of provisions (the party having been already several days on reduced rations) compelled me reluctantly to forego my purpose.

The whole country traversed from the San Francisco mountains was barren and devoid of interest. It consists of a succession of mountain ranges and desert plains, the latter having an average height of about 5,000 feet above the level of the ocean. The larger growth, almost exclusively of cedar, was confined to the mountains; and the scanty vegetation of the plains, parched by a long drought, furnished few specimens for the botanist.

November 7, *Camp No.* 33.—A well-worn trail leads down the river, by the side of which in several places were found traced on the ground Indian hieroglyphics, which Mr. Leroux and a Mexican of the party, who had passed many years among the Comanches, interpreted into warnings to us to turn back, and threats against our penetrating farther into the country. We had not gone far before Indians were seen in front in considerable numbers, who appeared to be assembling to dispute our advance. By the exchange of friendly signs, three of them, mounted on fine horses, were induced to approach, whom a few presents sufficed to convince of our peaceful intentions; and they joined the party, and accompanied its march. As we proceeded their number received accessions at every step, until it amounted to some two hundred men, women, and children, who followed on foot, running by the side of the mules,

and talking and laughing with every appearance of friendship. In the evening the camp was crowded with them, bringing in for barter small quantities of pumpkins, beans, corn, and, in one or two instances, of wheat, which seem to be the staples of their food, for no animals, except a few horses, were seen among them; and the few sheep we had left were the objects of great admiration, especially to the women.

The appearance of the Mohaves is striking, from their unusual stature, the men averaging at least six feet in height; and their stalwart and athletic figures offered a convincing proof of the excellence of a vegetable diet. Almost all the men were naked, with the exception of the breech-cloth. The hair, cut square across the brows in front, hung in loose braids behind, reaching frequently as low as the waist; occasionally it was matted on the top of the head into a compact mass with mud, for the purpose of destroying the vermin that infest them. The only garment worn by the women was a long fringe of strips of willow-bark wound around the waist, and falling as low as the knees. No covering to the feet was worn by either sex. Their arms are the bow and arrow, the spear and the club. The arrow is formed of two pieces—that to which the barb is attached, of hard wood, seven inches long, or one-fourth the entire length; and the other of a light reed that grows profusely along the banks of the river, feathered, as usual, at the extremity. The custom still prevails among them of carrying a firebrand in the hand in cold weather, which is mentioned in the account of Coronado's expedition in 1540, and induced those discoverers to give to the river the name of Rio del Tizon. Their lodges are rectangular, formed of upright posts imbedded in the ground, and rudely thatched on the top and three sides; a portion of the interior altitude being sometimes obtained by excavation. I saw none of so great a size as those described in the account just referred to.

November 8, *Camp No.* 34.—A large crowd of men, women, and children continued to follow us, many of them carrying beans and pumpkins, and all urgent for us to encamp among them, for the purpose, as they gave us to understand, of trading. I was myself anxious to obtain supplies from them; but their numbers and importunity had been so troublesome the day before, that it was resolved to exclude them from the camp, and to adopt some plan which should free us from a repetition of the annoyance. Before unpacking the mules, therefore, a chain of sentinels was placed around them, with instructions to prevent the entrance of the Indians, and places were designated on the outside where they might hold their market. This arrangement gave

great dissatisfaction, and did not fully answer the purpose intended; for many eluded the vigilance of the sentinels, or took advantage of their negligence, and the camp was soon again filled with them. A large number were observed to have arms; and the fact that no chiefs had presented themselves, notwithstanding our frequent demands for them, was regarded as suspicious, and calling for all possible vigilance. The retreat was therefore sounded, and the Indians ejected from camp, which was accomplished with difficulty, and hardly without the use of violence. They left us with scowling faces, and some old women were vociferous with what we supposed to be their threats and denunciations.

November 9, *Camp No.* 35.—While preparing for our departure before daylight, Dr. Woodhouse, who was warming himself by the fire, received an arrow through the leg, fortunately without doing him much injury. Several others were thrown into the camp and among the mules, but the darkness caused them to fall harmless. The sentinels, however, were thrown farther out, and we got under way without further annoyance, numbers following us with yells of defiance, but taking care to keep at a respectful distance.

Some days after (on the 16th) we came upon another large settlement of Indians, who represented themselves to be Yumas, and met us with assurances of friendship. One of them, who spoke Spanish tolerably well, informed us that we were about eight days' journey from the Gila, and that there was a military post near its mouth, and described accurately the persons of the officers whom we knew to have been stationed there. They were without provisions, living upon the fruit of the mezquit and tornilla trees, and seemed to have recently located themselves upon the spot. I was convinced of the sincerity of their professions, and distributed some presents among their old men; but we did not relax our customary vigilance, excluding them from the camp, and keeping a few men constantly under arms. The utility of the precaution was soon made apparent; for about the middle of the following day, as the advance of the party were engaged in unpacking the mules to give them their accustomed noon rest, a band of fifty or sixty Indians, approaching under cover of a thicket, fell upon a soldier of the escort who had lagged in the rear, and, having disabled him with an arrow wound in the elbow, despatched him with their clubs; following it up by a general attack upon the party, in which they displayed much boldness, advancing within easy arrow range, and maintaining their ground against the fire of our rifles and musketoons for some fifteen minutes,

when they were beaten off with loss, leaving four dead upon the ground, and carrying off several wounded. They possessed themselves of the musketoon of the soldier they had killed, but showed themselves unskilled in its use, firing it off several times at a distance of half a mile.

Our progress down the river, though heralded by signal fires as we advanced, was continued without further molestation. Numbers of the mules gave out daily for the want of food, until we were driven to the necessity of destroying all the spare saddles, blankets, tents, ammunition, books, and whatever was not absolutely essential to our safety. Our provisions, too, became exhausted; and the mules, the poorest of which were daily killed for the purpose, supplied our only food until the 30th November, when we arrived with a small remnant of them at Camp Yuma, near the mouth of the Gila, where rations were obtained for the subsistence of the party to San Diego, California.

Below the point at which we reached the Colorado, irregular lines of rugged mountains enclose its valley, now receding to a distance of some twenty miles, now advancing towards each other; and at three places abutting against the river, hem it in between rocky promontories, leaving no room for a roadway at their base. The passage of these defiles were the most difficult portions of the journey, requiring long detours over naked cliffs of extreme acclivity; to cross which we were sometimes obliged to break stepping places in the rock for the mules, and to assist them in their ascent by means of ropes, and where a misstep, or the jostling of a pack against an impending crag, would occasionally precipitate one of them to the bottom of the adjacent precipice. The arable land bordering upon the river is greatly encroached upon by extensive flat spurs, hard, gravelly, and destitute of vegetation, which reach far out into the valley, leaving a comparatively small proportion of the space between the mountains susceptible of cultivation. Some large cotton-wood trees grow directly upon the river banks, but the growth of the rest of the valley is small, consisting chiefly of mezquit, tornilla, willow, and a singular tree with a smooth, pale-green bark, and leaves so diminutive as to require a close proximity to discern them. The shrubs are the arrow-wood, wild sage, *hediondilla*, or creosote plant, and grease weed, so called from the brilliancy of its flame while burning. Cacti are not numerous; the most remarkable is the *pitahaya*, or *Cereus giganteus*.

Only two kinds of grass were found, at rare intervals and in small quantities; a tall, coarse variety, growing in large tufts, and a smaller kind, having a perceptible incrustation of salt upon the leaves.

The trap in some places along the river showed traces of carbonate of copper; and beneath the trap was seen a coarse, gray granite, and in one instance a stratum of clay slate.

Near Camp 51 a large rock occupies the middle of the channel, and ledges extend from it across to both banks. In many other places the river is obstructed by shifting sand bars, rendering its navigation difficult, if not impossible, except during a high stage of the water. The water-stains upon the rocks marked a height of twelve feet above the actual level, but the indications of overflow were partial, except near the mouth of the Gila, where a large surface appears to be subject to inundation.

Very respectfully, your obedient servant,

L. SITGREAVES,
Brevet Captain Top. Engineers.

Col. J. J. Abert,
Corps Top. Engineers.

IN THE SUPERIOR COURT
STATE OF ARIZONA
IN AND FOR THE
COUNTY OF APACHE

THE ST. JOHNS IRRIGATION COMPANY AND THE MEADOWS RESERVOIR IRRIGATION COMPANY, Corporations, et al, Plaintiffs

VS.

ROUND VALLEY WATER STORAGE & DITCH COMPANY, EAGAR IRRIGATION COMPANY, SPRINGERVILLE WATER RIGHT AND DITCH COMPANY, Corporations, et al,
Defendants

FINAL DECREE

Dated April 29, 1918

and

MODIFICATIONS

In the Superior Court of the State of Arizona, In and for the County of Apache

The St. Johns Irrigation Company and The Meadow Reservoir Irrigation Company, Corporations, et al., Plaintiffs, vs. Round Valley Water Storage & Ditch Company, Eagar Irrigation Company, Springerville Water Right and Ditch Company, Corporations, et al., Defendants.	JUDGMENT and DECREE

The complaint in this case was filed on the 24th day of March, 1904, in the District Court of the Fourth Judicial District of the Territory of Arizona, and for Apache County, and the evidence in the case was taken before W. S. Norviel, Commissioner of that Court, beginning on the 23rd day of July, 1906, and ending on the 3rd day of August, 1906. This court being the legal successor of the Court in which the Complaint was filed, and Hon. Reamer Ling, Judge of this

Court, being disqualified herein, and announcing his disqualifications, this matter was on the 12th day of July, A. D. 1912 referred to Hon. F. W. Perkins, Judge of the Superior Court of the County of Coconino, State of Arizona. And the matter being by stipulation, dated April 1, 1918, duly submitted for decision upon the evidence herein; and on the 20th day of June, 1914, in this Court and in a cause entitled "The Eagar Irrigation Company, a corporation, and the Round Valley Water Storage and Ditch Company, a Corporation. Plaintiffs, vs. Fred T. Colter, Defendant" a large number of the parties to this suit, who were farming on the upper part of the Little Colorado River, having settled their rights between themselves by a stipulated decree, and included in it a stipulation that, "there being now pending in this Court an action wherein the St. Johns Irrigation Co., et al., are plaintiffs, and the Round Valley Water Storage and Ditch Co., et al, are Defendants, in which suit the relative priorities of the parties hereto and all other users of the water of said river upon lands lying adjacent are to be determined, the Court reserves the right to make such consolidation of this suit with said suit or such amalgamation of the decree in each, or such order with respect to the Commissioner and his salary, and the payment thereof, as shall be conducive to a complete determination of the rights of all parties and of an economical administration and the conservation of the waters of said river," therefore in the formulation of this decree, the Court follows and applies the said decree of June 20, 1914, wherein said decree settles the right between any of the parties thereunder on the Little Colorado above Richville, insofar as that decree does not conflict with the proofs herein or is not derogatory of the right of other parties to this action.

The evidence given in behalf of the plaintiffs was so incomplete as to the acreage possessed and irrigated in certain bodies of land referred to in the evidence, but not specified by Government number, and the ditches under which various lands were situated in and about St. Johns, that, on the 14th day of September, 1917, the Court appointed a commission, composed of W. D. Rencher, Joseph Udall, and George E. Waite, to measure and report as to the acreage, the condition of the land as being capable of cultivation, and the respective ditches under which the lands belonging to the stockholders of the plaintiffs were located. And said reports, by a majority of the commission, having been duly received and filed on the 31st day of January, 1918, and as evidence in regard to the rights of various defendants at Richville was so incomplete that the Court could not ascertain the rights of the respective parties thereto, and a certain map, an exhibit herein regarding the rights in Richville being lost, and the Court having in the month of May, 1917, sent a commission, composed of W. D. Rencher and Joseph Stradling, to measure the said lands, and the Court having heretofore appointed W. D. Rencher a commissioner to determine the capacity of various reservoirs belonging to parties hereunto and the report having been received and filed, and the Court having been fully advised by the abstracts and briefs of Ross and O'Sullivan, Alfred Ruiz, and Isaac Barth, as attorneys for plaintiff, and later by Isaac Barth, acting solely for the plaintiffs, and the briefs of Herndon and Norris and George H. Crosby, Jr., and later of Norris and Mitchell, acting solely for the defendants, and the Court being fully advised of the results of one year's experience under a temporary decree in use during the season of 1917;

Now, Therefore, the Court being fully conversant with the evidence as heretofore taken, the decree herein

mentioned, and the reports of the Commissions and all of the briefs herein, and the case being fully submitted;

IT IS ORDERED, ADJUDGED, AND DECREED:

FIRST. That the number of acres, each year while they are under actual cultivation, of the tracts of land hereinafter mentioned, located in the County of Apache, State of Arizona, as the same now are, or heretofore have been, placed under cultivation are entitled to water for the irrigation thereof from the Little Colorado River and its branches and its tributaries in the following order as to the rights of priority of use of such water for the irrigation thereof, to-wit:

FIRST RIGHT.

All claims in Twp. 8 N, R. 29 E., G. and S. R. M.

Mrs. Dugan Colter: SW¼ of NW¼, Sec. 7 SE¼ of NW¼. S½ of NE¼, Sec. 7, SW¼ of NE¼ Sec. 5, number of acres, 100; date of appropriation, 1872.

John P. Rothlisberger: SW¼ of SW¼ and E½ of the SW¼ and the W½ of SE¼ of Sec. 5, N½ of NW¼ and SW¼ of the NW¼ of Sec. 8, number of acres, 150; date of appropriation, 1872.

Duane Hamblin (Successor to Thomas Berry): SE¼ of NE¼, Sec. 5. Number of acres, 5; date of appropriation, 1872.

Hiram Bigelow: SW¼ of NW¼, Sec. 7. Number of acres 5; date of appropriation, 1872.

SECOND RIGHT.

J. G. Homrighausen: E½ of SW¼ and W½ of SE¼, Sec. 33, Twp. 9N., R. 29 E. Number of acres, 140; date of appropriation, 1872; classed as second right.

THIRD RIGHT.

Same Party: NE¼ of SE¼, Sec. 32; 11 acres; date of appropriation, 1874.

Cesario Cordoba: E½ of NE¼, Sec. 32, SW¼ of NE¼, Sec. 32, NW¼ of NW¼, Sec. 33, SW¼ of SW¼, Sec. 28, SE¼ of SE¼, Sec. 29, Twp. 9 N., R. 29 E. Number of acres, 130; date of appropriation, 1874; 85 acres; classed as third right.

J. N. Homrighausen: SW¼ of NE¼, Sec. 32; number of acres, 34; date of appropriation, 1874.

FOURTH RIGHT.

Cesario Cordoba: 45 acres in land described in third right; date of appropriation ,1874; classed with fourt right.

FIFTH RIGHT.

Thomas Phelps: NW¼ of NE¼ and NE¼ of NW¼, Sec. 32, SE¼ of SW¼ and SW¼ of SE¼, Sec. 29, Twp. 9 N., R. 29 E. Number of acres, 50; date of appropriation, 1875.

Pedro Candelaria: N½ of NE¼, Sec. 29, S½ of SE¼, Sec. 20, Twp. 9 N., R. 29 E. 37 acres; date of appropriation, 1875.

Hamblin and Jarvis (successors to Thomas Berry): E½ of NW¼, Sec. 5, W½ of NW¼, Sec. 4, Twp. 8 N., R. 29 E.; 80 acres; date of appropriation, 1875.

St. Johns Irrigation Company: For use in Township 13 N., R. 28 E., and contained in Section 22, and the NE¼ and the NE¼ of the SE¼ of Sec. 34, and the S½ of the SE¼, and the SW¼ of the SE¼, and the N½ of the NE¼, and the W½ of the NW¼, and the NW¼ of the NE¼, of Sec. 27, the SW¼, the SW¼ of the NW¼, of Section 15, the SE¼ of Section 16, the W½ of the NE¼ of Sec. 16, and the S½ of Sec. 9; 750 acres; date of appropriation, 1875.

Jose Garcia: SW¼ of SW¼, Sec. 2, Twp. 12 N., R. 28 E.; 30 acres; date of appropriation, 1875.

SIXTH RIGHT.

Elisha Averett: S½ of NE¼ and E½ of NW¼, Sec. 29, Twp. 9 N., R. 29 E.; 27 acres; date of appropriation, 1876.

SEVENTH RIGHT.

J. G. Homrighausen: SE¼ of SE¼, Sec. 32, Twp. 9 N., R. 29 E.; E½ of NW¼ and NW¼ of NE¼, Sec. 4, Twp. 8 N., R. 29 E.; 80 acres; date of appropriation, 1876.

EIGHTH RIGHT.

Elisha Averett: in lands described in 6th right; 10 acres; date of appropriation, 1876.

Mrs. Neadice Thompson: N½ of SE¼ , Sec. 29, Twp. 9 N., R. 29 E.; 20 acres; date of appropriation, 1876.

Gustav Becker: NE¼ of NE¼, Sec. 18, NW¼ of NW¼, Sec. 17, W½ of SW¼, Sec. 8, Twp. 9 N., R. 29 E.; 25 acres; date of appropriation, 1876.

Eutimio Baca: W½ of the SE¼, the SE¼ of the SW¼, SW¼ of NE¼, Sec. 23, Twp. 11 N., R. 29 E.; 50 acres; date of appropriation, 1876.

NINTH RIGHT.

Hiram Bigelow: N½ of SE¼, S½ of NE¼, Sec. 12, Twp. 8 N., R. 28 E.; 13 acres; date of appropriation, 1877.

Reamer Ling: Lots 10 and 11, Sec. 2, Twp. 12 N., R. 28 E.; 30 acres; date of appropriation, 1877.

Manuel Tafolla: NW¼ of NE¼, Sec. 34, Twp. 13 N., R. 28 E.; 19 acres; date of appropriation, 1877.

TENTH RIGHT.

Jose Angel Chavez: the E½ of SE¼, Sec. 34, Twp. 13 N., R. 28 E.; 30 acres; date of appropriation, 1878.

Anastacio Chaves Estate: Lots 1, 2 and 7, Sec. 2, Twp. 12 N., R. 28 E.; 30 acres; date of appropriation, 1878.

ELEVENTH RIGHT.

Jacob Hamblin, Greer, Arizona: SE¼ of SW¼, Sec. 1, Twp. 7 N., R. 27 E.; 20 acres; date of appropriation, 1879.

Fred Hoffman: SW¼ of NE¼, Sec. 15, Twp. 8 N., R. 28 E.; 10 acres; date of appropriation, 1879.

T. H. Thompson: NW¼ of NW¼, Sec. 14, S½ of SW¼, Sec. 11, Twp. 8 N., R. 28 E.; 10 acres; date of appropriation, 1879.

Springerville Water Right and Ditch Co.: For garden and orchard and domestic use; E½ and SE¼ of NW¼, NW¼ of SW¼, Sec. 33, Twp. 9 N., R. 29 E.; 63 acres; date of appropriation, 1879.

James T. Campbell: W½ of SW¼, Sec. 17, SE¼ of SE¼, Sec. 18, NE¼ of NE¼, Sec. 19, Twp. 8 N., R. 28 E.; 20 acres; date of appropriation, 1879.

Cruz Rubi: The SW¼ of NW¼, SE¼ of NW¼, NE¼ of SW¼, and the NW¼ of SE¼ of Sec. 34, Twp. 13 N., R. 28 E.; 60 acres; date of appropriation, 1879.

J. B. Richey: Undescribed lands located at Richville: 32 acres; date of appropriation, 1879.

J. Moroni Richey: Undescribed lands located at Richville; 16 acres; date of appropriation, 1879.

Thomas Irwin (successor to John F. Sherwood): Undescribed lands located at Richville; 18½ acres; date of appropriation, 1879.

J. J. Baca (successor to William Sherwood): Un-

Undescribed lands located at Richville; 18½ acres; date of appropriation, 1883.

J. J. Baca (successor to William Sherwood): Undescribed lands located at Richville; 33 acres; date of appropriation, 1883.

J. W. Sherwood (successor to John F. Sherwood): Undescribed lands located at Richville; 7½ acres; date of appropriation, 1883.

Lawrence Sherwood (successor to John F. Sherwood): Undescribed lands located at Richville; 12½ acres; date of appropriation, 1883.

Fred Nielsen: Undescribed lands located at Richville; 17 acres; date of appropriation, 1883.

Luis Chavez: Undescribed lands located at Richville; 9½ acres; date of appropriation, 1883.

SIXTEENTH RIGHT.

John C. Hall: The SW¼ of NW¼, Sec. 12, Twp. 7 N., R. 27 E.; 5 acres; date of appropriation, 1884.

Benjamin Howell: The S½ of NW¼, Sec. 15, Twp. 8 N., R. 28 E.; 5 acres; date of appropriation, 1884.

Meadows Reservoir Irrigation Company: For lands mentioned in thirteenth right; 150 acres.

SEVENTEENTH RIGHT.

Round Valley Water Storage and Ditch Co.: The E½ of SE¼, and E½ of NE¼, E½ of NW¼, NE¼ of SW¼, Sec. 2, W½ of NE¼, E½ ofNW¼, E½ of SW¼, Sec. 3, S½ of NW¼ of NE¼, N½ of SW¼, of NE¼, Sec. 9, Twp. 8 N., R. 29 E.; S½ of SE¼, Sec. 27, NW¼ of Sec. 35, NW¼ and S½ and NE¼ of NE¼, Sec. 34, NW¼ of NE¼, Sec. 33, Twp. 9 N., R. 29 E.; 618 acres; date of appropriation, 1885.

St. Johns Irrigation Company: For Sec. 4 and the S½ of the NW¼ and the SE¼ of Sec. 5, the NE¼ of Sec. 9, the E½ of the NW¼ ofSec. 9, and the N½ of the SE¼ Sec. 9, the SW¼ of Sec. 10, the W½ of the NE¼ of Sec. 15, and the NE¼ of the NW¼ of Sec. 15, Twp. 13 N., R. 28 E.; 750 acres; date of appropriation, 1885.

EIGHTEENTH RIGHT.

Leandro Carillo: The E½ of SW¼ and NW¼ of SE¼, Sec. 20, Twp. 9 N., R. 29 E.; 10 acres; date of appropriation, 1886.

Caroline Desmont: The N½ of SE¼, Sec. 11, the N½ of SW¼, Sec. 12, Twp. 8 N., R. 28 E.; 25 acres; date of appropriation, 1886.

NINETEENTH RIGHT.

Howard Hale: The SW¼ of SW¼, Sec. 1, Twp. 7 N., R. 27 E.; 8 acres; date of appropriation, 1887.

J. C. Hall: The SW¼ of NW¼, Sec. 12, Twp. 7 N., R. 27 E.; 15 acres; date of appropriation, 1887.

T. H. Thompson: The NW¼ of NW¼, Sec. 14, the S½ of SW¼, Sec. 11, Twp. 8 N., R. 28 E.; 15 acres; date of appropriation, 1887.

TWENTIETH RIGHT.

Eagar Irrigation Co.: see land described under year of 1891; 387 acres; date of appropriation, 1888.

St. Johns Irrigation Company: Those fractional parts of Sections 21, 22 and 28, Twp. 13 N., R. 28 E.; lying under the St. Johns City Ditch and not included in the St. Johns Townsite entry; 102 acres; for orchards and garden use; date of appropriation, 1888.

Same Owner: For all of the St. Johns Townsite, and for garden use and orchards and domestic use, as the same appears of record in the county rec-

ords of Apache County; 200 acres; date of appropriation, 1888.

TWENTY-FIRST RIGHT.

Eagar Irrigation Co.: See land described under year 1891; 294 acres; date of appropriation, 1889.

TWENTY-SECOND RIGHT.

E. W. Wiltbank: The NE¼ of SE¼, the SE¼ of SE¼, Sec. 11, the NW¼ of NE¼, Sec. 14, Twp. 7 N., R. 27E.; 30 acres; date of appropriation, 1890.

W. S. Gibbons: The SW¼ of SE¼, Sec. 11, Twp. 7 N., R. 27 E.; 6 acres; date of appropriation, 1890.

TWENTY-THIRD RIGHT.

Eagar Irrigation Co.: The S½ of Sec. 7, the NW¼ of NW¼, Sec. 18, NW¼ of NW¼, E½ of NW¼ and NE¼ of Sec. 17, the S½, the S½ of N½, NE¼ of NW¼, and NW¼ of NE¼, Sec. 8, the E½ of SE¼, Sec. 5, the S½, and NE¼, and SE¼ of NW¼, Sec. 4, The NW¼, N½ of NE¼, the NW¼ of SW¼, Sec. 10, the SE¼ of Sec. 3, the W½ of SW¼ of Sec. 2, Twp. 8 N., R. 29 E., the SE¼, NE¼ of SW¼, SW¼ of SW¼, E½ of NE¼, SW¼ of NE¼, Sec. 33, E½ of SE¼, and SW¼ of SW¼, Sec. 34; W½ of SW¼, Sec. 35, Twp. 9 N., R 29 E.; date of appropriation, 1891.

J. P. Rothlisberger: The NW¼ of SW¼, Sec. 4, E½ of SE¼, Sec. 5; NE¼ of NE¼, Sec. 8, Twp. 8 N., R. 29 E.;30 acres; date of appropriation, 1891.

TWENTY-FOURTH RIGHT.

Jacob Hamblin: The SE¼ of SW¼, Sec. 1, Twp. 7 N., R. 27 E.; 9 acres; date of appropriation, 1893.

E. W. Wiltbank: The NE¼ of SE¼, and SE¼ of SE¼, Sec. 11, Twp. 7 N., R. 27 E.; 8 acres; date of appropriation, 1893.

John O. Hall: The NE¼ of NW¼ of Sec. 35, E½ of SW¼ and SW¼ of SE¼, Sec. 26, Twp. 8 N., R. 27 E.; 9 acres; date of appropriation, 1893.

Ike Hale: the NW¼ of NW¼, Sec. 12, SW¼ of SW¼, Sec. 1, Twp. 7 N., R. 27 E.; 22 acres; date of appropriation, 1893.

TWENTY-FIFTH RIGHT.

W. S. Gibbons: The SW¼ of SE¼, Sec. 11, Twp. 7 N., R. 27 E.; 8 acres; date of appropriation, 1894.

TWENTY-SIXTH RIGHT.

Fred T. Colter (successor to C. H. Sharp): The SW¼ of SE¼, Sec. 5, NE¼ of NW¼, Sec. 8, E½ of SW¼, Sec. 5, Twp. 9 N., R. 29 E.; 20 acres; date of appropriation, 1895.

TWENTY-SEVENTH RIGHT

Frank Wiltbank: the NE¼ of SE¼, Sec. 14, Twp. 7 N., R. 27 E.; 15 acres; date of appropriation, 1896.

W. W. Lund: The SE¼ of NE¼, Sec. 14, Twp. 7 N., R. 27 E.; 24 acres; date of appropriation, 1896.

Mollie Crosby: The NE¼ of NE¼, Sec. 14, Twp. 7 N., R. 27 E.; 8 acres; date of appropriation, 1896.

W. E. Wiltbank: The NE¼ of NE¼, Sec. 14, Twp. 7 N., R. 27 E.; 10 acres; date of appropriation, 1896.

TWENTY-EIGHTH RIGHT.

J. O. Hall: The SW¼ of SE¼, Sec. 27, Twp. 8 N., R. 27 E.; 7 acres; date of appropriation, 1897.

TWENTY-NINTH RIGHT.

W. S. Gibbons: The SW¼ of SE¼, Sec. 11, Twp. 7 N., R. 27 E.; 6 acres; date of appropriation, 1898.

THIRTIETH RIGHT.

Fred T. Colter: The N½ of SE¼, NE¼ of SW¼, Sec. 7, Twp. 8 N., R. 29 E.; 90 acres; date of appropriation, 1905.

Also the following lands under the Westside Ditch: The N½ of NW¼, N½ of NE¼, of Sec. 7, and S½ and NE¼ of SE¼ of Sec. 6, and NW¼ of SW¼ and S½ of NW¼ and SE¼ of NW¼ of Sec. 5, Twp. 8 N., R. 29 E., of G. and S. R. M.; 400 acres; date of appropriation, 1904.

The E½ and NW¼ of NE¼ of Sec. 6, and NW¼ of NW¼ of Sec. 5, Twp. 8 N., R. 29 E., G. and S. R. M.; the S½ of Sec. 31, and W½ of SW¼ of Sec. 32, Twp. 9 N., R. 29 E., G. and S. R. M., and NE¼ of NW¼ and NW¼ of NE¼, Sec. 5,, Twp. 8 N., R. 29 E., G. and S. R. M.; date of appropriation, 1905; 400 acres.

The SW¼ and the W½ of NW¼ of Sec. 6, Twp. 8 N., R. 29 E, and E½ of NE¼, Sec. 1, Twp. 8 N., R. 28 E., of G. and S. R. M.; date of appropriation, 1906; 300 acres.

RIGHTS ON NUTRIOSO CREEK IN ROUND VALLEY

FIRST RIGHT.

Elisha Averett: The S½ of NE¼, E½ of NW¼, Sec. 29, Twp. 9 N., R. 29 E.; 18 acres; date of appropriation, 1876.

SECOND RIGHT.

George Winsor and Joseph Udall: The N½ of NW¼, Sec. 34, S½ of SW¼, Sec. 27, NE¼ of NE¼, Sec. 33, Twp. 9 N., R. 29 E.; 12 acres; date of appropriation, 1881.

Same Owner for same land: 100 acres on North side of creek; date of appropriation, 1882.

THIRD RIGHT.

Barthold Wahl: The N½ of NW¼, N½ of NE¼, Sec. 35, Twp. 9 N., R. 29 E.; 52 acres; date of appropriation, 1883.

FOURTH RIGHT.

Edmund Nelson: The N½ of NE¼, Sec. 34, S½ of SE¼, Sec. 21, Twp. 9 N., R. 29 E.; 35 acres; date of appropriation, 1885.

FIFTH RIGHT.

George Winsor and Joseph Udall: Same lands described under second right; 88 acres; date of appropriation, 1885.

SIXTH RIGHT.

Wm. M. Rudd: The S½ of SW¼, Sec. 28, Twp. 9 N., R. 29 E.; 7 acres: date of appropriation, 1886.

SEVENTH RIGHT.

E. A. Burk: Same land described under fifth right; 10 acres; date of appropriation, 1888 .

SECOND. It is further ADJUDGED and DECREED that the irrigation waters of the said Little Colorado River and its tributaries shall be distributed to such portions of the said lands hereinbefore mentioned as are actually under cultivation, by a Commissioner hereinafter provided for, during the irrigation season hereinafter provided for; according to the rights of priority and to the extent that is, in the judgment of this Court necessary for the economical cultivation thereof, and no more, at such time and periods as said Commissioner may direct; subject to the supervision and control of the Court; provided that no person or corporation who is a beneficiary under this decree shall be entitled to draw water from the said Little Colorado River for any of the lands mentioned herein except the same be for that year devoted to be a useful crop; and that, if said land be grass land; the beneficiary shall only draw water for said land when, in the judgment of the Commissioner and the Court, the flow of the river is sufficient to water all planted and alfalfa lands and also the grass lands, and

unless otherwise provided by the Commissioner or Court, grass land shall not be allowed to draw water between the 20th day of May and the rise of the river after the beginning of the rainy season.

THIRD. An irrigation season, beginning with the 15th day of April and ending with the 15th day of September of each and every year, is hereby established. At such times after close of one irrigation season and before the opening of the next as there is a surplus of water in the river, owners of storage reservoirs may, and, when ordered so to do by the Water Commissioner, must, fill their reservoirs. The order of priority for filling of reservoirs is hereby found and decreed to be as follows, to-wit:

FIRST RIGHT.

Gustav Becker: For Becker's Lake, to its present capacity, measured to the bottom of the present outlet; 421.48 acre feet; date of appropriation, 1883.

SECOND RIGHT.

The St. Johns Irrigation Co.: For the Little Reservoir, near St. Johns, at its capacity for the irrigating season of 1917; 419.48 acre feet; date of appropriation, 1886.

THIRD RIGHT.

Round Valley Water Storage and Ditch Co.: For the Bunch Reservoir; located in Lee Valley at its capacity on December 4, 1917; 512.44 acre feet; date of appropriation, 1887.

Eagar Irrigation Company: Tunnel Reservoir No. 2, at Lee Valley, at its capacity on December 4, 1917; 694.32 acre feet; date of appropriation, 1887.

FOURTH RIGHT.

Edmund Nelson: On Nutrioso Creek only; 500 acre feet; date of appropriation, 1891.

FIFTH RIGHT.

Meadows Reservoir Irrigation Company: At Meadows; 900 acre feet; date of appropriation, 1894.

St. Johns Irrigation Company: For the First Salado Reservoir; 1300 acre feet; date of appropriation, 1894.

Eagar Irrigation Company: White Mountain Reservoir; No. 1, 2391 acre feet; date of appropriation, 1894.

SIXTH RIGHT.

Eagar Irrigation Company: For River Reservoir No. 3, in Lee Valley; 1669 acre feet; with the right as against the reservoirs of Fred T. Colter of repairing this reservoir to its surveyed capacity; date of appropriation, 1896.

SEVENTH RIGHT.

St. Johns Irrigation Company: For the Big Salado Reservoir; 17260 acre feet; date of appropriation, 1898.

EIGHTH RIGHT.

Fred T. Colter: Colter's Lee Valley Reservoir, to its present capacity, which is not now in evidence.

Colter Reservoir No. 1, situated upon Sec. 3, Twp. 6 N., R. 27 E., G. and S. R. M., to its present capacity, which is not now in evidence.

Colter Reservoir No. 2, situated upon Sec. 2, Twp. 8 N., R. 28 E., to its present capacity, which is not now in evidence.

Colter Reservoir No. 3, situated upon Sections 29 and 30, Twp. 7N., R. 28 E., to its present capacity, not now in evidence.

Colter Reservoir No. 4 situated upon Sections 19

and 20, Twp. 7 N., R. 28 E., to its present capacity, not now in evidence.

Provided, however, that all parties owning storage reservoirs are chargeable with any water they do not catch during the storage season, and that owners of reservoirs shall have the preferred right for storage purposes until the first day of April each year, and that when there is not sufficient to supply filling ditches and also irrigate such lands as may need irrigation for early crops, the water may be divided between the filling ditches and the irrigation ditches by the Commissioner; between the first day of April and the 15th day of April, giving the reservoirs located in the higher altitudes the preference for later spring filling; and when there is more water than is needed for irrigation, reservoirs may with the consent of the Commissioner or Court, be filled during the irrigation season;

And provided further, that the St. Johns Irrigation Company, except in periods of drought, shall not be required to fill, nor deemed negligent for not filling, its little reservoir, unless at least one-half fresh or mountain water, and that where possible the Commissioner shall supply said company three-fifths of mountain water to mix with the water from Salado Springs for filling said reservoir.

FOURTH. It is further ORDERED and DECREED that, unless otherwise ordered by the Commissioner or the Court, all reservoirs on the upper waters of the Little Colorado River may at all times be filled at the earliest possible times in the storage season, and that, if lower parties owning prior filling rights on the Little Colorado River shall not have been able with reasonable diligence to fill their lower reservoirs, then the Commissioner shall cause water to be released from the upper reservoirs in such quantities as in his judgment the lower reservoirs are entitled to, subject to the advice and order of the Court.

FIFTH. And also that during the irrigation season the natural flow of the Little Colorado River and of its tributaries shall be available and shall be used for the irrigation of the lands above mentioned in the order of their priority and under the direction of the Commissioner. The water duty for the irrigation of said lands is hereby set so that one cubic foot per second continuous flow of water shall be given to each 90 acres of land below the Lyman Dam on said river; and that one cubic foot per second continuous flow shall be given to each 110 acres of all lands lying above the Lyman Dam and below the narrows directly above J. T. Campbell's upper ranch; that all other lands be given one cubic foot per second continuous flow for each 180 acres of land, and that the Commissioner shall have full authority to arrange the water in "turns" at stated periods; that all measurements shall be made at the head of canals; but an allowance of two per cent per mile from the point of diversion to the head of the lateral shall be allowed for soakage and evaporation to all canals; and that twenty-five per cent additional shall be allowed for all orchards and garden land in the towns of Eagar, Springerville and St. Johns; and that no parties hereunto shall impound in any reservoir owned controlled or operated by them any of such water during the irrigation season, except with the consent of the Commissioner, when there is a surplus of water in the said river

SIXTH. And that the Water Commissioner shall be appointed by the Court, and he shall have full power and authority to supervise and direct the impounding, storing diversion, and distribution of the waters to all of the parties affected by this decree. And a Commissioner, when once appointed, shall hold office during the pleasure of the Court

and until his successor is appointed and qualified. The Commissioner shall have full power to enter upon the reservoirs, canals, dams, lands, gates, laterals, and other irrigation appliances of all parties to this decree, and he shall have full power to make any and all orders, which orders must be obeyed by each party to this decree, with the right of the party to appeal to the Judge of the Court from said order after the party has complied with the order only.

SEVENTH. And all of the parties to this decree are required to maintain proper diversion dams in the said Little Colorado River and to maintain proper measuring gates near the intake of each ditch, with a proper waste gate in the canal between the intake and the measuring gate for the releasing of the surplus water that enters the head of any canal; and no party hereunto shall be entitled to draw any water from said river until gates satisfactory to the Commissioner are arranged at the intake of each and every ditch; and all parties to this decree shall establish proper cement measuring and waste gates by the 15th day of April, 1920. All measurements of water shall be made by a uniform method, by the Commissioner or under his direction and control; and the Commisioner is authorized to make such rules and regulations as may be reasonable and expedient and proper to insure proper storage, delivery and carriage of water from said reservoirs to the parties entitled thereto, both as to the irrigation of lands and the impounding of waters, and shall see that no water is diverted to or carried by other ditches than those originally intended for such carriage, except as ordered by the Court. The Commissioner shall report at least once each month during the irrigation season to the Court as to his actions, and may at any and all times apply to the Judge of the Court for further or specific directions as to his powers and duties

and for further instructions and applications of this decree.

EIGHTH. Any party to this decree or any party interested in impounding, diverting or distributing water from the Little Colorado River or its tributaries may apply to the Court or the Judge thereof for an interpretation or modification, enlargement or annulment of any order, direction, or action of the Commissioner in carrying out the provisions of this decree. Any such person may also apply to this Court or the Judge thereof for an interpretation or modification of the provisions of this decree; and this decree shall at any and all times be open for permanent interpretation, modification, enlargement, or for the annulment of any of its terms, upon the giving of notice to parties whose rights will be affected and upon hearing had, under such terms and regulations as the Court may direct, subject to the right of appeal to the Supreme Court from any permanent modification, enlargement or annulment that may so be made.

NINTH. The salary of the Commissioner is fixed, subject to change by the Court, at Five ($5.00) Dollars per day and transportation costs, and shall be paid by equally assessing each acre of land that draws water from the Little Colorado River between the Meadows and the head of said river, and the Judge of the Court may at the close of the season also levy an assessment upon any storage reservoirs on said river, in proportion to the amount of total labo that may be occasioned by caring for said reservoirs.

TENTH. All stored water from reservoirs carrie through the river shall be measured at the point where th water enters the river or one of its running tributaries, a there shall be no deduction from the amount entering t river when the water is measured out into the canals at t point of diversion. The party running stored water into

river shall supply a measuring gate at the place where the stored water enters the river or its tributaries.

ELEVENTH. It is found by the Court that the water from the Salado Springs, when not diluted by mountain water is never fit for orchard and garden use, and is, when continuously applied to field lands and field crops, deleterious to them. Wherefore, it is ordered and decreed that, as long as possible without depriving upper appropriations of water belonging to them, all lands located below the said Salado Springs shall be given as much mountain water as possible; provided, that when the water of the river will no longer reach a lower prior appropriation, an upper junior appropriation, in order of preference, shall then, by order of the Commissioner, be given the right to use the water. In order to furnish more satisfactory irrigation heads or to prevent loss by soakage, the Commissioner or the Court may divide the water into "Turns" between ditches or communities located on this river.

TWELFTH. Whereas, because of the lapse of time, many persons, parties to this action, do not now own the land described in this decree, the right to use water as herein granted shall, in the absence of contracts to the contrary, belong to and be granted to the present owners of the land and their successors and assigns.

This decree does not replace any terms of the decree of June 20, 1914, heretofore mentioned; and any provisions of said decree not herein contained are still in force and effect. This decree shall be in effect from and after the 1st day of May, A. D. 1918.

The parties hereunto shall each pay its costs of this action.

Dated and signed this 29th day of April, A. D. 1918.

F. W. PERKINS,
Judge.

for the County of Apache
of the State of Arizona, In and
In the Superior Court

The St. Johns Irrigation Company And the Meadows Reservoir Irrigation Company, Corporations, et al., Plaintiffs,

vs.

Round Valley Water Storage and Ditch Company, Eagar Irrigation Company, Springerville Water Right and Ditch Company, Corporations, et al., Defendants.

Order Modifying Judgment and Decree.

This matter came on before the Honorable R. C. Stanford of Maricopa County, sitting instead of the resident Judge of this county. By stipulation of the attorneys the objections of the Lyman Water Company and the St. Johns Irrigation Company and J. B. Richey, J. M. Richey and Frederick Nielson and the Tucker Livestock Company had been previously argued at Phoenix by attorneys Stokes and Sherman for those who objected and George H. Crosby, Jr., in behalf of the petitioners, and the Court having decided that the petitions for the petitioners herein were sufficient to justify the opening up and modification of the decree;

Whereupon the matter coming before the Court on th

14th day of March, 1921, upon the petition of the Eagar Ditch and Reservoir Company, a corporation, successor to the Eagar Irrigation Company, a corporation, and of the Round Valley Water Storage and Ditch Company, a corporation, and of John C. Hall and George A. Winsor, doing business as "Hall and Winsor" and of Edmond Nelson, and the said four petitioners having each and all presented their evidence herein and the matter being duly heard by the Court and the objecting parties having failed to produce any evidence to the contrary and it being afterwards stipulated and agreed between George H. Crosby, Jr., attorney for the petitioners and Stokes and Sherman and Gilbert E. Greer, attorneys for the objecting parties, and the Court having fully considered the matter, does, as a matter of law, find, that the petitioners and each of them is entitled to a modification of the judgment and decree in this matter as said judgment and decree was entered by the Honorable F. W. Perkins, on the 29th day of April, A. D. 1918 in such rights as shall hereafter more fully appear;

WHEREFORE IT IS HEREBY ORDERED, ADJUDGED AND DECREED that the decree be so modified as to the rights of the petitioners, The Eagar Ditch and Reservoir Company so that the second paragraph of said decree under the 12th right herein be changed to read: The Eagar Ditch and Reservoir Company, a corporation, successors to The Eagar Irrigation Co., a Corporation, In the N. E. Corner of the SW¼ of the SW¼ of Sec. 7; 7½ acres; NE¼ of the SW¼ of Sec. 7; 15 acres; NW¼ of the SE¼ of Sec. 7; 25 acres; NE¼ of the SE¼ of Sec. 7; 34 acres: NW¼ of SE¼ of Sec. 8; 30 acres; NW¼ of SW¼ of Sec. 7; 10 acres: North part of the NE¼ of NE¼ of Sec. 8; 15 acres; South part of the NE¼ of NW¼ of Sec. 8; 15 acres; North part of the SE¼ of NW¼ of Sec. 8; 5 acres; All in Township 8 N., R. 29 E.; G. and S. R. M.; 156½ acres; date of appropriation, 1880.

And that paragraph one of said decree under the 20th right therein be changed to read: The Eagar Ditch and Reservoir Company, a corporation, successor to The Eagar Irrigation Company, a corporation, In the middle part of the N½ of Sec. 12, T 8 N., R. 28 E.; 4 acres; N½ of SW¼, S½ of NW¼, and SW¼ of Sec. 8; 136 acres; SW¼ of SW¼ of Sec. 4; 25 acres; A strip along the North side of the N½ of of N½ of Sec. 9; 20 acres; E½ of the SW¼ of Sec. 4; 47 acres; SE¼ of Sec. 4; 90 acres; S½ of NE¼ and NE¼ of NE¼ of Sec. 4; 65 acres; All in Township 8 N., R. 29 E.; 387 acres; date of appropriation, 1888.

And that paragraph one of said decree under the 21st right therein be changed to read: The Eagar Ditch and Reservoir Company, a corporation, successor to The Eagar Irrigation Company, a corporation; In the SW¼ of SW¼ of Sec. 33; 20 acres; NE¼ of SW¼ of Sec 33; 20 acres: N½ of S½ of SE¼ of Sec. 33 and N½ of SW¼ of SW¼ of Sec. 34; 59 acres; S½ of S½ of SE¼ of Sec. 33; 22 acres. N½ of SE¼ of Sec. 33; 55 acres; SW¼ of NE¼ of Sec. 33; 38 acres; E½of NE¼ of Sec. 33; 30 acres; S½ of SW¼ SW¼ of SW¼ of Sec. 34; 19 acres; SE¼ of SE¼ of Sec. 34, and SW¼ of SW¼ of Sec. 35; 31 acres; All in Township 9 N., R. 29 E.; 294 acres; date of appropriation, 1889.

And that paragraph one of said decree under the 22nd right therein be changed to read: The Eagar Ditch and Reservoir Company, a corporation, successor to The Eagar Irrigation Company, a Corporation: In the NW¼ of NW¼ of Sec. 18; 24½ acres; SW¼ of SW¼ of Sec. 7; 8 acres: NW¼ of NW¼ of Sec. 17; 15 acres; NE¼ of NW¼ of Sec. 17; 3 acres; W½ of NE¼ of Sec. 17; 69 acres; SE¼ of NW¼ o Sec. 17; 30 acres; S½ of SW¼ of Sec. 8; 42 acres: SW¼ o

SE¼ of Sec. 8; 24 acres; E½ of NE¼ of Sec. 17; 35 acres: SW¼ of SW¼ of Sec. 9; 31 acres; NW¼ of SW¼ of Sec. 9; 28 acres; SE¼ of SE¼ of Sec. 8; 28 acres; SW¼ of NE¼ of Sec. 8; 28 acres; SW¼ of NW¼ of Sec. 9; 15 acres: NE¼ of NE¼ of Sec. 8; 12 acres; SE¼ of SE¼ of Sec. 5; 32 acres; SE¼ of SW¼ of Sec. 9; 34 acres; NE¼ of SW¼ of Sec. 9; 38 acres; SE¼ of NW¼ of Sec. 9; 36 acres: South part of NE¼ of NW¼ of Sec. 9; 25 acres; NW¼ of NW¼ of Sec. 9; 24 acres; SE¼ of Sec. 9; 130 acres: SW¼ of NE¼ of Sec. 9; 30 acres; SE¼ of NE¼ of Sec. 9; 36 acres: NE¼ of NE¼ of Sec. 9; 36 acres; NW¼ of NW¼ and N½ of SW¼ of NW¼ of Sec. 10; 35 acres; NW¼ of NE¼ of Sec. 10; 15 acres; E½ of SW¼ of SE¼, Sec. 3; 10 acres; West part SW¼ of SE¼ of Sec. 3; 10 acres; NW¼ of SE¼ of Sec. 3; 25 acres: E½ of SE¼ of Sec. 3; 50 acres; N½ of NW¼ of Sec. 11; 50 acres; NW¼ of SE¼ of Sec. 3; 15 acres; SW¼ of SE¼ of Sec. 3; 15 acres; S½ of SE¼ and E½ of SW¼ of Sec. 4, 51 acres; Being the Eagar Townsite; all in Township 8 N., R. 29 E.; 1127½ acres; date of appropriation, 1891.

And that in behalf of the petitioner the Round Valley Water Storage and Ditch Company, a corporation, the decree be so modified that the first paragraph under the Third Filling Right be changed to read: Round Valley Water Storage and Ditch Co.; For the Bunch Reservoir; located in Lee Valley, at its capacity on December 4, 1917; 900 acre feet; date of appropriation, 1887.

And that the said decree be so modified in behalf of the petitioners John C. Hall and George A. Winson, doing business as "Hall and Winsor," under the fourth paragraph under the 13th right be changed to read: Hall and Winsor, successors to J. T. Campbell, a strip in the Northern part of the N½ of the S½ of School Section 16.; Township 8 N., R. 28 E.; 30.56 acres; date of appropriation, 1881.

And that between the 23rd and 24th rights there be inserted 23-B right Hall and Winsor, successors to J. T. Campbell, a strip in the northern part of the N½ of the S½ of School Section 16., Township 8 N., R. 28 E.; 10 acres; date of appropriation, 1892.

And it is further ORDERED AND DECREED that the said decree be modified in behalf of the petitioner Edmond Nelson so that the only paragraph under the 4th filling right shall be changed to read: Edmond Nelson: On Nutrioso Creek only; 831 acre feet; date of appropriation, 1891. And that all of the other terms of the said decree of April 29th, 1918, as to the general regulations therein and terms and conditions thereof apply as to these petitioners in administering these modifications and to enforce which let the commissioners and officers of this court to proceed in the regularly constituted manner of administering this decree.

Done in open Court this 17th day of March, 1921.

R. C. STANFORD,
Judge.

In the Superior Court of the State of Arizona, In and for the County of Apache

The St. Johns Irrigation Company and the Meadows Reservoir Irrigation Company, Corporations, et al., Plaintiffs,

vs.

Round Valley Water Storage and Ditch Company, Eagar Irrigation Company, Springerville Water Right and Ditch Company, Corporations, et al., Defendants.

Supplemental Decree on Behalf of the Lyman Water Co.

Now on this day this matter came on for further hearing upon the petition of The Lyman Water Company for an adjudication and confirmation of its rights to divert and impound waters of the Little Colorado River, and

It appearing to the Court:

That in the decree in this cause entered on April 29th, 1918 the Court specifically retained jurisdiction in this matter in order that any party to this proceeding, or any party interested in impounding, diverting and distributing water from the Little Colorado River, or any tributary thereof might apply for a modification or enlargement of any of the terms of said decree, upon giving notice to the parties

whose rights will be affected under such terms and regulations as the Court might direct;

That upon the application of the Eagar Irrigation Company and other parties to this proceeding, the said decree has been opened for the further adjudication of the rights of claimants of water from the said River;

That the terms and regulations fixed by the Court for the opening of said decree have been complied with, and the notice given as required by this Court, and that this Court now has jurisdiction of the waters of the said River, and in this proceeding it now has the right to adjudicate and determine the claim of the Lyman Water Company;

That by order of this Court heretofore made, the said Lyman Water Company was made a party to this proceeding, and it has been permitted to apply in this cause for an adjudication of its claim to the water of said River;

And this Court having heard the testimony offered in support of the petition of the said The Lyman Water Company, and having examined the exhibits offered in evidence and heard the argument of counsel, and being now fully advised in the premises;

IT IS ORDERED, ADJUDGED AND DECREED tha The Lyman Water Company is the owner of the Lyma Reservoir and Irrigation System in Apache County, Arizona

That said reservoir is located in Township 11 Nortl Range 28 East of the G. and S. R. Meridian, and that sa reservoir is formed by the construction of a dam across t main channel of said River in Section Nine, said Townsh and Range;

That on February 3rd, 1911, the right to store wat in said reservoir was initiated, and thereafter the work constructing said dam and reservoir was prosecuted w due diligence, and that said dam has been completed, and

said reservoir now has a capacity of thirty-two thousand, nine hundred sixty-four (32964) acre feet of water;

That the outlet canal from said reservoir is located at a point twenty (20) feet above the bottom of said reservoir, and that only twenty-eight thousand, four hundred sixty-four (28464) acre feet of water can be drawn from said reservoir for use upon the land hereinafter described;

That the remainder of the capacity of said reservoir, to-wit: four thousand, five hundred (4500) acre feet is required for the storage of a body of water to be permanently held in said reservoir for the purpose of raising the remainder of said water to the level of the outlet canal;

That the stockholders of said The Lyman Water Company are the owners of fifteen thousand (15000) acres of land, near the Town of St. Johns, Arizona, subject to irrigation from said reservoir and irrigation system, and that for the successful cultivation of said land, two (2) acre feet of water per annum is required for each acre, in addition to the natural rainfall;

That the appropriation of said water by the said Lyman Water Comany has been made for the use and benefit of its stockholders, owning land as aforesaid, according to their respective interests in said Company and that said stockholders intend to make, and to continue annually hereafter to make a beneficial use of said water upon said lands;

IT IS FURTHER ORDERED, ADJUDGED AND DECREED that there be permitted to flow into said reservoir annually from said Little Colorado River twenty-eight thousand, four hundred and sixty-four (28464) acre feet of water, with priority dating from February 3rd, 1911, for the use and benefit of the landowners lawfully entitled thereto, and that out of the waters of said River not otherwise appropriated, the said Lyman Water Company be permitted

to store permanently in said reservoir four thousand, five hundred (4500) acre feet of water for the purpose of raising the remainder of the water to be stored in said reservoir to the level of the outlet canal;

That the land to be irrigated by said water to be stored in said reservoir is limited and restricted to fifteen thousand (15000) acres, and that all of said land is situated within the following described sections:

Township 11 North, Range 28 East, of the G. and S. R. Meridian

Section five (5)

Township 12 North, Range 27 East, of the G. and S. R. Meridian

Section three (3)

Township 12 North, Range 28 East, of the G. and S. R. Meridian

Sections 4, 5, 7, 8, 9, 17, 18.

Township 12 North, Range 28 East, of the G. and S. R. Meridian

Sections 19, 29, 30.

Township 13 North, Range 27, East of the G. and S. R. Meridian

Sections 1, 3, 4, 9, 10, 11, 12, 13, 14, 15, 22, 23, 24, 25, 26, 27, 33, 34, 35.

Township 13 North, Range 28 East, of the G. and S. R. Meridian

Sections 5, 6, 7, 8, 17, 18, 19, 20, 21, 28, 29, 30, 31, 32, 33.

Township 14 North, Range 27 East, of the G. and S. R. Meridian

Sections 26, 27, 33, 35.

All of said land is situated in Apache County, Arizona

In so far as the provision of the decree heretofore en

tered are not in contravention of the rights hereby established, the general provisions of said decree are made applicable hereto, the same as though extended in full herein.

Done in open Court at St. Johns, Apache County, Arizona, this 17th day of March, A. D. 1921.

By the Court,

R. C. STANFORD,
Judge.

In the Superior Court of the State of Arizona, In and for the County of Apache

In the Matter of the Determination of the Relative Rights of the Waters of the Upper Little Colorado River and its Tributaries. } Judgment

Whereas, the above entitled matter was heard here
fore before Honorable W. S. Norviel, Water Commissio
for the State of Arizona.

And Whereas, the said Water Commissioner hear
the evidence of the interested parties, and had said evid
taken down in shorthand and typewritten and filed with
clerk of this court.

And Whereas, the said Water Commissioner did make findings of fact from said evidence, and in accordance with said findings of fact did make awards to the various interested parties of the waters as said Upper Colorado River and its tributaries, and did file the same with the clerk of this court.

And Whereas, when the matter came on for hearing in this Court, none of the claimants of the waters of Upper Little Colorado River and its Tributaries appeared and filed exceptions to the findings and awards made by the said Water Commissioner and filed as aforesaid.

It was ordered, adjudged and decreed that the said findings and award of the said Water Commissioner filed with the clerk of this court as aforesaid be in all respects approved and confirmed, and that the same be and remain in full force and effect until the further judgment of this court, changing or modifying the same, in the manner allowed by law.

It was further ordered, adjudged and decreed that all orders and awards of the said Water Commissioner, on file in this court, and not by him heretofore vacated, be, and the same shall remain, in full force and effect until the further order or judgment of this court.

NOW THEREFORE, It is ordered, adjudged and decreed that the said findings and awards of the said Water Commissioner filed with the clerk of this court as aforesaid be in all respects approved and confirmed, and the same be and remain in full force and effect until the further judgment of this court changing or modifying the same, in the manner allowed by law.

It is further ordered, adjudged and decreed that all orders and awards of the said Water Commissioner, on file in this Court, and not by him heretofore vacated, be, and the same shall remain, in full force and effect until the further order or judgment of this court.

Done in open court this third day of April, 1923.

ANDREW S. GIBBONS,
Judge.

NAME	STREAM	DITCH	Date	Acres Irrigated	Sub-Div.	Description Sec.	Twp.	Range	How Initiated
Jay Burgess	Water Canyon and Little Colorado		1884	7	SW SW	9	8	29	Div. and Use
			1887	10	SW SW	9	8	29	
			1889	15.3	SW SW	9	8	29	
			1910	2.	SW SW	9	8	29	
Geo. A. Eagar	Water Canyon	Eastside	1877	14.1	NE NE	21	8	29	Div. and Us
			1880	7.8	NE NW	21	8	29	
		Westside	1880	8.2	SW NE	21	8	29	
			1883	9|9	SE NW	21	8	29	
			1888	9.9	NE SW	21	8	29	
			1895	4.7	SE NW	21	8	29	
			1896	10.4	NE NW	21	8	29	
		Eastside	1906	14.4	NW NE	21	8	29	
	Atchison Lake	Westside	1908	25.5	W½ NW	21	8	29	
	Water Canyon		1907	7	NW SE	16	8	29	
			1911	8	NW SE	16	8	29	
Jos. H. Pearce		Wiltbank	1888	5	SE SE	8	8	29	Div. and Use
			1889	5	SE SE	8	8	29	(Flood water
			1890	10	SE SE	8	8		only)
Jesse W. Slade	Water Canyon	Westside	1906	13	NE SW	16	8	29	Div. and Use
			1908	2	NW SW	16	8	29	
			1916	10	NE SW	16	8	29	
		Eastside	1916	15	NW NW	16	8	29	
		Westside	1920	5	NE SW	16	8	29	
J. H. Slade	Water Canyon	Eastside	1906	1.5	SW SW	16	8	29	Div. and Use
			1908	19	(NE SW -SE SW NW SE-SW SE)	16	8	29	
		Westside	1916	3.5	SW SE	16	8	29	Div. and Use
			1920	3	SE SW	16	8	29	
Jos. K. Udall	Water Canyon and Little Colorado		1887	5	NE SE	8	8	29	Div. and Use
			1890	7	NE SE	8	8	29	
			1900	6	NE SE	8	8	29	
			1910	10.4	NE SE	8	8	29	
			1912	20	NW SW	9	8	29	
Henry H. Udall	Water Canyon	Private	1887	10	NW SE	8	8	29	(Flood water
			1892	10	NW SE	8	8	29	only)

NAME	STREAM	DITCH
C. E. Wiltbank	Water Canyon	Water Canyon Wiltbank
Ashel Burk	Nutrioso	N. Town Lund Lund Lund
Jos. S. Burk	Nutrioso	S. Town N. Town Extension
Melvin Brown	Milligan Valley Draw	Westside
W. T. Greenwood	Riggs Creek	Nelson
Carl Hamblin	Nutrioso	N. Town Lund
Willard Hamblin	Nutrioso Colter	South Town Colter
Marcellus Hulsey	Nutrioso	J. L. Hulsey Dry Valley

Date	Acres Irrigated	Sub-Div.	Description Sec.	Twp.	Range	How Initiated
1886	6.5	NE SW	9	8	29	Div. and Use
1886	4.5	SE SW	9	8	29	(Flood water
1887	20	NW SE	8	8	29	only)
1883	Lots 1 and 2, Town of Nutrioso					
1916	17	SW NW	21	7	30	Div. aid Use
1917	13	SE NE	20	7	30	
1882	Lot 1, Town of Nutrioso					
1915	19.8	NW NW	32	7	30	Div. and Use
1915	11.5	SW SW	29	7	30	
1915	1.5	SE SW	29	7	30	
1915	5	SE SW	4	7	29	Div. and Use
1916	15.2	SE SE	4	7	29	
1916	8.7	SW SW	3	7	29	
1917	.75	SE SE	6	7	30	
1917	.75	SW SW	5	7	30	
1917	3.5	NW NW	8	7	30	
1917	5	NE NE	7	7	30	
1883	Lot 2, Block 9, Lots 1 and 4, Block 10, Town of Nutrioso					
1909	20	NW NE	29	7	30	Div. and Use
1910	15	NW NE	29	7	30	Part hay
1911	14.75	NE NE	29	7	30	Hay
1912	11.46	SW NE	29	7	30	Part hay
1882	Lot 1, Block 23, Town of Nutrioso					
1907	13	SW SE	30	7	30	Div. aid Use
1907	6.6	SE SW	30	7	30	
1908	14.3	NE SE	30	7	30	
1908	4.5	NE NW	31	7	30	
1908	10.2	SE SE	30	7	30	
1879	10	SW NE	5	6	30	Div. and Use
1881	9.97	SW NE	5	6	30	
1883	21	NW SW	4	6	30	
1885	18.55	SE SW	4	6	30	
1893	4.4	NE SW	4	6	30	
1893	6	NE NW	9	6	30	
1907	29	NE NW	1	6	29	
1907	16.76	SE NW	1	6	29	

NAME	STREAM	DITCH	Date	Acres irrigated	Sub-Div.	Description Sec.	Twp.	Range	How Initiated
Sylvester Hulsey	Nutrioso	Lund	1913	10	SW SE	9	7	30	
			1915	3.1	SW SE	9	7	30	
			1915	4.9	NW SE	9	7	30	
			1915	5.9	NE NE	16	7	30	
			1918	20	SE SE	9	7	30	
H. G. Knowlton	Nutrioso	J. L. Hulsey	1879	10.4	NE SE	5	6	30	
			1882	8	SW NW	4	6	30	
			1885	13.47	SE NE	5	6	30	
John W. Lee	Nutrioso	North Town	1883	Lots 2 and 3, Block 16, Town of Nutrioso					
		Old Town	1909	24.6	NW SW	20	7	30	
			1912	28.9	NE SW	20	7	30	
			1912	7.8	NW SE	20	7	30	
			1912	19.2	NW SW	20	7	30	
Marion Lee	Nutrioso	S. Town	1882	Lot 2, Block 18, Town of Nutrioso					
		Private	1917	5	NE SE	6	6	30	
Claud Lee	Nutrioso	S. Town	1882	Lot 4, Block 18, Town of Nutrioso					
Garland Lee	Nutrioso	S. Town	1882	Lot 3, Block 8, Lot 3, Block 9, Town of Nutrioso					
Thomas R. Lee	Nutrioso	S. Town	1882	Lots 3 and 4, Block 2, Lots 3 and 4, Block 7, Nutrioso					
		Lower Town	1908	20	SE SW	17	7	30	
David Love	Hood	D. Love	1879	24	SW NE	7	6	30	Div. and Use
			1879	20	NW SE	7	6	30	
			1881	33.5	NW NE	18	6	30	
			1881	30.5	SW SE	7	6	30	
		S. Town	1882	Lots 3 and 4, Block 15, Town of Nutrioso					
		N. Town	1883	Lot 1, Block 15, Town of Nutrioso					
		D. Love	1907	3	SE NE	7	6	30	
			1907	20	NW NE	7	6	30	
			1907	20.8	NE NE	7	6	30	
			1907	11.67	SW SE	6	6	30	
			1907	37	SE SE	6	6	30	
Lund	Nutrioso	Lund	1907	26.26	SE NW	29	7	30	Div. and Use
			1908	18.26	NE NW	29	7	30	
			1908	27	SE SW	20	7	30	
			1908	30.5	SW SE	20	7	30	

NAME	STREAM	DITCH	Date	Acres Irrigated	Sub-Div.	Description Sec.	Twp.	Range	How Initiated
Archibald and Lydia Maxwell, Nutrioso		North Town	1881	10.3	(sw nw and nw nw (se nw and ne se)	32 31	7	30	Div. and Use
			1881	10	NE NE NW NW	31 32	7	30	
			1902	23.3	NW NW	5	6	30	
Mrs. Bernice Reagan Murray	Reagan Lake	Private From Reagan Lake	1917	7	NE NE	26	8	30	(Agreement
			1917	13	NW NE	26	8	30	With J. S. Rea-
			1917	3	SE NE	26	8	30	gan, re Reagan Lake)
McKay Cattle Co.	M. Rudd	McKay	1872	1.3	NE SW	1	7	29	Div. and Use
			1872	20	NW SE	1	7	29	
			1876	6	NE NE	1	7	29	
			1876	14	SE NE	1	7	29	
			1876	10.6	NE SE	1	7	29	
			1876	15	SE SE	1	7	29	
			1876	26	SW NW	6	7	30	
			1877	7	SW SW	6	7	30	
			1877	29	NE NW	6	7	30	
			1877	8.65	SE SW	31	8	30	
			1884	24.50	SW SE	31	8	30	
			1884	26.87	NW SE	31	8	30	
			1884	5.60	NE SE	31	8	30	
			1884	3.05	SW NE	31	8	30	
			1914	25.47	SE NE	31	8	30	
			1920	20	NW SW	6	7	30	
J. E. Nelson	Rudd Creek	Riggs and Rudd Creek	1908	20	NE NW	7	7	30	Div. and Use
			1908	2	NW NW	7	7	30	
			1908	3	SW NW	7	7	30	
			1911	25	SE NW	7	7	30	
M. L.Odell	Nutrioso	Private	1916	1.3	SW NW	4	7	30	Div. and Use
			1916	10.5	NE SW	4	7	30	
			1916	4.7	NW SE	4	7	30	
Clem L. Saffell	Nutrioso	Private	1895	25	SE NW	17	8	30	Div. and Use
Julius S. Reagan	Nutrioso	Reagan	1907	15.75	NE NW	9	7	30	Div and Use
			1910	40	NW NE	9	7	30	
			1911	7.60	SE NW	9	7	30	
			1911	10	SW SE	9	7	30	

NAME	STREAM	DITCH
A. and B. Schuster Co.	Nutrioso	Wakefield
C. H. Sharp	Colter Creek	J. W. Lee
	Nutrioso	Lower Town Colter Creek
Wm. Swain	Nutrioso	N. Town
B. A. Thompson	Mulligan Valley	Private
Henry Thompson	Little Colorado and Nutrioso	Ortega
	Nutrioso	Thompson
Orson and Ernest Wilkins	Nutrioso	South Town
Orson Wilkins	Nutrioso	S. Town Dry Valley
Ernest Wilkins	Nutrioso	S. Town S. Town and Lund
Lucinda Wilkins	Nutrioso	N. Town Dry Valley

Date	Acres Irrigated	Sub-Div.	Description Sec.	Twp.	Range	How Initiated
1883	28	NE SW	33	8	30	Notice posted
1883	20	SE SW	33	8	30	
1883	32.7	NE SW	4	7	30	
1883	12.16	SE NW	4	7	30	
1907	19.4	SW NE	1	6	29	Div. and Use
1886	32.3	SE NE	1	6	29	
1912	31.36	SW NW	20	7	30	
1915	10	SE NE	19	7	30	
1881	15.5	NE NW	5	6	30	Div. and Use
1881	6.68	NW NE	5	6	30	
1882	11.43	SE SW	32	7	30	
1913	1	SW NE	9	7	29	Div. and Use
1885	12.3	NW SW	28	9	29	Div. and Use
1887	10	SW NW	28	9	29	
1887	10	SE NW	35	9	29	
1907	15	NE NE	35	9	29	
1882	Lot 2, Block 12, Town of Nutrioso					
1882	Lots 1 and 2, Block 13, Town of Nutrioso					
1882	Lots 1 and 2, Block 20, Town of Nutrioso					
1877	23.3	SE NE	31	7	30	Div. and Use
1877	21.9	SE NE	31	7	30	
1881	32.8	NE SE	31	7	30	
1882	Lots 3 and 4, Block 18, Town of Nutrioso					Div. and Use
1886	28.83	NW NW	1	6	29	
1886	33	SW SW	36	7	29	
1882	Lots 3 and 4, Blk. 11, Lots 1 and 2, blk. 14, Lot 2, Blk 15					
1916	20	NE SE	20	7	30	Div. and Use
1917	5	NE SE	20	7	30	
1919	13	NE SE	20	7	30	
1883	Lot 3, Block 10, Town of Nutrioso					
1886	25	(NW SW (NE SE	36 35	7	29	Div. and Use

NAME	STREAM	DITCH
James P Reagan	Reagan Lake	Private
Mary W. Wilkins		S. Town
Parley Wilkins	Nutrioso	Private
		S. Town
Alzian Hale	Fish Creek	Fish Creek
Miner L. Hall	Fish Creek	Fish Creek
Ferdinand Hoffman	Fish Creek	Fish Creek
Michael Hale	Fish Creek	Fish Creek
W. L. and Lena Robinson	Canero Creek	Robinson and Phelps
Ellis Wiltbank	Fish Creek	Fish Creek

Date	Acres Irrigated	Description Sub-Div.	Sec.	Twp.	Range	How Initiated
1916	6.3	SW NE	35	8	30	Div. and Use
	2.3	SE NW	35	8	30	
1917	.4	SW NE	35	8	30	
	1.9	SE NE	35	8	30	
	5.2	NW SE	35	8	30	
	6.2	NE SE	35	8	30	
	7.2	SW SE	35	8	30	
	2.6	SE SE	35	8	30	
1920	1.9	SE NW	35	8	30	
	4.2	SW NE	35	8	30	
1882	Lots 1 and 2, Block 21, Block 22, Town of Nutrioso					
1881	18.5	NE NE	31	7	30	Div. and Use
1881	4	SE NE	31	1	30	
1882	Lots 3 and4, Block 17, Town of Nutrioso					
1916	8.3	SE NW	9	8	28	Div. and Use
1914	23.5	W½ NW	5	8	28	Div. and Use
1916	10	SE SE	31	9	28	
1917	6.56	NE SE	31	9	28	
1918	8.75	NW SE	31	9	28	
1913	10.5	SW SE	9	8	28	Div. and Use
1913	3	SW NE	9	8	28	
1916	8	SE SE	9	8	28	
1919	5	SE SE	9	8	28	
1913	10.4	SE SW	9	8	28	Div. and Use
1914	8.3	SW SW	9	8	28	
1915	6.1	NE SW	9	8	28	
1913	37.50	SW NW	8	8	28	Notice posted
	16.25	SE NW	8	8	28	
	16.50	NE NE	7	8	28	
	2.50	NW NW	8	8	28	
	1.	SE SE	6	8	28	
	23.20	SE NE	7	8	28	
1913	5	SE NE	10	8	28	Div. and Use
1914	10	SE NE	10	8	28	
1915	8.3	SW NE	10	8	28	
1915	13.4	NE SE	10	8	28	
1916	9	NW SE	10	8	28	

NAME	STREAM	DITCH
Fred T. Colter	Nutrioso	Westside
	Nutrioso	N. Town
Joseph E. Jarvis	Little Colorado Big Hollow Wash	Private
J. B. Jolly Estate	Little Colorado Little Colorado	Private Private

Date	Acres Irrigated	Sub-Div.	Description Sec.	Twp.	Range	How Initiated
1906	7.4	NW SE	6	8	29	Div. and Use
1906	25.3	SE NE	6	8	29	
1906	40	SE NW	6	8	29	
1906	40	NE NW	6	8	29	
1906	34.1	SW NW	5	8	29	
1906	36.4	SE NW	5	8	29	
1906	31.8	NW NW	5	8	29	
1906	33.5	NE NW	5	8	29	
1906	34	NW NE	5	8	29	
1907	14.9	NE NE	5	8	29	
1907	8.8	NE NE	12	8	28	
1907	10.5	SE NE	12	8	28	
1907	4.4	SW NE	12	8	28	
1907	15.3	NE SE	1	8	28	
1907	34.6	SW SW	32	9	29	
1907	2.4	SE SW	32	9	29	
1907	12.6	SW NW	7	8	29	
1907	26.5	NE NE	1	8	28	
1907	35.8	SE NE	1	8	28	
1883	Lots 1 and 4, Block 3, Town of Nutrioso Lot 1, Block 2					Div. and Use
1916	30	Lots 3, 4 E½SW¼	30	14	28	Div. and Use
1916	35	Lots 3, 4 E½SW¼	30	14	28	Flood water only
1882	15	NW¼	24	14	27	
1882	80	NW¼	24	14	27	Flood water for hay land

RESERVOIRS
Little Colorado River Determination

Name of Owner	Name	Capacity Acre Feet
Fish Creek Irriga. Co.	Noron	566.50
	Sunnyside	33.35
Marcellus Hulsey	M. Hulsey	39.80
Lund-Lee-Martin (Washed out in 1918. Permit to rebuild and complete within five years.)	L. L. Martin	48.25
McKay Cattle Company	San Salvador	259.00
	St. Joseph's	270.78
	St. Mary's	611.70
	Trinity	42.75
	Glen Livet	109.75
	McKay	245.00
C. H. Sharp	Lee-Burgess	289.00
	Wilkins and Sharp	82.88
E. and C. Wilkins, S. Hulsey, W. Lund and A. W. Burke	Nutrioso	178.53
W. L. and Lena Robinson and Thos. and Maud Phelps	Tyler	375.00
Fish Creek Irrigation Co. Wiltbank, E. W., et al	Et Wiltbank	205.00
Julius Reagan	Riggs Creek	79.52
	Reagan Lake	188.70
J. W. Lee, T. R. Lee, and C. H. Sharp	Jarvis	135.32

RESERVOIRS
Little Colorado River Determination

Stream	Date	Sec.	Location Twp.	Range
Fish Creek	1916	20 29 and 30	8	27
	1912	30 SE Corner	8	27
Board Hollow	1887	NW NE 10	6	30
Nutrioso	1910	SE SW 29	7	20
Rudd Creek	1888	SE¼ 24, NW¼ 30, SW¼ 19,	7	28 29
		SE¼ 24	7	28
		NE¼ 19	7	29
		NE¼ 6	7	30
		SE SE¼ 1	7	29
Colter Creek	1892	NW NE	6	29
Nutrioso Hood	1878	SE¼ 31	1	30
Canero	1878	SE¼ 31	8	27 Notice
Fish Creek	1913	14	8	27
Riggs-Creek	1890	NE¼ 24	7	29
Davis Creek	1892	NE¼ 2	7	30
Colter Creek	1906	SW¼ 20	7	30

RESERVOIRS
Little Colorado River Determination

Name of Owner		Name	Capacity Acre Feet
Goe. A. Eagar, Henry Slade and J. W. Slade		Atchison Canon No. 5	204.32 23.30 (now 30 to be 94.54)
Geo. A. Eagar		Rudd	609.30
Nelson and Greenwood		Bailey	321.00
Fred T. Colter	1908	River No. 1	724.20
	1908	Hay Lake 2	821.35
	1908	Pool Corral 3	992.97
	1908	Hog Wallow 4	1000.00
	1899	Lee Valley 5	463.95
	1896	West Side 0	586.00

RESERVOIRS
Little Colorado River Determination

Stream	Date	Location Sec.	Twp.	Range
Water Canon	1886	SW¼ 13	7	28
	1893	SE NE 1 3	7	29
	1912	SE¼ 7	7	29
Water Canon	1895	SE¼ 23, SW¼ 24	7	28
Riggs Creek	1910	W½E½ 7	7	30
Little Colorado		3	6	27
N. Prong. S. Fork, Little Colo.		1 and 2	8	28
S. Prong, S. Fork, Little Colo.		29 and 30	7	28
S. Fork, Little Colo.		NE 30, S½ 19	7	28
E. Fork		4	6	27
Little Colorado		6	8	29

UNIVERSITY OF ARIZONA
AGRICULTURAL EXPERIMENT STATION.

BULLETIN NO. 63.

A reprint of Bulletin No. 235, Office of Experiment Stations, U. S. D. A., being No. 2, cooperative, by the U. S. Department of Agriculture and the Arizona Agricultural Experiment Station.

RRIGATION AND AGRICULTURAL PRACTICE IN ARIZONA.

BY

R. H. FORBES.

DISTRIBUTED, TUCSON, ARIZONA, JUNE 30, 1911.

WASHINGTON:
1911.

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SUPPLEMENTARY ITEMS

Area irrigated in 1909, preliminary report, 13th Census. Compare p. 12.

The total acreage irrigated was 306,665 acres, excluding Indian reservations. The author's estimate of 227,770 acres includes irrigated and productive areas only, and excludes projects where irrigation has not yet resulted in economic success.

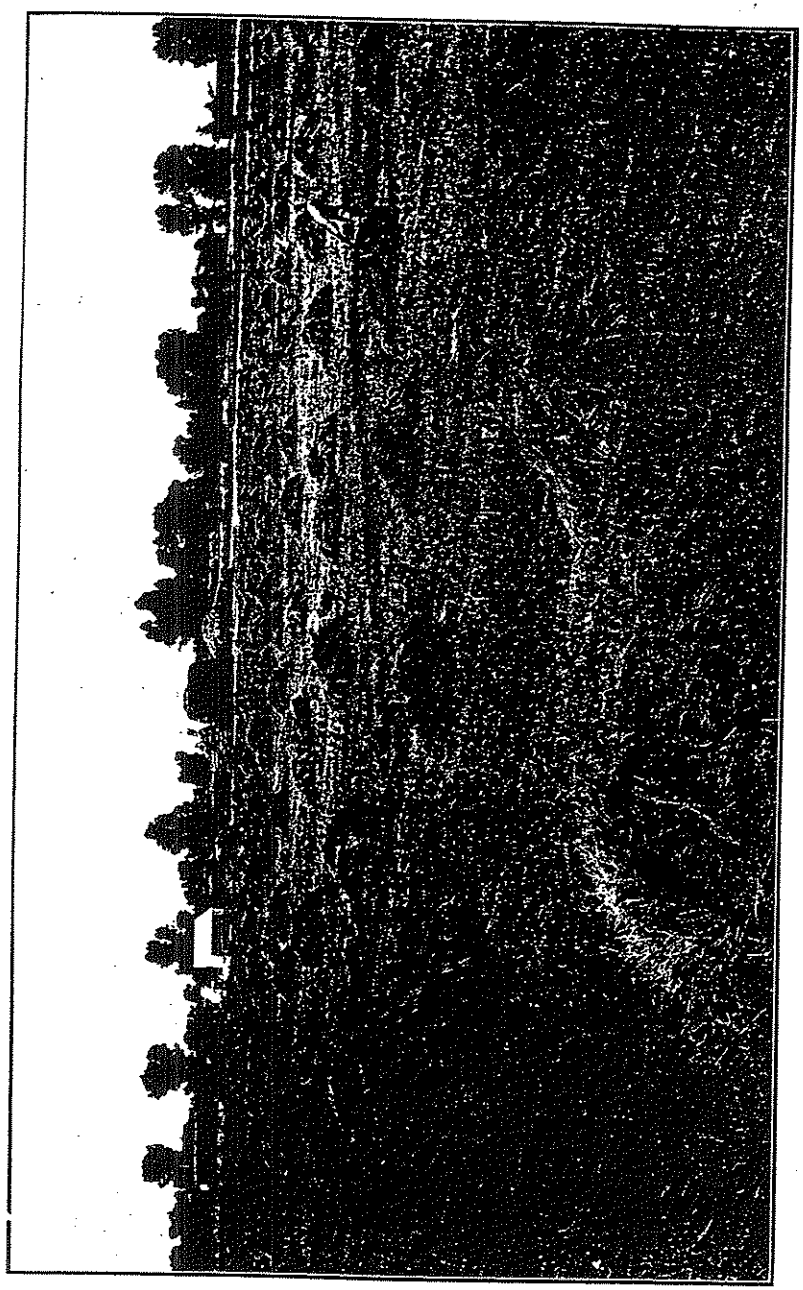
*Assessed valuation of property, 1911.** Compare p. 15.

Land and improvements	$14,139,689.31
All mining property	19,242,331.26
Town and city lots and improvements	26,476,175.66
All livestock	7,780,544.00
Railroads	19,052,313.94
All other property	13,122,055.47
Total, all property	$99,813,109.64

Value of livestock on farms and ranges, preliminary report, 13th Census. Compare p. 21.

	Number	Value
Poultry	5,498 turkeys 252,657 chickens 1,824 ducks 418 ostriches,† etc.	$282,500
Bees	23,770 hives	104,400
Dairy cows	28,199	1,255,000
Other cattle	783,567	13,153,000
Horses and colts	85,248	3,942,000
Sheep and lambs	1,061,363	3,797,000
Goats and kids	223,512	531,000
Mules and colts	3,785	392,000
Swine	17,205	114,000
Burros	5,687	65,700
		$23,636,600

*Proceedings Terr. Board of Equalization, August, 1911.
†Underestimated—R. H. F.



A LITTLE FARM, WELL TILLED, IN THE COLORADO VALLEY, NEAR YUMA.
The alfalfa in the foreground produced 71.7 tons of hay on 7.6 acres in 1910

IRRIGATION IN ARIZONA.

INTRODUCTION.

HISTORY OF IRRIGATION DEVELOPMENT.

Irrigation, which for the most part is a prerequisite to agriculture in Arizona, was first practiced in this region by ancient peoples. In the valleys of the Little Colorado, Salt, and Gila Rivers, and along the Verde River and smaller tributaries are found unmistakable remains of ditches and reservoirs, together with ruins of the cliff dwellings and the communal houses of tribes which had been scattered long before the advent of the Spanish explorers. The character of these remains indicates that these ancient Indians possessed considerable skill in the art of irrigating. Their ditches and reservoirs were finished with hard linings of tamped or burnt clay, and one instance is known where a main canal was cut for a considerable distance through solid rock. Sometimes a smaller ditch was sunk in the bottom of a large canal to facilitate the carriage of small runs of water, and thus seepage and evaporation were diminished in times of scant flow (fig. 1). The ancient canals in the Salt River Valley aggregated a length of at least 150 miles and were sufficient for the irrigation of 250,000 acres of land,[1] although it is not likely that the whole of this area was ever watered at any one time (fig. 2). In the ruins of the houses of grouted clay are found relics of cotton and corn; beans, squashes, and tobacco were also grown.

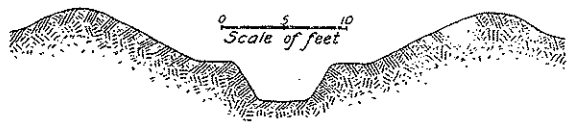


FIG. 1.—Cross section of prehistoric ditch, showing channel in bottom for carrying a small irrigating stream.

The Pimas and Papagos, who are probably descendants of this prehistoric people, have continued to water and till the soil. The Pimas particularly are good irrigating farmers. They are a sedentary tribe which, since modern records began, has maintained itself in the Salt and Gila River Valleys in south-central Arizona. Their nomadic relatives, the Papagos, taking advantage of the uncertain rains which

[1] Prehistoric Irrigation in Arizona. F. W. Hodge, American Anthropologist, July, 1893.

char[illegible]upon them, utilize the run-off from summer storms, soak their soil[illegible] plant quick-growing crops of corn, beans, squashes, and melons. The several tribes along the Colorado River—the Mohaves, Chemehuevis, Yumas, and Cocopahs—grow crops in that fertile valley after a peculiar method necessitated by the behavior of the river. Their main crop season begins immediately after the subsidence of the annual flood in July. Millets are sown in the mud flats exposed by the falling waters, much after the fashion of Egyptian irrigators under the old basin system used along the Nile. Other crops, such as corn, squashes, and melons are planted, as soon as the bottom lands are dry enough, in pits sometimes 2 feet deep, from which the plants issue quickly in profuse growth. Sufficient moisture is brought within the reach of the plant roots by this method of deep planting to insure a crop without further irrigation.

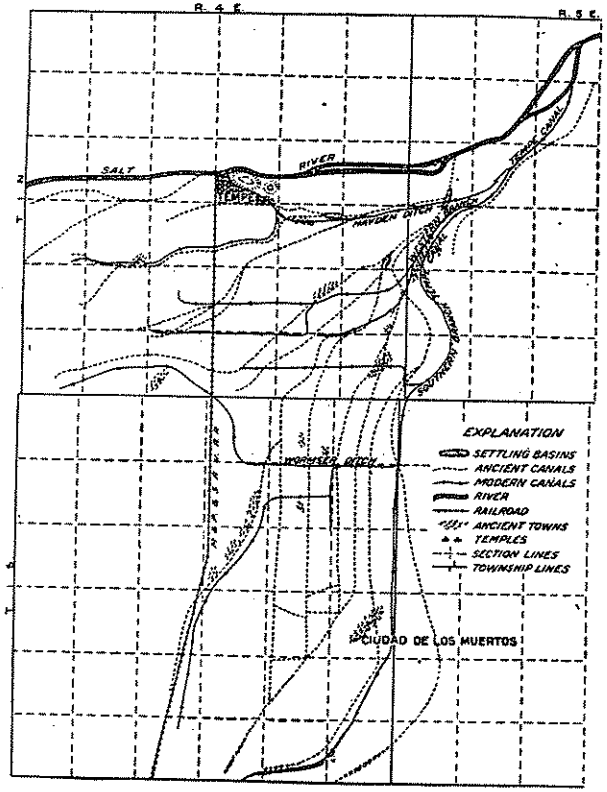


FIG. 2.—Prehistoric and modern canals in a portion of Salt River Valley, located by James C. Goodwin, Tempe, Arizona.

The first European irrigators in Arizona were, without doubt, the Jesuits, who first established themselves at the old missions of Guevavi and San Xavier in 1732. It was not until the more prosperous period from about 1768 to 1822, however, that there was any considerable development of irrigation at favorable points along the Santa Cruz River, near the missions and the Spanish presidios of Tubac and Tucson. During the chaotic period of Mexican rule which followed acequias were maintained, orchards were planted, and annual crops of barley, wheat, corn, tobacco, beans, melons, squashes, and peppers—both native and introduced crops—were cultivated. Although from an engineering standpoint the head works and canals of this period were of the simplest construction and of small extent, the [illegible]ican people were skillful in the management of water and possessed an agricultural aptitude well expressed by them in their phrase "el mano por sembrar"—the planting hand. They also adopted certain ideas in equity, and customs relating to the distribution and use of water, which are approved in the best irrigation practice of the present time. Among these was the rule that water is appurtenant to the land.

The Americans in Arizona received their first instruction in irrigation from the Mexicans. The third, or modern, stage of agricultural development may be said to date from the Gadsden purchase in 1854, after which increasing numbers of Americans—military followers, stragglers from the immigrant stream to California, and pioneers by instinct—began to make permanent homes in the land.

Irrigation in the Salt River Valley began soon after the close of the Civil War, when military occupation of the region was resumed and the Army posts offered the settlers both safety and remunerative prices for their products. Canal construction was rapid, beginning with the old Swilling Ditch in 1867, and 20 years later about as much land had been reclaimed as could be irrigated from Salt River in seasons of scant flow. Nevertheless, during a series of wet years that followed, additional areas were put under cultivation until more ground was nominally reclaimed than could be irrigated by the "critical minimum" water supply. The inevitable hardships which resulted from this condition during ensuing dry years, especially 1898–1904, led to anxious discussion of remedial measures and prepared the way for the construction under United States Reclamation Service auspices of the Roosevelt Storage Dam, which is now (March, 1911), completed.

The second largest irrigated district in Arizona (1911) is in Graham County on the upper Gila River. It was settled by Mexican colonists in 1874 and later by the Mormons in 1879. As in the Salt River Valley, there has been a tendency to overappropriate lands under the available water supply, with consequent distress in dry years. Thus far, however, conditions in this locality are prosperous, owing to the fact that the flow of the Gila River at this point is comparatively regular and fairly adequate to irrigate the area under cultivation, although the total amount of land under ditch is in excess of the water supply.

The Colorado River Valley, although the most extensive and potentially the richest and best watered of the agricultural regions, is the last to be developed through irrigation, principally because of the unmanageable character of this eccentric stream and the large expense of the permanent irrigation works required for its control. Although a few small enterprises near Yuma have achieved temporary successes during the past 15 years, it was not until the United States

Recl ion Service undertook the construction of the Laguna Ba rage . the irrigation of considerable areas was assured. The com pletion of this barrage in March, 1909, presages the early irrigatio in Arizona of 90,000 acres of alluvial bottom lands, and later of abou 40,000 acres of adjacent mesa.

Along the Little Colorado, the Verde, the San Pedro, and the Sant Cruz Rivers and many smaller streams, numerous ditches take prac tically the whole of the minimum flow for the irrigation of little farm leveled, often with much labor, in nooks and corners of an angula country.

The progress of irrigation in Arizona during the pioneering stag of American occupation may be suggested by the following summary

Areas irrigated in Arizona at different dates.

Date.	Source of information.	Area actually irrigated.
		Acres.
1854.....	Old map in Pima County assessor's office, and Mexican traditions.....	2,00
1890.....	Eleventh Census Report.....	65,82
1899.....	Twelfth Census Report, Volume VI, part 2, page 820.....	185,39
1909.....	Author's estimate.....	227,77

NOTE.—Lands irrigated by uncivilized Indians within the Territory not included. According to Rev. C. H Cook, who has lived among the Pimas since 1870, that tribe in 1854 irrigated about 3,000 acres on the Gil below Sacaton. The Moquis and the Navajos in the north, the Mohaves and Chemehuevis on the Colorad River, the Apaches, and the nomadic Papagos of the southwestern district, all irrigated small patche of ground aggregating possibly an additional 2,000 acres. A fair approximation of land crudely farmed b the Indian tribes in 1854 is 5,000 acres.

The continuation of a development which has increased the irri gated area from 2,000 to 228,000 acres in the 55 years of American occupation is worthy of study. With the whole of the minimum surface flow of the Territory now in use and only flood waters escap ing, it is evident that any further expansion of agricultural industry must depend upon the storage of flood waters, the development o underground supplies, and improved cultural methods.

AREA AND TOPOGRAPHY.

Arizona has an area of 113,956 square miles, of which all but about 116 square miles,[1] or over 99.9 per cent, is land surface.[2] The Terri tory is situated in the midst of the semiarid, subtropical region of the southwestern part of the United States and northwestern Mexico. Its remoteness from communications by land or sea and the hereto-

[1] U. S. Dept. Commerce and Labor, Statistical Abstract, 1908, p. 20.

[2] The water surface is occasionally expanded by recurring floods, especially in the Colorado River. The shifting course of this river along the Mexico-California boundary also causes noteworthy changes in the area of the Territory.

fore more attractive domains of Texas and California on either side, have left it to be one of the last of the Commonwealths to be developed. The mining, stock raising, and agricultural industries, however, are now in a stage of rapid advancement.

This great oblong of primitive country—about 340 by 390 miles in its extreme dimensions—may be divided nearly equally into two distinct climatic zones by a somewhat irregular diagonal line running from the point where the Gila River enters the Territory to that point on the Nevada boundary where the Colorado River turns southward. The region north and east of this line consists in large part of comparatively level plateaus 5,000 to 8,000 feet above sea level, diversified by isolated buttes and short mountain chains, and cut by eroded canyons, chief among which is the tremendous chasm of the Colorado River. The southwestern half of the Territory is less elevated and is crossed from northwest to southeast by a succession of low mountain ranges and wide valleys decreasing gradually in altitude from the New Mexico line to the Colorado River. San Francisco Mountain, an extinct volcano in north-central Arizona, 12,794 feet in altitude, is the highest point of land, the lowest being the Colorado River bottoms at the Mexican boundary below Yuma, with an elevation ranging down to 83 feet at times of minimum stream flow.

Nearly the whole visible water loss of Arizona passes by way of the Colorado River to the Gulf of California. The Little Colorado pours most of the run-off of the northeastern plateau into the Grand Cañon of the main stream, while the Gila River collects the drainage of the central and southern parts of the Territory and joins the Colorado just above Yuma.

FLORA.

The indigenous vegetation of the Territory corresponds in different localities to varying climatic conditions, especially rainfall and temperature. Mountain masses and plateaus above 5,000 feet elevation, by reason of their cooler temperature and greater rainfall, are in large part forested, often very densely so. The valleys of intermediate elevation below the forested zone are covered in season with grasses and oftentimes with drought-resistant perennials. These decrease in amount and value as the altitudes grow less, and the conditions become most extreme toward the Colorado River. The narrow ribbons of watered soil along the rivers, widened here and there by artificial means, support a dense and luxuriant growth of vegetation which is largely subtropical in character and indicative of rich returns to the irrigator when the natural resources of climate, soil, and water are administered effectively.

INDUSTRIES.

principal industries of Arizona are mining, stock raisin agriculture, and transportation. Copper is the principal met mined, the Territory having led the States of the Union with a smelt output of 256,778,437 pounds in 1907, and of 289,523,267 pounds 1908.[1] The production of copper in Arizona up to the end of 190 totals about 3,000,000,000 pounds, with a value approximatin $400,000,000.

Stock raising on the open range, principally sheep and cattle, is very important industry, notwithstanding the great decline in graz ing values since 1893. The problems of range administration ar now being worked out in the forest reserves of the Territory, whic on December 31, 1910, embraced about 14,811,145 acres of importan watershed areas wholly or partially forested.

Agriculture, the youngest of the three principal industries of th Territory, is just entering upon a period of rapid advancement both in the areas cultivated and in the intensity of the cultural method employed. The fluctuating flows of the irrigating streams, with consequent failures of water supply at critical times and unmanage able floods at others, have heretofore restricted and discouraged the operations of irrigation farmers. The installation of the two great Reclamation Service projects, one in the Salt River Valley and the other on the Colorado River near Yuma, and the consequent storage and regulation of the principal irrigating water supplies of the Terri tory, will soon enable a majority of Arizona farmers to work with their moisture conditions under perfect control. Certainty of crop returns, the diversity of crops possible, the all-year growing season of the southern valleys, and the intensive methods will lead to high and varied productiveness, with land values far above those of the average humid regions of the United States.

By reason of its isolation, Arizona is dependent upon its transportation facilities to an unusual degree. These consist chiefly of three great railroad systems, which, in order of their construction, are the Southern Pacific, the Santa Fe, and the El Paso & Southwestern. The Santa Fe crosses the northern tier of counties from east to west, and with its branches opens up the mining and lumbering districts of the more elevated half of the Territory. The Southern Pacific runs a roughly parallel course south of the Gila River, and its feeders tap the rich mining districts and the warmer irrigated valleys at lower altitudes. The El Paso & Southwestern road affords an outlet for the copper mines of southeastern Arizona and northern Mexico. A few steamboats of shallow draft ply the Colorado River, and in remote localities freighting with teams is still practiced.

[1] U. S. Geol. Survey, "Mineral Resources of the United States," 1908, pt. 1, pp. 194, 195.

ASSESSED VALUATION AND POPULATION.

The assessed valuation of Arizona property in 1910 was as follows:[1]

Assessed valuation, 1910.

Land and improvements	$12,624,759.90
All mining property	19,714,592.16
Town and city lots and improvements	24,957,628.36
All live stock	7,480,050.00
Railroads	13,224,292.04
All other property	9,912,049.04
Total	87,913,371.50

These valuations are notably low, due to the difficulties incident to the assessment of mines and live stock and to the prevailing custom of rating realty, merchandise, improvements, etc., at one-third to one-half of their actual worth.

The census of 1910 records 204,354 people in the Territory, of which about 26,000 are Indians. The greater part of the population consists of those who have immigrated to the Territory from other States and countries during comparatively recent years and of Mexicans native to the Southwest.

CLIMATE.

The climatic zone within which Arizona chiefly lies may be roughly defined as one which combines a low rainfall with a very high percentage of possible sunshine, a long, hot season, frosty minimum temperatures in winter, and usually a very low atmospheric humidity.

The region of smallest rainfall extends along the Colorado River, the mean annual at Yuma for 38 years being 3.13 inches and at Fort Mohave for 37 years being 5.07 inches. Precipitation increases gradually with elevation east of the river until average maxima of over 20 inches are recorded at the higher stations. The following table shows the average annual precipitation in the three most important watersheds:

Elevation and average annual precipitation of points in Arizona.[2]

Watershed.	Period.	Elevation.	Average annual rainfall.
	Years.	*Feet.*	*Inches.*
Colorado—northern Arizona:			
Fort Mohave	37	604	5.07
Flagstaff	17	6,907	23.87
Holbrook	19	5,069	8.99
Fort Defiance	15	6,500	14.01
Salt River—central Arizona:			
Phoenix	31	1,108	7.27
Camp McDowell	23	1,800	10.38
Prescott	40	5,320	17.40
Fort Apache	32	5,200	18.90
Gila River—southern Arizona:			
Yuma	38	141	3.13
Maricopa	31	1,173	5.83
Tucson	40	2,390	11.66
Bisbee	18	5,500	17.46

[1] Proceedings of the Territorial Board of Equalization of Arizona, 1910.
[2] U. S. Dept. Agr., Weather Bur., Summary of Climatological Data for the United States, secs. 3–4.

The seasonal distribution of the rainfall varies in different portions of the Territory. In the central and western districts the winter rains exceed those of summer, thus favoring the growth of certain winter-growing annuals; while in the southeastern region summer rains predominate, supporting the grasses which constitute the best wild forages.

With respect to temperature and seasons, the Territory may be divided into two distinct regions. The northeastern and more elevated half, although semiarid, is comparatively cool, being frost bound in winter and having temperate summers. The southwestern and lower half may be described as arid-subtropical. The summers are ardent and prolonged, but occasional moderate frosts are known in winter. The mildness of the winters and the length of the summers make possible an all-year succession of crops in southern Arizona, a circumstance which with irrigation will lead to a highly intensive cultural development of that region. The following mean maximum and minimum records, representative of the Territory, are sufficient for illustration:

Mean monthly maximum and minimum temperatures for Prescott and Yuma.[1]

Month.	Maximum.		Minimum.	
	Prescott.[2]	Yuma.	Prescott.	Yuma.
	°F.	°F.	°F.	°F.
January	46.9	64.7	20.7	42.0
February	51.6	70.5	24.3	43.8
March	57.8	77.8	29.[illegible]	50.3
April	65.3	85.3	36.2	55.2
May	75.2	93.5	42.5	61.6
June	84.2	101.2	48.7	68.7
July	88.1	106.3	59.0	77.4
August	84.9	104.7	58.0	77.8
September	80.3	99.2	48.8	70.3
October	69.0	86.3	38.2	58.5
November	57.4	73.9	27.1	48.6
December	51.2	68.0	26.4	46.0

[1] Arizona Sta. Bul. 20, p. 20.
[2] Altitude of Prescott, 5,320 feet; Yuma, 141 feet.

The daily range of temperature averages about 30° F. and in dry, clear weather it may reach 50° F. occasionally. The extremes of temperature at inhabited points thus far noted are as follows: At St. Michaels, −24° F.; at Parker, 127° F.[1]

The dearth of vegetal covering in the desert regions, the dry air, and the clear skies favor rapid radiation of heat at night. The drainage of cooled air to lower levels further increases the effect of radiation, and the valleys are therefore subject to frosts. In some localities frosts are so late and so variable in time of occurrence as to interfere seriously with the growing of certain fruits sensitive to cold. However, the rise and fall of temperatures are rapid and the duration of the extremes is short. Low minima of short duration in arid regions, therefore, do less harm than the same temperatures in more humid regions where a certain minimum indicates much longer exposure to killing cold.

[1] U. S. Dept. Agr., Summary of Climatological Data for the United States, sec. 4, p. 7.

The relative humidity is usually low, being least during June, when temperatures are high and rainfall small. Relative humidities of less than 10 per cent are often recorded in June, the annual average for four years at Phoenix being 35 per cent.[1] The so-called dry rains of Arizona, which are of common occurrence during the summer season, attest the extreme aridity of the air at certain times. These "horse-tail" showers start at a few thousand feet altitude, but are entirely evaporated and disappear before reaching the earth.

Wind movement is light ordinarily, averaging from 2.4 miles an hour at Phoenix to 6.9 miles at Prescott.[2] This is a fortunate circumstance in connection with the heat and aridity of the summer season. Dust storms of a few to several hours duration are known, usually during March, April, and May. Thunderstorms occur for the most part in summer. Deep snow falls at higher altitudes, and light snowfall on rare occasions lies in the southern valleys for a short time. Hail storms cause occasional damage, but tornadoes are unknown.

Sunshine percentages are very high, over 80 per cent of the possible being the rule in southern Arizona. Wholly cloudy days are rare. The intense insolation of clear, hot, summer weather is a serious factor in connection with more sensitive crop plants, and shading devices often are employed to advantage.

CROPS.

The northeastern and more elevated part of Arizona, with cold winters and a moderately warm growing season of six to seven months, produces such crops as are grown in the Mississippi Valley in the latitude of the Ohio River. Apples, peaches, pears, cherries, grapes, and other deciduous fruits and berries are very successful with, and sometimes without, irrigation, but the winters are too cold for the subtropical evergreens, such as oranges, olives, eucalyptus trees, and palms. A satisfactory variety of forage and grain crops does well on the plateau. Alfalfa yields two or three cuttings and additional pasturage. Corn, oats, barley, wheat, and rye produce heavily under irrigation, and by dry-farming methods, with proper selection of varieties, are thought to be capable of remunerative returns in favorable localities with rainfall only. Vegetables of various kinds are grown in season in profusion, according to elevation, soil, and moisture available. Flagstaff, with an elevation of

[1] Arizona Sta. Bul. 41, p. 11; Bul. 48, p. 355. [2] Arizona Sta. Bul. 20, pp. 36 and 37.

...uits, vegetables, and forages grown in southern Arizona—Continued.

Months in which they mature.	Fruits.	Vegetables.	Grains and forages.
July	Apples, pears, grapes, figs, peaches.	Sugar beets, cucumbers	Alfalfa, cowpeas.
August	Grapes, figs, pears, almonds, peaches.	Chillies, eggplant, beans	Alfalfa, Egyptian corn, sorghum, cowpeas.
September	Dates, melons, pears, grapes, pomegranates, peaches.	Chillies, eggplant, potatoes, beans.	Alfalfa, Egyptian corn, cowpeas, sorghum.
October	Dates, quinces, grapes, pears, apples.	Cucumbers, squashes, string beans.	Alfalfa, sorghum, millet, Indian corn, cowpeas.
November	Dates, olives, grapes, oranges, pears, strawberries.	Celery, lettuce, beans, squashes, potatoes.	Indian corn, sorghum, alfalfa.
December	Dates, olives, oranges, pears.	Celery, radishes, beets, lettuce.	Alfalfa pasture.

Under irrigation the yields of the crops best adapted to the region are high, especially where the soil has been improved by alfalfa and by beneficial river sediments. Some verified records made under fair conditions, collected from time to time in various localities, are as follows:

Yields per acre of various crops in southern Arizona.

Crops.	Yield.	Crops.	Yield.
Alfalfa hay, 4 to 8 cuttings.	6 to 12 tons.	Cabbage	14,000 pounds.
Alfalfa, seed crop, 1 cutting.	65 to 650 pounds.	Onions	5,000 to 20,000 pounds.
Barley	1,800 to 2,500 pounds.	Tomatoes	10,000 to 27,000 pounds.
Wheat	1,500 to 2,400 pounds.	Cantaloups	100 to 345 standard crates.
Barley hay	4 tons.	Strawberries	3,500 to 14,000 ¾-lb. boxes.
Wheat hay	3¼ tons.	Egyptian cotton lint	400 to 1,000 pounds.
Sugar beets	9 to 19 tons.	Corn	2,000 to 2,800 pounds.
Potatoes	3,000 to 15,000 pounds.	Seedless raisins	6,000 to 8,000 pounds.
Watermelons	13 tons.	Oranges (young trees).	½ to 5 boxes per tree.
		Dates	50 to 250 pounds per tree.

Steer feeding, dairying, poultry keeping, horse and mule breeding, apiculture, and sheep raising are the final and usually the most profitable development of forage production, and the greater part of the forage output of the Territory finds a market in the form of animal products.

MARKETS AND FARM INCOME.

CULTIVATED CROPS.

A large trade in valley products is maintained with the several thriving mining towns of Arizona, which consume large quantities of baled hay, grains, fruits, dairy products, and vegetables. Southern California cities take fat cattle, early fruits, and vegetables. Much finished live stock reaches Kansas City, and more distant eastern markets receive oranges, cantaloups, honey, and other agricultural commodities from Arizona through farmers' shipping associations.

The income per acre to the farmer varies greatly with ... character of his operations. Small, intensively cultivated areas not infrequently yield values from $100 to $300 gross per acre annually, while forages and animals may easily return $50 gross per acre annually. Agricultural statistics for 1910[1] indicate that from 183,000 acres of corn, wheat, oats, barley, and hay a total valuation of $5,302,000 was obtained, or an average of $28.97 per crop per acre. This does not include the value of alfalfa seed and pasture produced to an additional value of fully $500,000. When allowance is made for the fact that corn in large part follows barley and wheat on the same ground, the actual productiveness in grains and forages of Arizona lands was more than $30 per irrigated acre. Intensive cultures, including fruits, melons, vegetables, and sugar beets, from an estimated 11,000 acres produced about $2,000,000 worth of products, or about $200 per acre. The total of 194,000 irrigated acres estimated therefore produced values approximating $7,802,000, an average of about $40 per acre. This estimate places Arizona among the first of the Commonwealths of the Union in values per acre produced, a fact due not only to excellent crops, but to the high prices paid in the home markets of the Territory.

LIVE STOCK.

The number, value, and income-producing power of live stock in Arizona on January 1, 1910, were approximately as follows:

Kinds, number, value, and income from live stock in Arizona, January 1, 1910.

Kinds.	Number.[1]	Value.[2]	Income (gross sales during 1909).[2]	
			Amount.	From—
Horses and mules	121,000	$7,778,000	$185,670	Sales.
Milch cows	25,000	1,075,000	1,000,000	Dairy products at $40.
Other cattle	626,000	12,082,000	5,659,261	Beef and veal.
Sheep	1,020,000	3,774,000	4,260,000	Wool and mutton.
Hogs	22,000	209,000	500,000	Pork.
Total	1,814,000	24,918,000	11,604,931	

[1] U. S. Dept. Agr., Crop Reporter, Feb. 7, 1910.
[2] Estimates based on reports of Live Stock Sanitary Commission and current valuations by stockmen.

Besides these there were 5,000 ostriches valued at $1,000,000 and producing $125,000 worth of feathers annually. The number of goats, poultry, and stands of bees or the value of their products is not known.

While the live-stock industry as a whole is but partly supported by irrigation, the irrigated valleys may be considered an essential factor, especially in dairying and the finishing of cattle and sheep for market.

[1] U. S. Dept. Agr., Crop Reporter, Dec. 22, 1910.

FOREST PRODUCTS.

The forests of Arizona should also be included in a broad sense as agricultural resource, timber being a product of the soil. The pi forests of northern Arizona constitute a timber resource of gre value, as yet little encroached upon. Large mills at Williams a Flagstaff have been in operation for nearly 30 years and small mi are scattered at accessible locations elsewhere in the Territor These mills own considerable forest land which they are now clearin One of the largest sawmill operators in the Territory states that t annual cut of lumber in northern Arizona is approximately 50,000,0 feet, with a market value of $750,000. The major portion of t forests, however, is included within National Forests. Timber available within these reserves under Forest Service restriction which prevent destructive lumbering.

The stand of merchantable timber thus available for cuttin in Arizona, according to available (October, 1909) Forest Servic estimates, is as follows: Saw timber, 6,263,800 M feet; cordwoo 14,142,604 cords. Figuring conservatively upon an approximat annual increase of 1 per cent for saw timber and 1⅓ per cent for cord wood, the annual growth for Arizona would be—saw timber, 62,63 M feet, worth, at $3.25 per M, $203,573, and 188,520 cords of cord wood, worth, at 67 cents a cord, $126,308, making a total output o $329,881.

The National Forest income realized from timber and grazing fee in 1910 was $204,917.52, one-fourth, or $51,229.38, of which wa turned over to the Territory for use by the various counties withi which the forests lie, and used by them for the benefit of their road and public schools. In addition to native forests the planting o introduced trees, especially Eucalyptus, offers considerable oppor tunities in agricultural forestry.

LANDS.

CLASSIFICATION FOR ADMINISTRATION.

Including a limited and variable water surface of approximately 116 square miles, the area of Arizona is about 72,931,840 acres. (Pl. I.) Administratively this area is divided into military reserves, Indian reserves, National monuments and forests, public lands, including those under Reclamation Service restrictions, and lands in private ownership, including railroad grants and private land grants dating from Mexican occupation. The areas of these different classes of lands are approximately as follows:

Lands in Arizona.

Class.	Area.	Authority.	Date of information.
	Acres.		
Military reserves	97,932	United States Department of War	Aug. 17, 1908.
Indian reserves	15,055,600	Scaled from General Land Office map.	Do.
National Forests exclusive of alienated lands.[1]	14,083,928	Forest Service Circular 167 and correspondence.	Dec. 13, 1909.
National monuments outside of National Forests and Indian reserves.	61,726	Report of Secretary of Interior	1909.
Total reserves	29,299,186		
Railroad land grants	2,141,435	Proceedings Territorial board of equalization.	Aug., 1909.
Spanish grants and transferred railroad lands.	547,282	....do	Do.
Small agricultural holdings	939,142	....do	Do.
Patented mining claims	90,000	Estimated from Proceedings territorial board of equalization.	1908–9.
Town lots	8,000	....do	1908–9.
Railroad rights of way	34,000	....do	1908–9.
Total in private ownership exclusive of unpatented mining claims	3,759,859		
Unappropriated and unreserved public lands, by difference—including a portion of the lands under United States Reclamation Service restrictions.	39,273,755		

[1] The total area of National Forests has been reduced from 15,258,861 to 14,811,145 acres. Figures as to the areas of alienated lands included are not available at this date.

This statement does not include approximately 4,130,100 acres of public lands partly within National Forests and Indian reserves subject to United States Reclamation Service restrictions. Of this area 1,818,300 acres, withdrawn under the first form, can not be entered upon, while the remaining 2,311,800 acres, withdrawn under the second form, may be homesteaded, subject to subsequent decision as to the size of farm unit allowed. University and school lands are not considered separately.

Under the "dry farming" or "enlarged homestead" act, 26,657,280 acres of the unappropriated and unreserved public lands (fig. 3) also have been designated in Arizona as available in 320-acre holdings (November 1, 1910). It is evident, from the above table and statements, that the land situation in Arizona is very complex, and the following brief suggestions are therefore offered as to the acquisition by settlers of lands within the Territory.

METHODS OF ACQUIRING LAND.

UNRESERVED PUBLIC LANDS.

Without going exhaustively into details, the unreserved and unappropriated public lands available under the various provisions of the land laws may be obtained in the following forms:

(1) The homestead of 160 acres, requiring for final proof either five years' residence or 14 months' residence with commutation at $1.25 to $2.50 per acre.

(2) The homestead of 320 acres, for nonirrigable lands which lack sufficient rainfall to produce crops without the system of cultivation commonly known as "dry farming." Proof without commutation privileges is made as in ordinary homestead entry, and one-fourth of the entry must be cultivated continuously, beginning with the third year.

(3) The desert land entry of 320 acres costing 25 cents an acre on entry and $1 an acre annually expended in improvements as evidence of good faith until reclaimed, with $1 per acre in cash to the Government on final proof.

(4) Government land scrip entries, costing from a few dollars to as much as $50 an acre. Scrip sometimes is difficult to obtain.

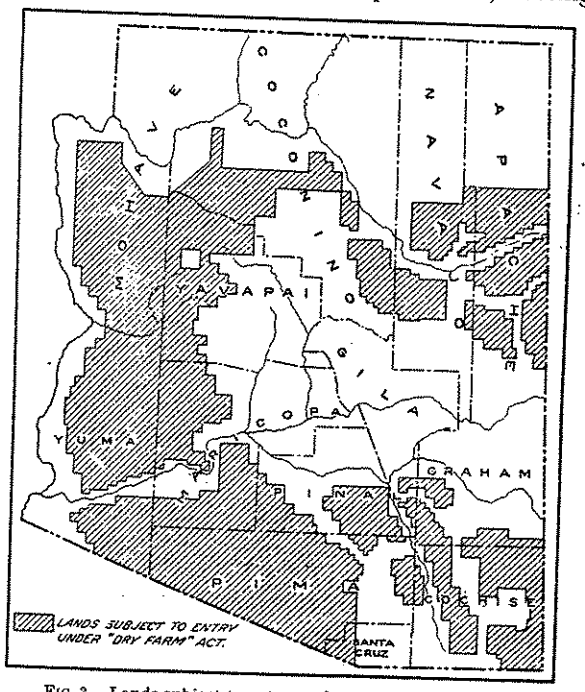


FIG. 3.—Lands subject to entry under the "dry-farm" act.

(5) School lands, which thus far have been leased of the Territory, subject to appraisement in value and purchase when Arizona becomes a State.

(6) For special purposes, as reservoir sites for impounding water, canals, railroad rights of way, etc., public lands may be appropriated so long as they are used in good faith for the purpose for which they were appropriated.

(7) As mining claims, mill sites, etc., in accordance with the mineral laws.

RESERVED PUBLIC LANDS AND RAILROAD LANDS.

Military and Indian reserves, national monuments, and United States Reclamation Service reserves of the first form are inaccessible to settlers; but in some cases are likely at a future time to be thrown open wholly or in part to entry. Certain of these reserves are of value to irrigation interests as watershed protectors. The Fort Apache and White Mountain reserves, for instance, covering approximately 5,500 square miles, lie in the watershed of the Salt and Gila

Rivers, and conserve and equalize the flow of those important streams. Similarly, the immense but less forested Navajo Indian Reservation may protect a fraction of the Colorado watershed to some extent.

More extensive and important in its relation to irrigation interests is the great system of National Forests, formerly known as forest reserves, which, beginning with the Prescott Reserve in 1899, has grown to a total area of about 15,000,000 acres, comprising all the forest lands in the Territory otherwise unadministered. The National Forests are available for timber, for grazing, for mining, for building and town sites, and for agriculture, under provisions securing the nondestructive use of forest values. Wherever agricultural lands are included within a National Forest they may be listed and entered upon by settlers on practically the same terms as ordinary homestead lands.

The map of Arizona (Pl. II) shows the several Indian reservations, National monuments, etc., as given on the General Land Office map of 1909. The map has been revised so as to show the forest reserves as they existed December 31, 1910.

Considerable areas, mostly along the Colorado River, have been temporarily withdrawn from homestead entry pending investigations as to whether these areas can be ultimately irrigated or utilized in constructing irrigation works. These withdrawals are often only for short periods, and it is not possible to show them on the map with any degree of accuracy.

United States Reclamation Service reserves of the second form may be homesteaded under the United States Reclamation Service regulations, the land laws having been modified so that farm units of 10 to 160 acres, according to the value and productiveness of the land, may be fixed upon as the limit of the entry by the Secretary of the Interior. Commutation privileges do not apply to such entries.

Railroad land grants, more particularly those belonging to the Santa Fe system, are subject to purchase at prices ranging easily from $10 to $200 an acre for unimproved agricultural land favorably situated with reference to irrigating water.

AGRICULTURAL CLASSIFICATION OF LANDS.

According to the general methods by which they may be utilized, the lands of the Territory may be classed as irrigable, dry-farming, grazing, forest, and waste lands. There are considerable tracts of the latter under present conditions.

Except along the Colorado River, lands valuable because of their connection with an actual or possible irrigating or stock water supply have for the most part long since passed into private hands. This area is represented by the 939,142 acres shown in the table, page 23, and lies almost entirely along valley bottoms adjacent to stream

co[illegible]s. The extensive and fertile Colorado Valley is as yet li[illegible]
se[illegible] except under the United States Reclamation Service proj[illegible]
near Yuma. This is partly because of the reserved areas situated[illegible]
this river, but chiefly because of the great annual summer flood [illegible]
the unmanageable character of the stream. When finally reclaim[illegible]
by the great engineering projects now under construction or conte[illegible]
plation, the Colorado Valley probably will be one of the most p[illegible]
ductive agricultural regions within the national boundaries.

Dry farming—that is, farming on rainfall with special attention[illegible]
the conservation of soil moisture—is apparently feasible in consid[illegible]
able but undetermined areas in the eastern and northern parts of [illegible]
Territory. In the lower southwestern valleys, excepting during ye[illegible]
of unusually abundant or timely rainfall, ordinary dry-farmi[illegible]
methods must at least be supplemented by irrigation, and by a care[illegible]
choice of drought-resistant crop plants and trees especially suited[illegible]
more severe conditions.

The grazing industries, both cattle and sheep, are at present acco[illegible]
modated in National Forests, upon Indian reserves, and upon una[illegible]
propriated and unreserved Government lands—the so-called op[illegible]
range. Within the National Forests and the Indian reserves t[illegible]
number of cattle and sheep is under Government regulation, t[illegible]
object being to prevent overstocking and consequent deterioratio[illegible]
The open range, however, is thus far without supervision, and [illegible]
virtue of the inapplicability of the homestead laws to range countr[illegible]
without ownership also. Lack of ownership and of proper regulati[illegible]
has led to overstocking the ranges during favorable seasons [illegible]
when prices did not encourage shipment, and when dry years ens[illegible]
from time to time there are enormous losses, especially of catt[illegible]
which are most sensitive to a shortage of feed and water. [illegible]
these times not only animals suffer, but the ranges themselves som[illegible]
times are bared of vegetation and depleted beyond the possibility [illegible]
complete recovery. Stock raising has been a precarious busine[illegible]
because of these conditions. Fortunes have been made during su[illegible]
cessions of rainy years and lost during the seasons of drought th[illegible]
followed. Under the present lack of administrative control of th[illegible]
open range there is little or no opportunity for further expansion [illegible]
the grazing industries. Properly controlled, however, with referenc[illegible]
to the exigencies of nature and the necessities of individual stockme[illegible]
the open range is undoubtedly capable of industrial restoratio[illegible]
The National Forests, including about 14,811,145 acres on Decembe[illegible]
31, 1910, are probably not more than 50 per cent continuously fo[illegible]
ested, the remaining area being but sparsely covered with trees, an[illegible]
even the continuous forests often being interspersed with open park[illegible]
and glades. These unforested portions of the reserves are of interes[illegible]

to settlers, inasmuch as they may be homesteaded for agri[illegible]ral purposes. Adjacent to purchasable timber and grazing privileges, and oftentimes with small but protected water supply, these forest-reserve locations are usually very desirable. In the northeastern plateau country, also, there are considerable areas of dry-farming lands available for homestead entry within the National Forests.

The waste lands of Arizona are for the most part situated in the western third of the Territory, excluding the Colorado and tributary ri[illegible]er bottoms. This vast desert expanse of over 30,000 square miles must always remain waste country, except for doubtful artesian possibilities. There is almost no running water in this region, springs and tinajas are few, and the ground water usually is far below the surface. On rare occasions brief violent storms give rise to short-lived torrents, and are followed by a transient flush of desert annuals, but this can not be utilized by stockmen, because of its distance from dependable forage supply and from water. These desert plains and hostile mountains, peopled with curious and exaggerated forms of drought-resistant vegetation, offer no inducements to the agricultural settler, being a temptation only to the prospector, the naturalist, and the adventurer.

Summarizing briefly, the more apparent opportunities for immigrant farmers in Arizona are: (1) By purchase in irrigated valleys, mainly those of the Salt, Gila, and Colorado Rivers; (2) by homesteading Government lands under Reclamation Service projects and in National Forests; and (3) by homesteading unappropriated and unreserved public lands in localities apparently favorable to dry farming and to development by pumping.

SOILS.

The character of the irrigable valley soils is very variable, both in physical and chemical particulars. Physically, they vary chiefly through the agency of the waters by which they were transported from distant points and through the influence of near-by mountain masses. Coarser soils usually are found nearest the slopes contributing to their formation, where they were deposited from flood waters of higher velocities. Heavy adobe soils, formed of the finest materials, are deposited chiefly through the action of comparatively quiet waters, and at points distant from the place of their origin. In some localities a caliche or calcareous hardpan, formed slowly through the agency of scant rainfall and evaporation, underlies the surface of soils which have remained long in place. The deficiency in humus usual in desert soils is an unfavorable character, in so far as it decreases the water-holding power, injures the tilth, augments losses by erosion, and increases extremes of soil temperature.

Chemically, the arid soils of the Southwest are rich ... me... potash, but deficient in organic matter and nitrogen. These ... ciencies may be remedied very cheaply in Arizona by mean... leguminous plants, including peas, lupines, sour clover, bur clo... and, chief of all, alfalfa. The latter crop yields remunerative ret... and at the same time improves the soil for grain, garden vegeta... or fruit trees through the addition of atmospheric nitrogen ... organic matter resulting from the decay and incorporation of its r... and leaves.

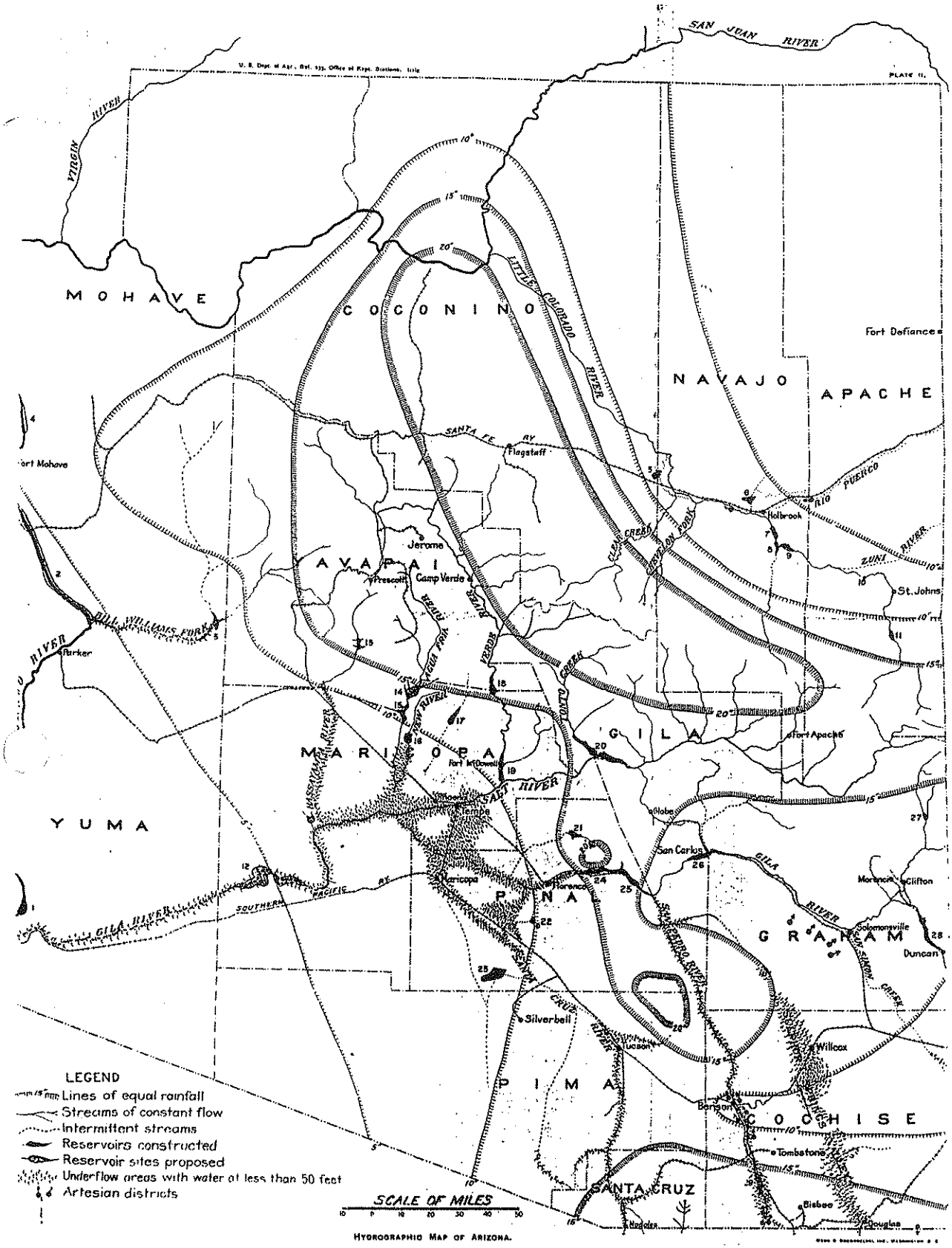
The fertility of irrigated soils in most localities is maintained ... by the sediments contributed by the river waters. These sedim... often contain large amounts of partially decomposed animal ... vegetable matter swept by storms into the irrigating streams f... the surface of the range country. When incorporated with the ... by suitable methods of culture, they contribute materially to c... production. In this way the southwestern farmer's fertilizer ta... paid in large part, quietly and without extra expense, by his wa... supply.

Consequent upon arid conditions, the soils of the Southwest c... tain notable quantities of soluble or alkaline salts varying loc... in amount and kind. The irrigated districts in Arizona being co... paratively well drained, injurious percentages of alkali salts are ... common. These salts have accumulated, however, in certain loc... ties where irrigation has been excessive and drainage neglected, t... degree that depreciates seriously the productiveness of the la... Intelligent methods of culture and the choice of alkali-resistant c... plants will, to some extent, overcome or utilize alkaline accumu... tions; but good drainage, which should be secured under any w... planned irrigating system, is the most satisfactory expedient for ... purpose.

It may be stated briefly, therefore, that the soils of this region ... rich in certain elements of fertility; that their deficiencies in nitrog... and organic matter are remediable; and that the management ... harmful accumulations of alkaline salts is facilitated by genera... favorable drainage conditions.

WATER RESOURCES.

The critical factor in Arizona agriculture is not land but the wa... supply. Excellent lands are nearly everywhere in excess of ... water available for their irrigation, and under present conditions ... minimum flows of the interior streams are consumed comparative... near their sources while the lower courses are left dry except in tim... of flood. The Colorado River, accumulating its flow from an immen... watershed outside of the Territory, carries an amount of wa...



HYDROGRAPHIC MAP OF ARIZONA.

greatly in excess of the requirements of alluvial bottoms and irrigable bench lands lying along its lower courses in Arizona. This excess, however, will be greatly diminished when the possible demands of upstream districts and of the delta in Mexico and the Californias are satisfied. Considering the whole Territory, even after storage has been provided sufficient to retain the floods which now escape from the region so much in need of them, only a comparatively small acreage can be irrigated. (Pl. II.)

This deficiency in run-off, due primarily to scant rainfall, is compounded by thirsty soils, excessive evaporation from land and water surfaces, and the pervious formations common in the débris-filled valleys which often entirely absorb small streams. The following table affords an interesting comparison between the elements of gain and of loss in two streams of the humid region and an arid-region river:

Comparison of rainfall, evaporation, and run-off in humid and arid regions.

Stream.	Date.	Watershed.	Rainfall.	Evaporation.	Run-off.
		Sq. miles	*Inches.*	*Inches.*	*Inches.*
Hudson River, New York [1]	1888–1901	4,500	44.2	20.9	23.3
Muskingum River, Ohio [1]	1888–1895	5,828	39.7	26.6	13.1
Salt River, Arizona	1889–1901	12,260	[2] 16.8	[3] 76.1	2.26

[1] U. S. Geol. Survey Water-Supply and Irrig. Paper No. 80, p. 99.
[2] Average of U. S. Weather Bureau rainfall records, including 1908, for stations at Fort Apache, Arizona Canal Dam, Tonto, Prescott, Jerome, and Natural Bridge.
[3] Average of observations at the station farm, Phoenix, and the University at Tucson.

The precipitation on the Salt River watershed not only is less, but the evaporation—possible, not actual—is vastly greater than on the eastern watersheds. The loss by seepage in the stream bed is probably greater also. It is not surprising, therefore, that under these conditions the proportion of run-off to rainfall is less than from humid-region watersheds. Arid conditions apparently return upon themselves, involving nature in a circle of moisture losses that requires the best skill of the engineer and the irrigator to break.

Irrigating waters, as known and utilized in Arizona, may be classed as surface streams, ground waters, and artesian wells.

SURFACE STREAMS.

COLORADO RIVER.

Nature of watershed.—The lower Colorado River is the largest apparent water supply available for irrigation in Arizona, but it is also the least utilized in proportion to its value. The area of its watershed, including the delta region below Yuma, is about 300,000 square miles, lying approximately between latitudes 31° and 43½° N., within the boundaries of Wyoming, Utah, Colorado, New Mexico, Nevada, Arizona, California, and Old Mexico. The axis of the area

early north and south and its drainage passes off from the so
west corner into the Gulf of California. It rises to an elevatio
over 14,000 feet in Colorado.

The upper two-thirds of the watershed consists largely of plat
4,000 to 8,000 feet above sea level, bounded by the high mount
in which rise the headwaters of tributary streams. The rain
snowfall in this higher portion of the drainage is equivalent to 8 t
inches of water. The climate is temperate in character because o
altitude and latitude, and in the higher mountains there are reg
of perpetual snow. The higher plateaus and the mountain range
the Colorado watershed are considerably forested, although in s
sections serious inroads have been made upon the forest cover.
regions of middle elevation are comparatively bare and are rem
able for the great systems of deep canyons resulting from the
elevation of the Rocky Mountain masses, the restricted local ero
due to scant rainfall, and the constant attrition along drainage l
of never-failing streams from the higher mountains.

The lower third of the Colorado Valley, for the most part in Ari
and California, is below an altitude of about 4,000 feet. This re
is arid or semiarid in character, the average annual rainfall ran
from 13 to 20 inches. By reason both of its low elevation and
southerly latitude its temperatures are semitropical.

The characteristic flow of the lower river is due to the peculiar
of the watershed briefly described above. The winter season fo
upper Colorado is a time of water storage due to the accumulatio
heavy snowfall in the mountains of Wyoming, Utah, and Colo
At this time the river sinks to its minimum flow, though occasio
augmented from the Gila at Yuma by the irregular run-off du
somewhat eccentric winter rains in Arizona. With the openi
spring the melting of the winter's store of snow begins in the sou
latitudes and at lower altitudes, increasing and extending until du
May and June thousands of little streams and rivulets are conve
from many mountain sides into the main watercourses. The G
River is formed in this manner from the mountain slopes of s
western Wyoming, northwestern Colorado, and the eastern ha
Utah, while the Grand is derived from the even steeper watersh
western Colorado. These two rivers unite in southeastern Ut
form the Colorado proper, into which flows successively the San
the Little Colorado, and lesser tributaries, which complete the
age from the more elevated part of the watershed.

The run-off of this region is comparatively uniform in tim
quantity, giving rise to the annual summer flood which begins
April 15 and continues until approximately July 15. Irregul
occur, due to deficient snowfall some years, to the chinooks or

winds which at times cause rapid melting, and to other climatic influences. In recent years also deforestation of certain areas has left snow surfaces more exposed. This has resulted in earlier and quicker melting and tended toward briefer and higher floods.[1] With the dwindling of the snows the upper river falls gradually to a low stage in September, at which it usually remains with minor fluctuations until the next spring.

The upper Colorado River, with its steep gradients averaging 5.7 feet to the mile, from the source of the Green to Grand Wash at the Nevada line, is an eroding stream which carries a heavy load of sediment. For the last 600 miles of its course, however, from the mouth of the Grand Canyon to the sea, the gradients are gentle, averaging but 1.7 feet to the mile, and as the current slackens the river drops its sediment and changes from a land destroyer to a land builder. By this means the alluvial ground bordering the lower courses of the river has been formed, and the delta extending on the west into the depressions of Salton and Pattie Basins is still being pushed southward into the Gulf of California.

The immense quantities of silt carried in the course of a year are shown in the following statement of results obtained by multiplying the percentage of silt found in daily samples of water by the total flow of the river:

Silt carried by the Colorado River annually.[1]

Year.	Amount of silt.	Equivalent area of submerged mud 1 foot deep.	Equivalent area of dry soil 1 foot deep.
	Tons.	*Acres.*	*Acres.*
1900.....	61,000,000	104,960	33,920
1904.....	120,961,000	181,900	58,681

[1] Arizona Sta. Buls. 44, p. 200; 53, p. 60.

These figures explain the rapidity with which changes in land surface and in sea room are occurring near the mouth of the Colorado. The building up of the margins of the lower river by deposited sediment also so elevates the stream above the adjacent country that sudden and sometimes disastrous changes result from the breaking of these high banks. Salton Sea was formed by such a break in 1905–6, and other changes of direction in the delta have occurred since that time.

Under primitive conditions agricultural operations are governed by the annual flood which overflows the alluvial margins and delta of the river, and the growth of winter crops ordinarily harvested from April to July is prohibited. The Indians of the Colorado Valley, like the people of ancient Egypt, grow only such crops as can be planted in the

[1] Colorado Sta. Bul. 55; U. S. Geol. Survey Water-Supply and Irrig. Paper No. 234, pp. 10–24; also oppo- view in Am. Soc. Civil Engineers, Proc. Sept. 1908, pp. 924–997.

wet soil left by the receding waters. Quick-growing varieties of co beans, melons, squashes, and sorghum are among the principal cr thus grown.

Discharge.—In the southern lower watershed the Gila River c lects the drainage from lesser altitudes and, flowing west across sou ern Arizona, delivers its waters to the Colorado River at Yuma, abo 90 miles by channel above its mouth. The Gila is a comparative small and irregular stream, due to its arid watershed and uncerta rainfall, although occasionally it carries enormous floods. Since t appropriation of its upstream waters for irrigation its lower cours are often dry for months in succession.

The following table, compiled from reports of the United Stat Geological Survey and the United States Reclamation Service, giv the mean monthly flow and the total annual discharge of the Colorad and Gila Rivers at Yuma and other points for the years 1902–1909:

Flows in thousands of acre-feet of the Colorado River at Hardyville and Yuma, and the Gila River near Yuma, 1902–1909.[1]

Year and place of measurement.	Jan.	Feb.	Mar.	Apr.	May.	Jun
1902.						
Colorado at Yuma	229.2	219.7	301.5	367.7	2,211.2	2,53
Gila at Yuma						
Colorado, net, at Yuma	229.2	219.7	301.5	367.7	2,211.2	2,53
1903.						
Colorado at Yuma	189.9	187.3	376.1	852.4	2,074.3	3,16
Gila at Yuma	0	0	0	30.2	.8	
Colorado, net, at Yuma	189.9	187.3	376.1	822.2	2,07[illegible]5	3,16
1904.						
Colorado at Yuma	223.5	218.4	367.6	479.5	1,703.0	2,60
Gila at Dome	0	0	0	0	0	
Colorado, net, at Yuma	223.5	218.4	367.6	479.5	1,703.0	2,60
1905.						
Colorado at Yuma	499.9	1,561.0	3,108.0	2,251.0	2,[illegible]03.0	4,55
Gila at Dome	189.2	680.3	1,020.0	768.2	299.7	4
Colorado, net, at Yuma	310.7	880.7	2,088.0	1,482.8	2,233.3	4,50
Colorado at Hardyville					1,973.0	4,50
1906.						
Colorado at Yuma	422.0	531.0	1,560.0	1,930.0	3,330.0	5,01
Gila at Dome	136.0	168.0	576.0	422.0	122.0	
Colorado, net, at Yuma	286.0	363.0	984.0	1,508.0	3,208.0	5,00
Colorado at Hardyville	297.0	327.0	756.0	1,880.0	3,970.0	5,67
1907.						
Colorado at Yuma	1,320.0	1,040.0	1,480.0	2,100.0	2,330.0	5,64
Colorado at Hardyville	502.0	600.0	1,030.0	1,890.0	2,760.0	5,11
1908.						
Colorado at Yuma	389.0	817.0	999.0	1,060.0	1,670.0	2,35
1909.						
Colorado at Yuma [2]	615.7	772.8	975.1	1,805.0	3,324.7	6,24

[1] U. S. Geol. Survey, Water Supply and Irrigation Papers Nos. 85, p. 20; 100, pp. 25, 27; 133 pp. 32 20 134, p. 25; 175, p. 130; 172, p. 16; 211, pp. 99, 125; 213, p. 29; 249, p. 46.
[2] United States Reclamation Service measurements.

Flows in thousands of acre-feet of the Colorado River at Hardyville and Yuma, and of the Gila River near Yuma, 1902–1909.

Year and place of measurement.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Total.
1902.							
Colorado at Yuma	770.3	257.2	227.2	264.3	249.1	332.8	7,960.2
Gila at Yuma							(1)
Colorado, net, at Yuma	770.3	257.2	227.2	264.3	249.1	332.8	7,960.2
1903.							
Colorado at Yuma	2,304.5	668.3	403.8	521.5	321.3	267.0	11,329.0
Gila at Yuma	0	9.2	7.3	13.6	0	0	61.2
Colorado, net, at Yuma	2,304.5	659.1	396.5	507.9	321.3	267.0	11,267.8
1904.							
Colorado at Yuma	1,417.1	1,054.1	691.5	715.8	366.0	275.3	10,119.0
Gila at Dome	5.8	139.6	41.7	32.8	6.5	0	226.4
Colorado, net, at Yuma	1,411.3	914.5	649.8	683.0	359.5	275.3	9,892.6
1905.							
Colorado at Yuma	1,864.0	744.0	386.5	494.2	714.0	946.9	19,712.5
Gila at Dome	4.3	0	3.0	11.0	271.2	375.1	3,665.1
Colorado, net, at Yuma	1,859.7	744.0	383.5	483.2	442.8	571.8	16,047.4
Colorado at Hardyville	1,556.0	726.2	414.9	527.0	452.6	559.4	(2)
1906.							
Colorado at Yuma	2,400.0	1,180.0	696.0	719.0	578.0	1,130.0	19,490.0
Gila at Dome	0	25.1	4.3	0	0	332.0	1,790.0
Colorado, net, at Yuma	2,400.0	1,154.9	691.7	719.0	578.0	798.0	17,700.0
Colorado at Hardyville	2,460.0	1,130.0	797.0	719.0	587.0	569.0	19,162.0
1907.							
Colorado at Yuma	5,930.0	2,310.0	1,380.0	836.0	643.0	458.0	25,500.0
Colorado at Hardyville	4,630.0	2,000.0	1,090.0				
1908.							
Colorado at Yuma	2,000.0	1,490.0	678.0	585.0	481.0	978.0	13,700.0
1909.							
Colorado at Yuma [3]	4,896.9	2,508.5	2,888.6	860.8	561.9	517.1	25,967.6

[1] Very small. [2] Incomplete. [3] United States Reclamation Service measurements.

The Colorado proper at Yuma, after deducting the Gila, is shown to deliver from about 8,000,000 to over 25,000,000 acre-feet of water annually; and the Gila from a few thousand to 3,665,000 acre-feet. The flow of the Colorado, excluding the Gila, for the years 1902 to 1909, inclusive, during which regular measurements have been taken at Yuma, has averaged about 16,000,000 acre-feet annually. Allowing for the years of exceptionally high water included above, it is estimated that the Colorado alone at Yuma carries a safe average of 12,000,000 acre-feet of water a year with an eccentric and very variable run-off from the Gila in addition. It is of interest to note that during 1906, 1,500,000 acre-feet less water was carried by the Colorado at Yuma than at Hardyville, 270 miles above. This loss, occurring mainly during the flood season, apparently is due to the

ab ion of overflow waters by the dried-out lowlands and evaporation, similar to that of the Nile below the Atbara, its important tributary.[1] What portion of the total flow of the Colora River, as measured at Yuma, will be available for irrigation in A zona, is a matter which can only be approximated at this time.

Storage possibilities.—The Gila floods will be stored in large p in the reservoirs projected on the Salt, Verde, and Gila Rive Surveys for reservoirs having an aggregate capacity of abo 3,000,000 acre-feet, including the Roosevelt Reservoir of 1,284,0 acre-feet, have been made on the principal sites. The greater p of the run-off of the Little Colorado River and its tributaries northern Arizona likewise can be utilized and stored.

After deducting these tributaries, the main dependable supply irrigation in western Arizona, southern California, and the Mexic delta must come from the upper branches of the Colorado in Wy ming, Colorado, and Utah, and the disposition of these upper strea is consequently of vital interest to prospective downstream irrigato Probable developments can be surmised only in a very general w at this time. According to the best information available, there a now approximately 420,000 acres irrigated above the Grand Cany of northern Arizona, with additional areas to the extent of a po sible 750,000 acres, to which water may be applied ultimately. rough outline of the probable effect of these extended operatio upon the Colorado is supplied by the following table, which is offer as an approximation based upon estimates of agricultural are derived from irrigation engineers resident in Wyoming, Utah, a Colorado, and of run-off and duty of water from United Stat Reclamation Service records:

Estimates of upstream water surplus of Colorado River.

Supply streams and places of measurement.	Area irrigated in watershed in 1908.	Estimated additional irrigable area.	Duty of water.	Water required to irrigate additional area.	Average run-off available.	Surplu
	Acres.	*Acres.*	*Acre-feet per acre.*	*Acre-feet.*	*Acre-feet.*	*Acre-f*
Wyoming:						
Green River at Browns Park, Colo	100,000	600,000	2	1,200,000	2,500,000	1,300
Colorado:						
Yampa River at Maybell, Colo	42,680	95,000	2.5	237,500	1,000,000	762
White River at Rangely, Colo	3,853	50,000	2.5	125,000	400,000	275
Grand River at Palisades, Colo	84,900	232,000	2.5	580,000	3,000,000	2,420
Gunnison River at Whitewater, Colo	131,800	190,000	2.5	475,000	2,000,000	1,525
Dolores River at Dolores, Colo	9,445	60,000	2.5	150,000	300,000	150
San Juan River at Farmington, N. Mex	48,918	123,000	3	369,000	800,000	431

[1] Ann. Rpt. Smithsonian Inst., 1908, p. 485, Some Geographical Aspects of the Nile.

Estimates of upstream water surplus of Colorado River—Continued.

Supply streams and places of measurement.	Area irrigated in watershed in 1908.	Estimated additional irrigable area.	Duty of water.	Water required to irrigate additional area.	Average run-off available.	Surplus.
Utah:						
Duchesne and Uinta Rivers at Myton and Fort Duchesne, Utah	*Acres.*	*Acres.* [1] 180,000	*Acre-feet per acre.* 2	*Acre-feet.* 360,000	*Acre-feet.* 660,000	*Acre-feet.* 300,000
Additional run-off below gaging stations, estimated						1,500,000
Total	321,596	1,530,000		3,496,500	10,660,000	8,663,500

[1] Indian reserve.

It is believed that in this table the estimates of additional areas to be irrigated and the allowance of water therefor are liberal, and those of run-off reasonably accurate. It appears, therefore, from these figures that after allowing for prospective upstream developments there remains a vast excess of water, especially in the rivers of western Colorado—an excess which may be stated in round numbers at 9,000,000 acre-feet. This supply, once delivered to the deep canyons which begin in eastern Utah, can not be drawn from again until it emerges upon the alluvial levels of the lower Colorado in western Arizona.

Most of the run-off, however, occurs in May and June; and its complete utilization by downstream districts will require storage to retain this flood and equalize the flow of the river throughout the downstream irrigating season. Fortunately there are many reservoir sites on the upper watershed of the Colorado, some of them very extensive. A few of the largest are named below, there being many smaller sites:

Proposed upstream reservoir sites on the Colorado River and tributaries.

Reservoir sites.	Height of dam required.	Storage capacity.	Authority.
	Feet.	*Acre-feet.*	
Flaming Gorge, on Green River in northeastern Utah.	100	350,000	United States Reclamation Service.
Browns Park, on Green River in northwestern Colorado.	200	2,520,000	Do.
Island Park, on Green River in northeastern Utah.	100	150,000	Do.
Mouth of Minnie Maud Creek, on Green River in eastern Utah.	120	1,200,000	Records of office of State engineer, Salt Lake City, Utah.
Green River, 27 miles north of Green River, Utah.	155	800,000	Do.
Kremmling, on Grand River in northern Colorado.	230	2,200,000	United States Reclamation Service.
Junction of Green and Grand Rivers in southeastern Utah.	160	2,500,000	Records of office of State engineer, Salt Lake City, Utah.
Total		9,720,000	

In general there appears to be abundant storage room for the surplus waters shown in the table on page 34, should the sites prove

feasible and the expense of construction be warranted by the a
cultural values in Arizona, California, and Mexico. The rocky
yons of the Colorado for the 700 miles between the mouth of Gr
River and the upper irrigable areas in Arizona should convey
equalized stream with minimum loss to those lower districts wh
unusual productiveness may at some future time warrant upstre
reservoirs.

As to the maximum probable areas and water requirement
the lower districts, allowing 5.5 acre-feet per acre, we have a
approximate knowledge, as shown in the following table, der
chiefly from United States Reclamation Service data:

Irrigable areas and water requirements in southern Arizona, California, and Mexic

District.	Irrigable areas.	Irriga requi men
Arizona:	*Acres.*	*Acre*
Mohave Valley	47,171	
Colorado Valley	133,536	
Yuma Valley	90,913	1,8
Mesa lands at Parker (by pumping—estimated)	40,000	
Yuma (irrigable by pumping)	40,000	
Total	351,620	
California:		
Mohave Valley	17,395	
Colorado Valley	80,588	
Yuma Valley	24,600	2,8
Imperial Valley	400,000	
Total	522,583	
Mexico:		
Colorado delta and Pattie basin lands	500,000	2,7
Grand total	1,374,203	7,3

It appears, therefore, estimating acreages liberally and assum
high water duties, that the equalized surplus of 9,000,000 acre-
roughly calculated to be available from the upper Colorado,
be adequate for the reclamation of all irrigable downstream a
The details of the estimates presented above may be consider
modified with increased knowledge of the vast region involved,
in a general way it may be stated with considerable confidence
the water supply of the Colorado, with storage, is sufficient for
whole of its dependent irrigable lands. This is a most fortu
fact in view of the interstate and international character of
stream, looking toward a harmonious and confident developme
all portions of the Colorado watershed, including those area
Arizona with which this publication is chiefly concerned, and
which an ultimate water requirement from the Colorado of appr
mately 2,000,000 acre-feet, annually, should be anticipated.

In addition to its agricultural value, the Colorado has imm
power possibilities, especially along the canyons of the upper

and its tributaries, with their steep gradients and numerous dam sites. By reason of gentler gradients, power development along the lower Colorado will be small in proportion to the size of the stream, but valuable by reason of the contiguous agricultural and industrial population which will occupy this region ultimately.

LITTLE COLORADO RIVER.

The watershed of the Little Colorado, situated almost entirely in northeastern Arizona, is a plateau region, lying for the most part between 5,000 and 7,000 feet altitude. This plateau is diversified with square-topped hills or buttes and intersected by watercourses which deepen into precipitous canyons as they approach the Colorado. The rainfall averages about 10 inches, this small precipitation being due to the loss of moisture from north-bound winds on the southern slopes of the Mogollon rim, which divides the plateau from the lower and warmer part of the Territory. The run-off is small, and, because of the porous character of stream beds, hard to estimate satisfactorily. Measurements at various points by the United States Reclamation Service are as follows:

Stream measurements on Little Colorado River.

Place of measurement.	1905	1906	1907	1908
	Acre-feet.	*Acre-feet.*	*Acre-feet.*	*Acre-feet.*
Little Colorado at St. Johns	.....	[1] 24,400	50,973	[2] 17,649
Little Colorado at Woodruff	[3] 114,400	85,200	72,543	.....
Little Colorado at Holbrook	[3] 213,700	117,000	[4] 78,498	.....
Silver Creek excess at Snowflake	.....	1,440	.....	.....
Chevelon Fork near Winslow	.....	80,300	176,179	1,047,555
Clear Creek near Winslow	.....	[5] 22,300	.....	282,336
Total	328,100	330,640	378,193	1,347,540

[1] April to December, inclusive.
[2] January to August, inclusive.
[3] March to December, inclusive.
[4] January to April, inclusive.
[5] June to December, inclusive.

Deducting flood waters at St. Johns and Woodruff, the measurement of which is repeated in large part at Holbrook, the net run-off thus far measured has been about 250,000 to 1,300,000 acre-feet from the watershed of approximately 15,000 square miles above Winslow. Storage is possible for this run-off as follows:

Storage possibilities on the Little Colorado River.

Place of storage.	Contour.	Capacity.
Little Colorado from Woodruff to St. Johns:	*Feet.*	*Acre-feet.*
Woodruff reservoir	100	108,000
Forks reservoir above Woodruff	85	148,000
Udall reservoir at Hunt	.....	13,000
Lyman reservoir above St. Johns	.....	20,000
On Silver Creek:		
Snowflake and Taylor reservoirs (large additional storage possible in this vicinity)	.....	3,900
Below Holbrook:		
Le Roux reservoir	35	54,000
Tucker Flat reservoir near Winslow	50	117,000
Total	.....	463,900

So far as these fragmentary data show, ample storage is possibl
the entire run-off of the Little Colorado above Woodruff and
portion of the flood waters of Chevelon and Clear Creeks.
storage, probably 300,000 acre-feet annually of the run-off of n
eastern Arizona can be utilized for irrigation, which, assuming a
of 3 acre-feet annually as necessary for a region of high elevation
relatively short growing season, should irrigate about 100,000 ac

SALT RIVER.

Nature of watershed.—The watershed of Salt River, including
of its nearly equally large tributary, the Verde River, has an are
12,240 square miles lying in central and east-central Arizona. Ne
the whole of this watershed is mountainous, ranging from an
tude of 1,310 feet at the Granite Reef diversion dam, 27 miles a
Phoenix, to upward of 10,000 feet in the White Mountains, near
New Mexico boundary. The main tributaries of upper Salt Riv
Bonita, White Mountain, Carrizo, Cibicu, Canyon, Cherry, and T
Creeks—all come from the north and drain the southern escarpm
of the northern plateau country. The Verde River, with its
system of tributaries, also flows from the north into the Salt R
at the head of Salt River Valley.

The region of highest rainfall in Arizona is due to the high s
slopes of the Salt and Verde River watersheds which precipitate
moisture of the winds from southerly directions. This rai
occurs in two not very sharply defined seasons, summer and wi
The summer rainfall, for the most part in July and August, is lar
torrential in character, resulting in sudden floods which are lar
lost downstream, and in intervening seasons of low flow. The
ter rains are usually gradual in character and generate a more
form stream flow. The winter precipitation on higher ranges
is largely in the form of snow, the melting of which in the sp
equalizes and prolongs the irrigating supply.

The watershed of the upper Salt River is largely forested. Fo
nately it is also occupied largely by the Fort Apache Indian Rese
tion. This has resulted in restricted use of the region for gra
purposes, and in the conservation of original conditions of ru
in this important district. The Verde River country, howe
which resembles that of the Salt, has remained unreserved
recently and has been overgrazed for many years. Floods here
sequently are more sudden and wasteful of water, the minimum
is less and more prolonged, and greater amounts of sediment are
ried by the aggregate run-off from comparatively bare land surfa
These two streams afford an excellent illustration of the ben
arising to irrigation interests from administrative control
watersheds.

Discharge and storage possibilities.—The flow of the Salt and Verde Rivers has been measured longest and most accurately of the irrigating streams of the Territory. The following table, constructed from data afforded by the Salt River Valley water companies, the water commissioner, the United States Reclamation Service, and the United States Geological Survey, affords an excellent idea of the united flow of the Salt and Verde Rivers just below their junction:

Monthly flow of Salt River below junction with Verde River, in thousands of acre-feet.[1]

Year.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	Total for year.	Monthly average.
1888..								21.5	20.8	20.3	50.1	411.9		
1889..	365.7	144.6	537.8	236.5	63.9	28.0	30.5	25.6	31.0	27.1	34.3	349.7	1,874.7	156.2
1890..	306.4	560.4	394.9	109.4	56.2	30.4	32.2	238.9	139.2	160.2	280.7	384.9	2,693.9	224.5
1891..	210.1	2,175.7	303.9	158.9	148.3	79.5	45.9	34.9	48.9	31.7	30.5	35.9	3,304.1	275.3
1892..	41.6	24.5	25.2	26.1	20.5	10.4	22.3	24.8	20.3	27.4	30.5	33.5	316.1	26.3
1893..	33.8	82.9	849.0	86.2	48.7	13.5	33.0	100.7	65.7	46.2	35.2	38.7	1,433.6	119.5
1894..	35.8	31.9	83.5	50.9	31.9	15.7	17.5	55.0	36.2	29.7	27.3	54.3	469.7	39.2
1895..	617.7	177.6	345.1	161.5	59.9	29.5	19.9	52.2	26.8	89.1	78.1	65.3	1,722.7	143.5
1896..	50.6	33.7	73.5	75.3	42.4	20.6	106.6	106.6	69.0	55.7	58.6	43.3	735.9	61.3
1897..	313.0	107.7	237.1	353.8	89.5	32.6	19.3	54.9	104.3	57.4	33.6	34.9	1,438.1	119.9
1898..	38.8	63.3	85.3	69.0	40.6	24.0	47.8	50.8	42.9	21.2	25.0	39.1	547.8	45.6
1899..	45.9	42.7	48.1	47.7	29.5	22.5	52.9	72.4	41.1	51.4	26.6	26.7	507.5	42.3
1900..	27.7	24.5	25.2	26.1	29.5	10.3	7.6	18.9	15.0	22.5	51.2	27.5	286.0	23.8
1901..	52.7	250.7	150.3	80.4	56.8	25.4	36.7	74.6	25.8	18.8	26.4	29.4	828.0	68.9
1902..	24.6	24.8	27.3	23.9	22.3	14.0	10.6	61.9	134.0	18.0	24.9	57.2	443.5	36.9
1903..	26.9	37.0	53.8	62.6	26.7	23.7	22.9	42.7	49.1	33.8	24.0	26.1	429.3	35.8
1904..	26.0	22.8	21.4	14.9	14.9	7.5	70.5	204.2	59.2	28.1	23.0	26.6	519.1	43.3
1905..	225.6	992.9	1,442.5	1,126.2	374.2	108.9	50.0	71.2	101.2	60.8	796.5	179.7	5,529.7	460.8
1906..	151.9	164.9	829.0	364.3	116.2	47.3	45.6	100.8	35.2	29.7	41.0	458.0	2,383.9	198.7
1907..	381.8	323.4	517.9	197.9	69.8	45.6	39.2	95.4	94.2	110.4	80.5	56.0	2,012.1	167.7
1908..	44.1	342.2	325.5	117.5	86.1	35.8	79.3	188.8	89.5	40.3	39.1	428.2	1,816.4	151.4
1909..	178.7	283.3	314.1	306.7	50.7	49.0								
Av.	152.4	281.5	318.6	176.0	70.8	32.1	39.5	80.8	59.5	46.7	86.5	133.9	1,464.6	122.4

[1] From estimates contained in Water Supply and Irrigation Papers Nos. 2, 73, and 83; also measurements in Water Supply and Irrigation Papers 85, 100, 133, 175, and 211.

The fluctuations each year, the differences between years, and the average flows for months and years are shown for 21 years. Reckoning on an irrigable area of 275,000 acres in Salt River Valley, the amount of water delivered each year is sufficient to cover this area to a depth of 1 to 20 feet; that is, there is one-fourth to five times enough water for general agricultural operations. This condition of fluctuation from month to month and from year to year indicates the necessity for water storage in order to equalize the water supply and, especially, to make available the occasional floods which have heretofore escaped in large part to the ocean. Storage capacity exists as follows:

Storage capacity on Salt and Verde Rivers.

Reservoir.	River.	Height of dam.	Capacity.
		Feet.	*Acre-feet.*
Roosevelt	Salt	284	1,284,000
McDowell	Verde	210	280,000
Horseshoe	do	150	205,000

T. roblem of the irrigating efficiency of the Salt and Ver Rivers with the help of feasible storage sites is of such unusual intere as to warrant especial attention. The accompanying sketch is ne essary to an understanding of the elements of that problem (fig. The Salt and Verde Rivers, which unite to afford the Salt River Vall supply, join just above Granite Reef, at which point the irrigati stream is diverted to the valley. Of these two rivers, the Salt is t larger, separate measurements being available since January, 190 as shown in the following table:

Monthly flow of the Salt and Verde Rivers at McDowell, near Lehi, Ariz., in thousands acre-feet.[1]

River.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.
1903:							
Salt	11.6	16.9	21.5	[2] 40.0	[2] 18.0	15.6	
Verde	15.3	20.1	32.2	22.6	8.7	8.1	14
1904:							
Salt	11.4	9.8	10.1	7.9	7.2	3.8	
Verde	14.6	13.0	11.3	7.1	7.7	3.7	4
1905:							
Salt	138.3	564.8	902.6	815.2	323.0	92.1	3
Verde	87.3	428.1	539.9	311.0	51.2	16.8	15
1906:							
Salt	102.0	98.3	493.0	303.0	101.0	38.4	
Verde	49.9	66.6	336.0	61.3	15.2	8.9	16
1907:							
Salt	232.0	178.0	285.0	148.0	54.3	33.9	
Verde	149.0	146.0	232.0	49.9	15.4	12.4	13
1908:							
Salt	25.3	229.0	240.0	99.4	58.8	27.1	
Verde	18.8	113.0	86.1	17.9	27.2	8.7	2
1909: [3]							
Salt	64.5	202.8	188.3	232.0	38.4	40.9	
Verde	114.2	80.5	125.9	74.7	12.4	8.1	

River.	Aug.	Sept.	Oct.	Nov.	Dec.	Total.	
						Salt.	Verde
1903:							
Salt	22.4	18.6	14.2	11.7	12.1	211.0	
Verde	20.2	30.5	19.6	12.3	14.0		21
1904:							
Salt	104.3	30.5	16.5	10.5	11.8	249.4	
Verde	99.9	28.7	11.6	12.5	14.8		26
1905:							
Salt	36.3	55.3	27.3	592.3	125.9	3,708.1	
Verde	34.9	45.9	33.5	204.2	53.8		1,82
1906:							
Salt	55.1	22.6	18.6	22.4	296.0	1,580.0	
Verde	45.7	12.6	11.1	18.6	102.0		80
1907:							
Salt	68.9	70.2	72.6	58.3	34.1	1,260.0	
Verde	26.4	24.0	37.8	22.3	19.9		76
1908:							
Salt	135.0	68.4	24.0	22.3	236.0	1,220.0	
Verde	54.1	21.2	16.3	16.7	192.0		60

[1] U. S. Geol. Survey, Water Supply and Irrigation Papers Nos. 100, pp. 36, 41; 133, pp. 221, 227; 1 p. 181; 211, pp. 137, 139; 249, pp. 190, 191, 195.
[2] Measurements for only part of month. Monthly flow is estimated from rainfall.
[3] U. S. Reclamation records.

For the period of measurement it appears that the Salt carried abou 65 per cent of the united flow, and the Verde about 35 per cent. Th elements of the physical situation involved are, therefore—

(1) Salt River carries 65 per cent of the total supply under the following conditions: (*a*) About 10 per cent of its watershed lies below Roosevelt reservoir and the run-off of this area can not be regulated; (*b*) the power canal, skirting the south side of Roosevelt reservoir, has a capacity of 250 cubic feet per second, or 15,000 acre-feet a month, which, theoretically, can not be stored and must be taken as it comes at Granite Reef; (*c*) Roosevelt reservoir, with a capacity of 1,284,000 acre-feet, is available for the storage of the waters of Salt River less the two above subtractions, which leaves approximately 70 per cent of the average whole flow; (*d*) the evapo-

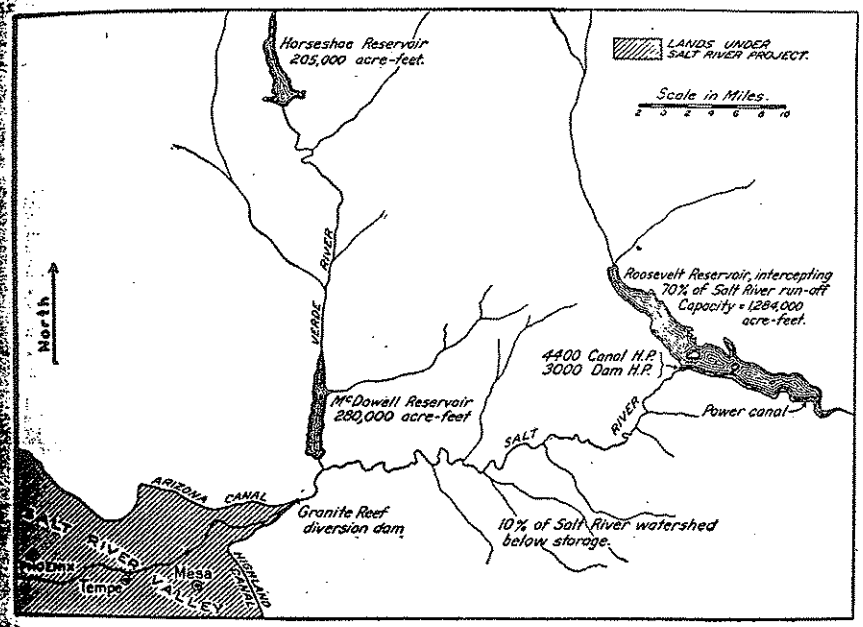


FIG. 4.—Hydrographic features of the Salt River Valley.

ration from the water surface in the reservoir, estimated at 66 inches, less 13 inches rainfall, leaves a net loss of 53 inches in depth each year. This would amount to a loss by evaporation of about 70,000 acre-feet a year, when the reservoir is full; (*e*) the power to be generated by the reservoir supply at times when that supply is being drawn upon can be used to pump supplementary ground waters for irrigation in Salt River Valley, and thus conserve the storage room of the reservoir and lengthen its period of duty during times of prolonged drought; and (*f*) power installations for pumping and industrial purposes derive their motive power from the power canal at Roosevelt Dam and at other feasible sites on Salt River and dependent canals.

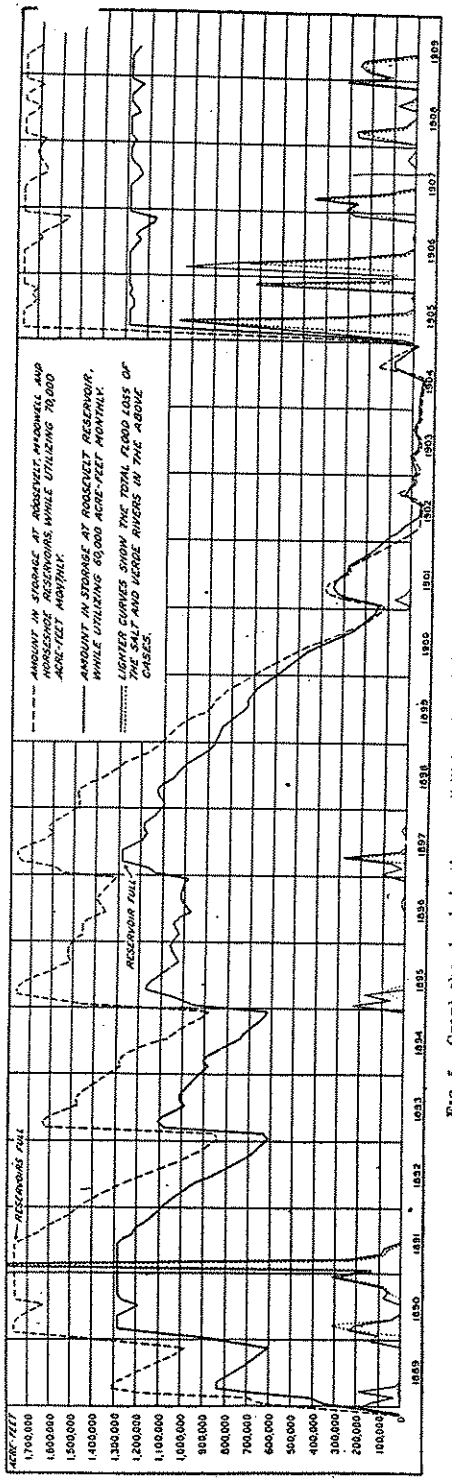


Fig. 5.—Graph showing irrigation possibilities of the Salt River under different conditions.

(2) The Verde River
ries 35 per cent of the
water supply, with the
lowing possibilities: (*a*)
McDowell storage reserv
with 280,000 acre-feet
pacity, lying at the mo
of the river and intercept
all of the Verde flood wat
(*b*) Horseshoe reservoir, w
205,000 acre-feet capac
a short distance above,
tercepting nearly all of
Verde flood waters; (*c*)
evaporation, subtracti
rainfall, may be appro
mated at 53 inches for th
reservoirs also; (*d*) there
canal and reservoir po
possibilities, as at Roosev

Irrigable area in valley
It is necessary in arriv
at the possible future wa
supply of Salt River Val
to estimate the maxim
continuous flow which th
two rivers, each with
own storage, coordinat
administered, may be m
to deliver. The follow
graph (fig. 5) represents
efficiency of the two riv
under two sets of conditio
(1) With a monthly deliv
of 60,000 acre-feet, us
first, the unregulated
of a portion of Salt R
and all of the Verde,
second, supplementing
with stored water f
Roosevelt reservoir, the to
storage capacity be
1,284,000 acre-feet; and
with a monthly delivery
70,000 acre-feet, using

storage on both the Salt and the Verde, total storage capacity being 1,769,000 acre-feet.

In both cases the estimates expressed in the graph take into consideration (1) the unstored 10 per cent of Salt River plus the Roosevelt power canal supply, (2) the Verde, with or without storage, as the case may be, and (3) the Roosevelt reservoir supply corrected for evaporation and rainfall. The Verde reservoirs, when used, are also corrected for evaporation. The figure for evaporation used is 66 inches less 13 inches of rainfall, leaving 53 inches of net loss, divided between months of the year as follows:[1] January, 0.2 inch; February, 1.2 inches; March, 2.7 inches; April, 5.2 inches; May, 7.9 inches; June, 9.3 inches; July, 10.1 inches; August, 4.7 inches; September, 5.9 inches; October, 4.3 inches; November, 0.9 inch; and December, 0.6 inch.

The power which can be derived from the reservoir water at the three sites, and which could be used to raise an auxiliary pumped supply, does not enter into the estimates, which relate to surface waters only; neither is a possible small reduction of reservoir capacity, due to filling in of sediments, allowed for.[2]

The tables on which the graph (p. 42) is based, showing the theoretical behavior of the water supply for the last 21 years—August, 1888, to June, 1909—under the two conditions of storage and output considered, are too voluminous to print, but may be summarized as follows:

(1) With a monthly delivery of 60,000 acre-feet, using 1,284,000 acre-feet of storage at Roosevelt only, to supplement the unregulated fraction of the Salt and the whole unregulated Verde:

Water supply of Salt River, 1888 to 1909.

[Total flow, 31,079,000 acre-feet.]

	Acre-feet.	Per cent of total flow.
Flood waste	14,375,000	46.2
Regulated stream flow delivered to Salt River Valley	14,528,000	46.7
Evaporation	1,083,000	3.4
In storage at end of period	1,246,000	4
Total	31,232,000	[3] 100.3
		Per cent of full supply.
Periods of shortage:		
April to August, 1902, 5 months		49
November, 1902, to March, 1903, 5 months		73
May, 1903, to June, 1904, 14 months		43
December, 1904, 1 month		71

[1] This evaporation was observed at the station farm near Phoenix during the dry season of 1901–2. The rainfall is averaged between McDowell and Tonto for a period of years.
[2] Arizona Sta. Bul. 44, pp. 157–159.
[3] Three-tenths of 1 per cent error, due to approximations employed.

(2, th a monthly delivery of 70,000 acre-feet, using 485,0
acre-feet of storage at McDowell and Horseshoe reservoirs on th
Verde and 1,284,000 acre-feet of storage at Roosevelt on the Sal

Water supply of Salt River, 1888 to 1909.

[Total flow, 31,079,000 acre-feet.]

	Acre-feet.	Per cen of total flow.
Flood waste	11,773,000	37
Regulated stream flow delivered to Salt River Valley	16,130,000	51
Evaporation	1,129,000	4
In storage at end of period	1,676,000	5
Total	30,708,000	1 99
		Per cent full sup ply.
Periods of shortage:		
October, 1900, to January, 1901, 4 months		
December, 1901, to August, 1902, 9 months		
November, 1902, to June, 1904, 20 months		
December, 1904, 1 month		

[1] Three-tenths of 1 per cent error, due to approximations employed.

In the first case, with only the Roosevelt reservoir and a monthl
supply of 60,000 acre-feet used, four periods of shortage occur, thre
of which could have been easily tided over with the help of pumpe
water. The fourth period of 14 months, occurring at the end of
series of dry years, would probably have proved manageable also i
the same manner, as a succession of power sites on the Salt River an
dependent canals, taking the whole future into consideration, wil
place great power resources at disposal, even at times of low strea
flow.

In the second case, with all three reservoirs and a monthly supp
of 70,000 acre-feet used, four periods of shortage occur, two of whic
are unimportant. A third, of nine months' duration would probabl
have proven manageable by means of pumped water. The fourt
shortage, of 20 months' duration, with less than a half supply of ir
gating water available, would probably represent an extreme cond
tion, occurring, so far as present records show, but once in 21 years
Probably such an exigency can be risked for the sake of a large
utilization of Salt River, especially as the water will be less wastefull
applied eventually, requirements will tend to grow less, and method
of apportionment in times of extreme need will probably be devised

It may be reasonably assumed, therefore, that with a total storag
at the Roosevelt, McDowell, and Horseshoe reservoirs of 1,769,00
acre-feet the Salt and Verde Rivers may, except on rare occasion
be relied upon to deliver about 70,000 acre-feet of river water eac
month to the irrigated valley below. This amounts to 840,000 acr
feet annually, which, assuming a requirement under improved con

ditions of 4 feet deep of irrigating water a year, is sufficient for 210,000 acres. This does not include the pumped water supply, which is to be considered independently of the gravity water supply discussed above.

Power and pumping.—It is estimated by the United States Reclamation Service that about 26,000 horsepower will be developed at the Roosevelt Dam, at several sites along Salt River between Roosevelt and Granite Reef, and in the canals of the Salt River Valley. The respective amounts of horsepower contemplated are: Roosevelt power canal, 4,400; reservoir power, 3,000; three sites on Salt River between Roosevelt and Granite Reef, 10,500; four sites in Salt River Valley canals, 8,000; total, 25,900.

This is much in excess of the amount of power necessary to lift the estimated underground water supply within the limits of the project, leaving a valuable surplus which may be sold for industrial purposes in the valley and in neighboring mining towns. The amount of pumped water now contemplated will be about 200,000 acre-feet annually, an amount sufficient to irrigate 50,000 acres. This pumped supply, moreover, may be economized or supplemented from time to time by a judicious use of occasional flood waters, just as on the other hand lowering reservoir waters may be supplemented by pumped supplies. Estimating liberally that 6,000 horsepower will care for pumping operations contemplated within the district, a residue of approximately 20,000 horsepower remains, which, in operation, it is believed will have a market value of not less than $1,000,000 annually. Salt River, therefore, as it will be developed ultimately is to be considered not only an irrigating stream of great value, but, in a region of limited fuel supply, an immensely important source of power also.

GILA RIVER.

Watershed and run-off.—The Gila River, rising in southwestern New Mexico, pursues a general westerly course across southern Arizona, joining the Colorado about 90 miles above the mouth of the latter. That portion of the watershed of the Gila lying west of its confluence with Salt River is of little or no value for irrigation on account of its very arid character. The water-productive territory east of Florence, Ariz., has an area of nearly 18,000 square miles. This region is for the most part of low elevation, and is forested only on the upper slopes of the mountains and in the bottoms of the valleys, where mesquite thrives. The extensive plains at higher elevations are grass or browse covered in season, while those in the western more arid districts are usually barren. The Gila watershed has been occupied by cattle for the last 40 years, and at times has been overstocked and overgrazed. This has resulted in destruction of the grass cover, in permitting rapid run-off from the bared surfaces, and in consequent erosion along lines

of r flow, so that fully 500 miles of the valley bottoms are
gullied and the hydrographic conditions greatly changed. In stri
contrast to the Salt River, the Gila is an example of a stream wi
watershed has suffered irreparable damage to the land surfac
years past from a total lack of administrative care.

The run-off of the Gila is difficult to estimate, differing in this resp
from the Salt and Colorado Rivers, which, confined in rocky bed
their upper courses, can be quite definitely and completely measu
at established gauging stations. The Gila, flowing in a pervi
bed of low gradient, is in varying proportions an underground ri
and rising and sinking as it does, according to local formations,
not be measured definitely by ordinary methods. The amoun
surface flow, as estimated from the not very continuous or prolon
measurements available, indicates a limited but comparatively
stant stream in the upper Gila near the New Mexico line, but
increasingly variable and inconstant irrigating supply between
Carlos and Yuma. The San Pedro and the Santa Cruz Rivers res
ble the Gila and give tribute to it mainly in flood waters. The seep
from the Salt River irrigation appears near its confluence with the
and affords a very constant and reliable supply for the irrigation of
lands near Buckeye and Arlington. Below the latter point the
supply is so uncertain as to preclude satisfactory farming operati

An approximate idea of the run-off of the Gila at the New Mex
line, at Florence, midway of the Territory, and at Yuma may
derived from somewhat fragmentary observations taken during
last 20 years. At the New Mexico line the combined measureme
at Cliff, N. Mex., on the Gila River, and at Alma, N. Mex., on
tributary San Francisco River, approximate the upstream sup
upon which irrigation in Graham County depends. Available m
urements, by years, as given in the reports of the United St
Geological Survey, are as follows:[1]

Run-off of Gila and San Francisco Rivers near the Arizona-New Mexico line.

Date.	Place of measurement.	Run
		Acr
1905	The Gila at Cliff, N. Mex.	[2]
1905	The San Francisco at Alma, N. Mex.	
	Total	
1906	The Gila at Cliff, N. Mex.	
1906	The San Francisco at Alma, N. Mex.	
	Total	
1907 [3]	The Gila at Cliff, N. Mex.	
1907	The San Francisco at Alma, N. Mex.	
	Total	

[1] U. S. Geol. Survey, Water-Supply and Irrigation Papers, Nos. 175, pp. 162, 170; 211, pp. 123, 1
[2] Jan. 1–May 22, not measured.
[3] U. S. Reclamation Service records.

The average for these three years is about 443,000 acre-feet, though measured incompletely. Even this figure is somewhat high, inasmuch as the run-off was exceptional for 1905 and 1907. Only a small portion of this run-off is available for irrigation, however, without storage, as is shown by the records by months for the three years of measurement.

Combined flow, by months, of the Gila at Cliff, N. Mex., and the San Francisco at Alma, N. Mex.[1]

Year.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.
[2]						17,477	9,641
[3]	17,430	44,200	97,200	49,000	17,210	4,356	7,350
[3]	143,188	90,740	54,453	34,528	17,266	13,195	15,063
Mean	80,309	67,470	75,826	41,764	17,238	11,676	10,685

Year.	Aug.	Sept.	Oct.	Nov.	Dec.	Total.
[2]	14,676	21,540	11,966	93,350	44,669	
[3]	32,070	8,590	5,846	7,220	65,100	355,572
[3]	54,290	45,917	17,537	20,320	14,382	520,879
Mean	33,679	25,349	11,783	40,297	41,384	

[1] U. S. Geol. Survey, Water-Supply and Irrigation Papers, Nos. 175, pp. 162, 170; 211, pp. 123, 128.
[2] U. S. Reclamation Service records.

The fluctuations here shown range from 4,356 acre-feet in June, 1906, to 143,188 acre-feet in January, 1907. As in other unregulated southwestern streams, irrigation is to a considerable extent limited by the summer minimum flow, usually occurring in June.

At Florence, midway of the course of the Gila River and below the mouth of the San Pedro River, probably the best knowledge of average flow is due to J. B. Lippincott,[1] who, on a basis of 60 months' observations made at various times from 1889 to 1899, estimated an average annual run-off of 469,093 acre-feet. This estimate, however, did not include the wet season of 1891. The mean monthly flows in acre-feet of the Gila River at Florence, as compiled by Lippincott, are as follows: January, 40,828; February, 26,675; March, 23,783; April, 20,481; May, 8,030; June, 4,072; July, 65,745; August, 77,247; September, 52,503; October, 83,109; November, 36,491; December, 30,129; annual total, 469,093.

The Gila River is not infrequently dry at Florence, sometimes for several months at a time, as, for instance, from March to July, 1899. Without storage, therefore, agriculture at this point is less assured of the necessary irrigating supply than near the New Mexico boundary, where, even in driest years, the river has never failed entirely.

At Yuma the Gila is even more variable than at Florence, and the discharge has ranged, it is said, from nothing for a period of a year

[1] U. S. Geol. Survey, Water-Supply and Irrigation Paper, No. 33, p. 30.

to as ...ı as 3,665,148 acre-feet in 1905. Following are avail... records of annual discharge of the Gila near Yuma, Ariz., taken ... the reports of the United States Geological Survey: [1]

Annual discharge of Gila River near Yuma, Ariz.

Year.	Acre-feet.	Year.	Acre-feet.
1903	61,196	1905	3,665,000
1904	226,400	1906	1,790,000

With such fluctuations in the unregulated supply, agriculture ... never succeeded in establishing itself permanently on the lower ... to any important extent.

It may be stated summarily that the fluctuations in water sup... become more and more extreme from the source to the mouth of ... Gila. In obedience to this fact and to the increasing appropriat... of the headwaters, agricultural development for the past 40 y... has readjusted itself gradually toward upstream locations. In ... absence of measurements the actual use made of the waters of ... Gila may be best estimated by the areas of land irrigated therefr... This amounted in 1909 to about 36,000 acres adjacent to the m... stream above its confluence with the Salt. This area, assuming ... average application of 4.5 feet in depth on the land, would acc... for about 160,000 acre-feet of water per annum. Although th... but little more than 30 per cent of the supposed average flow a... the Salt River junction, without storage it is very nearly the m... mum possible use of this stream. The remaining flood wa... escape, part being absorbed by the porous river bed and the res... sometimes reaching the sea.

Storage possibilities.—A considerable number of storage sites ... on or near the Gila River, the chief ones being given in the follo... table:

Storage sites on the Gila River.

Site.	Stream.	Location.	Height of dam by contour.	Ca...
			Feet.	*Acr...*
Red Rock	Gila	Above Duncan in New Mexico	100	
Alma	San Francisco	Alma, N. Mex.		
Dix Creek	do	22 miles north of Clifton	110	
Guthrie	Gila	Guthrie, Ariz.	140	
San Carlos	do	San Carlos, Ariz.	130	
Riverside	do	Riverside, Ariz.	153	
Buttes	do	Near Florence, Ariz.	150	
Queen Creek	Queen Creek	do	130	
Total				1,...

[1] U. S. Geol. Survey, Water-Supply and Irrigation Papers Nos. 100, p. 27; 133, p. 206; 175, p. ... p. 125.

Storage sites on the Gila River, however, though of large total capacity, seem peculiarly subject to misfortune. The Guthrie site is traversed from end to end by the Arizona and New Mexico Railroad; the San Carlos site is at present (March, 1911) in controversy between railroad and irrigation interests; the Riverside site is controlled by mining properties located within its limits; and both the Riverside and the Buttes sites are traversed by the Arizona Eastern Railroad. Further storage than that described above is believed to be possible by means of a series of comparatively small earth-embankment reservoirs in the tributary valleys southwest of Florence, and a large site exists on the main stream north of Sentinel, Ariz., 90 miles east of Yuma.

Aside from the administrative difficulties in which most of them are involved, prospective reservoirs on the Gila are all endangered by the excessively muddy character of the flood waters which would be used to fill them. Daily samples of such waters were collected during August and September, 1900, and allowed to settle for one year. The sediment deposited was then found to occupy from 5.2 to 17.4 per cent of the original volume of the muddy waters.[1] No economical method of removing such volumes of sediments from large and deep reservoirs having yet been demonstated, the life of such reservoirs, on muddy streams, is a matter as yet under discussion by engineers. It is estimated that the Buttes reservoir, with 174,000 acre-feet capacity, would fill with sediment in 18.6 years; and that the San Carlos site, with 241,000 acre-feet capacity, would fill in 28.5 years.[2]

The problem of storage on the Gila River, therefore, is at present fraught with serious difficulties, both administrative and physical, which will probably tend to retard further development in irrigation on this important stream for years to come.

SMALL STREAMS.

There are a number of small streams, besides the four main rivers already discussed, which altogether afford water supply for a considerable acreage. These small streams are quite completely utilized as to their critical minimum flow, and storage is projected here and there for the utilization of flood waters. Few measurements have been made upon these small streams, the amount of use of which can be best approximated by multiplying irrigated acreages by an assumed average water requirement.

Upper Verde River.—The Upper Verde River, including Clear, Beaver, Oak, Dragoon, and Granite Creeks, is tapped by a large

[1] Arizona Sta. Bul. 44, p. 188.
[2] U. S. Geol. Survey, Water-Supply and Irrigation Paper No. 33, p. 40.

number of small ditches which utilize upstream waters not incl in the Salt River supply discussed on preceding pages. Prob the best estimate now available of water used in this region is made by the subcommittee representing the Salt River Valley w users, which visited the Verde Valley in July, 1901, and meas the ditches and areas irrigated.[1] At that time about 7,000 mi inches of continuous flow was in use. This is 175 cubic feet second, or 350 acre-feet per day, or 70,000 acre-feet for an irrig season of about 200 days. This amount of flow was applied to a 7,650 acres, indicating probably a too liberal use of water in the trict, although a portion returns as seepage to the river channel was used again downstream. It is stated that since 1901 not m additional irrigation has been undertaken, so that with small incr this estimate still stands.

San Pedro and Santa Cruz Rivers.—These rivers are tributar the Gila River from the south. They resemble the Gila in chara of water supply, which is most constant near their sources, but tuate between floods and complete dryness along their lower cou Measurements of both streams midway of their courses have made at Charleston and Tucson, Ariz., as follows:

	Acre-feet.
San Pedro River at Charleston, Ariz.:[2]	
1904 (April to December)	115,300
1905	45,200
1906 (January to August)	29,100
Approximate average	63,200
Santa Cruz River (including ditches) at Tucson:[3]	
1906	22,370
1907	37,200
1908	22,530
1909	22,275
Approximate average	26,100

But measurements at any one point on streams of this characte of little value in showing the entire run-off. Flowing in per beds, such waters are forced to the surface only at points where are confined by underground barriers and spread out and disap rapidly in the wide, sandy valleys. Probably the best metho approximating the available water supply from such imperf measured streams is to multiply the irrigated acreage by the assu average depth in feet of water applied. Estimated in this man the San Pedro, with about 5,800 irrigated acres, and an ave

[1] Water-Supply and Irrigation on the Verde River and Tributaries, 1901, by O. A. Turney.
[2] U. S. Geol. Survey, Water-Supply and Irrigation Papers Nos. 133, p. 21[illegible]; 175, p. 173; 211, p.
[3] Arizona Sta. Bul. 64, pp. 115, 116.

pplication of 3.5 feet in depth to the land, affords about 20,000 cre-feet of water annually. Similarly, the Santa Cruz and tribu- aries, with about 6,000 irrigated acres and an average application of .5 feet deep applied, affords about 21,000 acre-feet annually.

Storage sites exist on both the San Pedro and the Santa Cruz Rivers. Just below Charleston, on the San Pedro, a dam 120 feet high would impound about 120,000 acre-feet of flood waters, which amount is occasionally available from this stream. All known sites on the Santa Cruz are broad and shallow, and are favorable to the construction of retaining embankments of earth of comparatively low elevation. The Santa Cruz Reservoir Land Co. is now constructing (January, 1910) one such reservoir 50 miles northwest of Tucson. This company proposes to develop 295,000 acre-feet of storage capacity by means of an earthen dam 22,200 feet long with a maximum height of 45 feet.

Bill Williams Fork.—This stream, which drains west-central Arizona and empties into the Colorado River, is as yet unmeasured, but is known to vary from a few miner's inches to occasional floods of large volume. A reservoir site is said to exist 40 miles east of its mouth at the junction of the Big Sandy and the Santa Maria Creeks.

Other small supplies.—Throughout central and eastern Arizona small creeks are being more and more closely utilized. Even the waters pumped from mines at Tombstone and Bisbee are employed in gardening operations. These scattered increments of water, by reason of their proximity to mining markets, are often very valuable and yield their owners excellent returns for fruit and produce. The area irrigated from these small creeks and springs may be approximated at 4,300 acres scattered throughout the Territory, mostly at higher elevations. This area, at 4 feet in depth of water required a year, means a total annual water resource of 17,000 acre-feet.

SEEPAGE AND RETURN WATERS.

The initial application of irrigating waters, however, does not in many situations terminate its usefulness. A considerable percentage of the water applied to the soil may work its way back gradually to stream channels and again be taken and applied. In certain of our irrigated districts, where soils are pervious, gradients steep, and the lands disposed in comparatively narrow areas along river courses, conditions are very favorable for the return of seepage waters. The Upper Verde and Gila Rivers in Graham County and the Salt River are examples of streams whose waters are thus in part used over and over again. Decreasing increments of the waters of Salt River are thus used not less than four times between their first application at the head of Salt River Valley and their last appearance at Arling-

ton. As much as 65 per cent of the original application has found to be recovered and again applied along the Upper Gila R and in Salt River Valley 30 per cent of return waters has observed.[2] No data are available as to the actual amount of se made use of on the streams mentioned, but the return waters Salt River Valley and from the Gila are in part measured separ and applied to subjacent lands, including the Buckeye and Arli districts to the west of the confluence of these two streams. 13,000 acres are thus irrigated, which, allowing for the very l use of water made here, would require the application of ap mately 80,000 acre-feet of water annually. W. H. Code,[3] mea these return waters in 1900, when they were less than normal a total of 260 cubic feet per second, or about 190,000 acre-f water annually between Tempe and Gila Bend. Improved supply with increased and prolonged irrigation in upstream di will result in augmenting the return flow so that this water re will in future become of larger volume and importance than a ent. The return waters now in evidence from the Salt and Gil valleys and not otherwise included in the above estimates may fore be stated conservatively at 200,000 acre-feet annually.

RESERVOIR SITES.

As has been noted already, storage possibilities of greater size exist on nearly all of the streams of the Territory. About five of these have been surveyed by the United States Geolog vey and the United States Reclamation Service, or by privat and their capacities ascertained or estimated. The location reservoir sites is shown on Plate II, page 28, and their cap the highest contours are given in the following table:

Capacity of reservoir sites in Arizona.

No.	Name of reservoir.	Contour.	Capacity.	Authority.
		Feet.	*Acre-feet.*	
1	Laguna	[4] 19	25,650	U. S. Reclamation S
2	Bill Williams	75	1,300,000	Do.
3	Aquarius	250	1,500,000	Arizona Republican
4	Bulls Head	20	15,993	U. S. Reclamation S
5	Tucker Flat	50	117,567	Do.
6	Le Roux	35	54,298	Do.
7	Woodruff	100	108,644	Do.
8-9	Forks	85	147,943	Do.
10	Udall		13,000	Private correspon
11	Lyman		20,005	Do.
12	South Gila	[4] 50	([5])	U. S. Geological Su
13	Walnut Grove	135	60,000	Personal correspon
14	Agua Fria	150	150,000	U. S. Geological Su
15	Frog Tanks	100	50,000	Do.

[1] U. S. Geol. Survey, Ann. Rpt. 1899–1900, pt. 4, pp. 343–347.
[2] U. S. Dept. Agr., Office Expt. Stas. Bul. 104, pt. 2, p. 104.
[3] U. S. Dept. Agr., Office Expt. Stas. Bul. 104, pt. 2, pp. 103–104.
[4] Height of dam already constructed.
[5] Capacity not ascertained, but very great.

Capacity of reservoir sites in Arizona—Continued.

Name of reservoir.	Contour.	Capacity.	Authority.
	Feet.	*Acre-feet.*	
New River			U. S. Geological Survey.
Cave Creek	100	100,000	Do.
Horseshoe	150	204,935	Do.
McDowell	[1] 210	279,635	Do.
Roosevelt	[1] 284	1,284,000	U. S. Reclamation Service.
Queen Creek	130	50,665	U. S. Geological Survey.
Florence Canal		([2])	Do.
Santa Cruz Reservoir Land Co	[1] 45	295,330	Personal correspondence.
Buttes	150	174,040	U. S. Geological Survey.
Riverside	153	344,308	Do.
San Carlos	130	241,396	Do.
Dix Creek	110	12,000	Personal correspondence.
Guthrie	140	255,800	U. S. Geological Survey.
San Pedro	120	120,000	U. S. Reclamation Service.

[1] Height of dam already constructed. [2] Capacity small.

GROUND WATERS.

WATERS WITHIN 50 FEET OF SURFACE.

Surface flow, however, by no means exhausts the water resources the Territory. Beneath the surface in favorable locations there mmense capacity for the storage of flood waters. These ancient lleys are filled with detritus from adjacent mountain ranges and y contain in the interstices of their porous contents 20 to 40 per t of their volume of water. The storage possibilities of such a ley are illustrated by the disastrous flood of 1903 at Clifton. This d was 30 feet deep, and after destroying the town, passed down Gila River, but disappeared entirely before it reached the head he Buckeye Canal, 180 miles below, the entire flood, with the ption of the minor portion that found its way into ditches or ped by evaporation, having been absorbed into the underground age.[1] Irrigated valleys in like manner fill up with water escaping percolation from the surface where it is applied. The ground- er level, due to this cause, in some parts of the Salt and Upper River valleys has risen from a depth of 20 feet or more to the ace.

here are considerable areas in southern Arizona, as shown by the (Pl. II, p. 28), where ground waters are found within 50 feet he surface. This is assumed as the maximum depth from which ating water may be pumped. These ground waters are often n of as underflow, and sometimes are developed by means of es dug upgrade to water level. This is not practicable, how- in some localities, and the utilization of ground waters must be ly by pumping.

he subject of ground waters within the Territory has as yet been ed in only a few localities, and it is impossible therefore to forecast

[1] U. S. Geol. Survey, Water-Supply and Irrigation Paper 104, pp. 38, 39.

the nt to which they will be used ultimately, especially as
depends not only upon the amount and accessibility of the su
but also upon the cost of pumping and the value of products gr
One of the most detailed studies of ground-water supply thu
made is that of G. E. P. Smith, who finds that the Rillito V
between Fort Lowell and a point 10 miles west may probabl
made to supply 23,000 acre-feet annually by pumping.[1] Will
Lee, in his study of the ground waters of the Gila between the Bu
and the Salt River junction, found a reserve of 1,120,000 to 1,960
acre-feet of water within 50 feet of the surface, and estimates
each year this store is replenished by an underflow of not less
175,000 acre-feet.[2]

The same author finds under Salt River Valley between the V
and the Agua Fria, a reserve of approximately 4,704,000 acre
of water within 50 feet of the surface, replenished each year by
estimated underflow of 287,760 acre-feet.[3] These three streams
the localities studied, are estimated to carry about 500,000 acre-
of ground water annually within pumping distance of the sur
without drawing upon the reserve. As shown on Plate II (p.
there are large additional areas along the Agua Fria, New, Ha
yampa, and lower Gila Rivers, and in the Santa Cruz, San Pe
Sulphur Springs, and San Simon Valleys, which also carry gro
waters within 50 feet of the surface, replenished by underflow der
from adjacent mountain ranges. Sulphur Springs Valley, par
larly, probably will prove a source of large ground-water supp
valuable in supplementing dry-farming operations at times w
rainfall is inadequate.

These great bodies of ground water have, for the most part, b
drawn upon but little. Several successful pumping plants in
Salt River Valley have been in operation for something less th
10 years, and exhaustive pumping plants are under construction
the United States Reclamation Service. More or less crude attem
at pumping are to be found elsewhere within water-bearing ar
but the underground supply is as yet almost untouched. The
nificance of this supply is suggested by the history of irrigation
semiarid southern California, south of Tehachapi. Ground wate
that region, which was first irrigated from surface streams, now af
probably 75 per cent of the whole supply. Arizona is 20 to 25 y
behind California in the development of its ground-water supp
judging by the chronology of well-drilling operations in the
sections. Considering the all-year growing season in south

[1] Arizona Sta. Bul. 64.
[2] U. S. Geol. Survey, Water-Supply and Irrigation Paper 104, p. 50.
[3] U. S. Geol. Survey, Water-Supply and Irrigation Paper 136, p. 171.

Arizona, the diversity and value of crops, the intensive agric re possible, and the progress being made in pumping economy, Arizona is entitled to look with much hope upon the future value of its ground waters. It is perhaps not in excess of possibility to place the future utilization of groundwaters of the Territory by pumping at 750,000 acre-feet annually.

ARTESIAN WELLS.

There are three well-defined artesian districts within the Territory and indications of a fourth. The oldest of these is in the San Pedro Valley, extending from just north of Benson, southward for about 45 miles. This valley was once filled by an ancient lake and is bedded with clay strata favorable to the retention, under pressure, of artesian waters. These waters are derived apparently from adjacent mountain slopes whose run-off is caught under the edges of the old lake deposits and confined there until released by artesian borings. The first well was discovered in 1885 at St. Davids, 6 miles south of Benson. A reconnaissance of the district by the writer, in January, 1909, discovered 219 wells, 178 of which were at St. Davids. They range from 125 to 800 feet deep, and from 1.5 to 12 inches in diameter. Most of the flows are small, ranging from as small as 2 gallons a minute to a maximum, in one well at Hereford, of 180 gallons a minute. The total discharge for the district was estimated at about 3,500 gallons a minute, which is equal to 7.8 cubic feet per second, or about 5,700 acre-feet of water per annum.

The second artesian district is in Graham County, lying between Pima and Solomonville, along the northeast slope of Graham Mountain, roughly parallel to the Gila River. This district has been developed at intervals for a distance of about 20 miles. The water supply evidently is derived from the run-off of Graham Mountain, which accumulates, with pressure, under clay strata which were probably also laid down in the waters of an ancient lake. Artesian springs in this district are said to have appeared along the line of an earthquake crack opened in 1885. The first well was bored in 1897, and there are at the present time about 100 wells, large and small, ranging from 80 to several hundred feet in depth, with an aggregate flow possibly of 4,000 gallons a minute. This is about 8.9 cubic feet per second, or about 6,500 acre-feet per annum, mostly flowing in the vicinity of Lebanon and Artesia, 6 to 10 miles, respectively, south of Safford. Recently (February, 1911) this district has been considerably extended by the discovery of another large well at San Simon, 50 miles south, upon the Southern Pacific Railroad.[1]

Forty miles east of Bisbee, at San Bernardino, on the Mexican line, is a third small artesian district on the south slope of the

[1] Not shown on Plate II.

Chir[illegible]a Mountains. Ten wells were flowing in 1909, but m[illegible] urem[illegible] were not available. This district was not discov[illegible] until 1905 and its area is unknown. An artesian salt well has [illegible] known for several years at Adamana, on the Santa Fe Railroad, [illegible] recently (December, 1909) another well was discovered near [illegible] Joseph. At the latter point, at a depth of 400 feet, a flow o[illegible] gallons per minute has been secured in a formation probabl[illegible] considerable extent. These discoveries are important, being [illegible] first artesian water found in northern Arizona, and if sustained [illegible] further discoveries will be of great value to that region.

Summarizing all artesian districts, the entire well flow at [illegible] time is probably not in excess of 15,000 acre-feet per annum. [illegible] fortunately, this small but valuable asset is very wastefully hand[illegible] Drillers, aiming at economy in outlay, usually make the wells of sm[illegible] diameter without casing. For this reason they frequently choke [illegible] their flow is lost subterraneously. Oftentimes small flows are [illegible] properly stored, but are allowed to run without control, being thu[illegible] source of injury rather than of benefit to subjacent lands.

SUMMARY AND ESTIMATE OF WATER SUPPLY.

Summing up the surface stream flow of the Territory conser[illegible] by storage and replenished by seepage, and placing a moderate [illegible] mate upon the little-known ground waters, the potential, but as [illegible] only partly developed, annual water supply for Arizona is as follo[illegible]

Water resources of Arizona.

	Acre-feet.
Colorado River, portion of flow sufficient to irrigate adjacent lands in Arizona	2,000,000
Little Colorado River, with storage	300,000
Salt River, with storage	840,000
Gila River above the Salt, without storage	160,000
Upper Verde River, without storage	70,000
San Pedro River, without storage	20,000
San Cruz River, without storage	21,000
Small streams, without storage	17,000
Seepage waters not included in above estimates, under improved upstream conditions, probably	200,000
Ground waters within 50 feet of the surface, replenished by percolation from irrigation and surface stream flow	750,000
Artesian wells	15,000
Total	4,393,000

In round numbers, therefore, the water supply reasonably wit[illegible] expectation in Arizona, as now seen, is between 4,000,000 a[illegible] 5,000,000 acre-feet a year. This is sufficient for 1,000,000 acres intensively cultivated land.

LAWS AND USAGES RELATING TO IRRIGATION.

Irrigation law in Arizona, as in most other western commonwealths, is in a state of development rather than of completion. Irrigation practice as it now stands is derived from Mexican law, from Mormon customs, and from legislative attempts of American irrigators to solve problems new to them.

OLD MEXICAN LAWS.

Under the terms of an act of the first legislative assembly in 1864, "The regulations of acequias, which have been worked according to the laws and customs of Sonora and the usages of the people of Arizona, shall remain as they were made and used up to this day." [1] The laws and customs of Sonora referred to, transmitted from Spain, are based upon Old World experience. Water is strictly appurtenant to the land. Distribution is in rotation to users for time in proportion to acreage irrigated. Charges for water and for maintenance of main ditches are in proportion to irrigated acreage. In brief, the irrigated acre of land is the unit of rights and of responsibility in the water supply. This legal inheritance, however, applies to only a limited acreage in the Santa Cruz Valley, which was under cultivation at the time of the erection of Arizona into a separate Territory.

COOPERATIVE ORGANIZATIONS.

The first American ditches on the Salt, the Gila, and the Little Colorado Rivers were built by small companies of farmers who labored cooperatively to secure a water supply which, in early days, being sufficient for all, aroused no controversy. In course of time, appropriations of water and nominally irrigated lands proved to be far in excess of actual water supply. Also, many of the older canals fell under the control of corporations or were constructed by them. Certain ditches, however, including those operated by Mormon farmers, maintained their cooperative character, their affairs being managed by officers elected by the users of water, and assessments of money and of labor for maintenance of ditches being levied in accordance with shares or acres owned. The Tempe Canal in Salt River Valley, the San Jose, Montezuma, and other ditches on the upper Gila, and the canals along the little Colorado have all remained essentially cooperative in character.

Shares of stock in these organizations entitled the owners to their proportion of the water flowing in the ditch, but unfortunately these shares were not attached to specified areas of land, and the water derived from them was sometimes shifted from place to place. These floating water rights therefore became a cause of insecurity in values

[1] Revised Statutes of Arizona, 1901, par. 4199.

of im ed lands and were a serious evil, especially when drought le to the manipulation of a scant water supply.

The democratic character of the cooperative ditches, however, ha made them for the past 40 years of the irrigation history of th Territory the most satisfactory means of water supply, but to a co siderable extent the internal operation of these ditches has bee through the consent of those interested rather than through the rig application of the Territorial law.

DEVELOPMENT OF IRRIGATION LAW IN ARIZONA.

While the old Mexican acequias and the more modern cooperati ditches have in the main operated satisfactorily within themselve the usages governing them apply mainly to limited and contiguou acreages and are not adequate to settle the questions which arise i connection with the irrigating interests of an entire watershed These necessarily have been matters of Territorial law, an outline o whose development and character should be known to all irrigators.

In the bill of rights, enacted by the first Territorial legislature i 1864, it is provided that "All streams, lakes, and ponds of wate capable of being used for the purposes of navigation or irrigation ar hereby declared to be public property; and no individual or corpor tion shall have the right to appropriate them exclusively to their ow private use, except under such equitable regulations and restriction as the legislature shall provide for that purpose."[1]

At the same legislative session it was enacted, with other prov sions relating to irrigation, that—

(1) All rivers, creeks, and streams of running water in the Territory of Arizona a hereby declared public, and applicable to the purposes of irrigation and mining, hereinafter provided.

(2) All the inhabitants of this Territory, who own or possess arable and irrigab lands, shall have the right to construct public or private acequias, and obtain th necessary water for the same from any convenient river, creek or stream of runnin water.

(3) It shall be the duty of overseers of ditches to distribute and apportion the wa in proportion to the quantity to which each one is entitled, according to the land cu tivated by him; and, in making such apportionment, he shall take into considerat the nature of the seed sown or planted, the crops and plants cultivated; and to condu and carry on such distribution with justice and impartiality.

(4) During years when a scarcity of water shall exist, owners of fields shall ha precedence of the water for irrigation, according to the dates of their respective ti or their occupation of the lands, either by themselves or their grantors. The old titles shall have precedence always.[2]

These provisions, which are still a part of the statutory law of th Territory, establish that the rivers and streams are in the nature

[1] Revised Statutes of Arizona, 1901, par. 22.
[2] Revised Statutes of Arizona, 1901, pars. 4174, 4176, 4190, 4191.

a public resource, bestow upon irrigators the right to appropriate water from these streams for their lands, specify the beneficial use of water upon land, and secure priority of rights to water in the order of its application to the land.

In default of legal machinery wherewith to secure a comprehensive and thorough application of these principles to irrigated lands within the Territory, abuses demanding judicial or legislative correction have developed from time to time. Most of these have been associated with corporations organized for the purpose of managing or constructing ditches, diverting water, and, in some cases, expressly for sale, rental, and distribution of water. These organizations, in carrying out their purposes, not only deprived certain older canals of water rightfully theirs by priority, but public water supply was treated as corporate property, and water, instead of being strictly appurtenant to the land, was sold to users as a separable commodity. The resulting litigation culminated in the Kibbey decision announced in 1892. This decision reaffirmed the fact that the water of the streams and rivers is public property; that only owners and occupants of land are entitled to appropriate water from the public supply; that in so doing "no man has a right to waste a drop of water," but must apply it economically to the extent of its beneficial use; that priority of appropriation by actual use of water constitutes the better title to water; and that the right to irrigating water is permanently appurtenant to the land in connection with which it was acquired. Moreover, it was affirmed that canal companies are only carriers and not owners of water; that ownership of stock in a canal does not constitute ownership of water; and that the rights of canal companies are limited to carriage of water to the lands of appropriators.

The court did not specify the rights to water of individual landowners, the case for decision relating not to individuals but to the rights of different canal companies in the water supply. In accordance with this aspect of the case the decision provided a chronological table of totals of irrigated land under each canal year by year. A water commissioner was appointed whose duty it was to apportion the water between canals according to total prior rights under them.

The necessary want of explicitness in the decree gave opportunity for shifting water rights in violation of the intention of the court. Moreover, while the decision was pending an agreement was entered into between all but two of the canal companies of Salt River Valley whereby the available water supply was divided among them by agreement and not according to the provisions of the Kibbey decision. The operation of this agreement in default of adequate means to enforce the court decree was to defeat the principles of priority and

of att. ..ment of water to land. The result was that for the grea part of the 15 years following 1892 a majority of the Salt Ri Valley farming population was unlawfully dominated by the wa companies which controlled the water supply as though it were th own instead of acting as distributing agents only. An onerous a chaotic condition of affairs supervened in consequence, especia during the years of drought that occurred in the late nineties in t Salt River Valley, where, in the main, legal questions with referen to irrigation in Arizona have been fought out. Various legislat attempts were made toward improvement. The Ivy bill, introduc into the twenty-first session of the legislature, reaffirmed the origin water law of the Territory and the essential features of the Kibb decision and, following the Wyoming law, provided machinery f making the Arizona law effective. Although defeated, the discussi of this bill was enlightening to the water-using public.

The Fowler bill was passed at this same legislative session, p viding that counties with an assessed valuation of over $8,000,0 should be enabled to levy a tax for a water-storage fund to be us for reservoir construction. This bill has been in effect superseded the National Irrigation Act, the passage of which in 1902 marked t beginning of the end of this formative period of irrigation history.

In accordance with the National Irrigation Act, the Salt Riv Valley Water Users' Association was organized and incorporat in 1903, to provide an adequate supply of water by diversion, stora and pumping, for the lands of holders of shares in the associati and to enter into necessary agreements with the United Sta Government whereby to secure the benefits of the reclamation l The articles of incorporation, which before adoption were found meet the views of Government representatives, provide that on owners of lands shall hold stock in the association; that this sto shall be inseparably appurtenant to lands described in connecti therewith; that the apportionment of water for irrigation of la shall be limited to its beneficial use; and that vested priority rig to water should be maintained. The government of the associati is vested in a council, a board of governors, president, and v president elected by shareholders in the association. These offic transact business under restrictions provided in the articles of inc poration. This association has been very influential in bring about similar organizations elsewhere.

Through the medium of this organization and of the United Sta Reclamation Service, arrangements were made resulting in the co struction of the Roosevelt Dam for storage and power, and t necessary means for distribution of the supply. The cost of constru tion is secured by lien on the lands of shareholders and is to be repa

to the United States Government in 10 annual installments without interest. When the major portion of the water shares has been paid for, the management and operation of the irrigation works, with the exception of reservoirs, pass to the owners of the lands irrigated.

In completion of the preparations for an equitable dispensation of benefits flowing from the Roosevelt Dam, the Kent decision, March 1, 1910, defines the irrigation status of every parcel of land in Salt River Valley, and thus secures to each, by virtue of its vested rights in the original stream flow, or its share in reservoir water, or both, an equitable interest in the now augmented and thoroughly administered water supply.

The situation on the lower courses of the Gila River is even worse than the old order of affairs on Salt River, but the possibilities of storage point to a similar solution. At Florence, for instance, several thousand acres were irrigated in former years from what seemed at first a reliable flow, but subsequent diversions of water upstream have deprived the prior appropriators of their supply and annihilated farm values. By means of storage, should it be found feasible, not only can prior appropriations be honored, but more recent developments in the eastern part of the Territory can be safeguarded in a manner precisely similar to that employed in the Salt River Valley.

It is, in fact, quite generally true in Arizona that storage sites offer a means whereby the fundamental principle of priority may be made to apply without hardship to those interests which, in default of any effective system of control, have developed during the past 20 years to the detriment of the first appropriators. It is fortunate that all the irrigation rivers, except the Colorado, are practically within the Territorial boundaries. In so far as this is true, interstate complications over the use of irrigating streams can not arise, as they have between New Mexico and Colorado over the Rio Grande or between Colorado and Kansas over the Arkansas River.

Summarizing the legal progress and tendencies at the present time it may be stated that after many years of costly experience in the difficulties incident to water distribution, the people of Arizona are at last in a fair way to adopt and practice those simple principles which for many centuries have been recognized by irrigators in the arid regions of the Old World.

IRRIGATION ENTERPRISES AND AGRICULTURAL PRACTICE.

The Territory may be divided into seven somewhat distinct districts, each with its own climatic conditions and its own water supply, as follows: The Colorado River Valley, the Salt River Valley, the Gila River and its tributaries, the Verde River and tributaries, the Little Colorado River, districts where rainfall may be supple-

ment by irrigation, and grazing ranges supplied by springs and wells.

IRRIGATION IN THE COLORADO VALLEY.

The alluvial lands bordering the lower Colorado River will probably develop into one of the richest agricultural sections of the Southwest. The cultivated areas are limited as yet, but a successful beginning has been made under the United States Reclamation Service operations and rapid progress in the exploitation of this rich region seems to be assured. The peculiar advantages of the region reside in its favorable climate, its abundant water supply, and its unusually fertile soils.

CLIMATE.

The climate is distinguished by its mild winters, its all-year growing season, and the nearly rainless summers, which minimize the loss due to untimely precipitation. As commonly observed in arid regions, occasional frosts of some severity occur at lower levels, due to air drainage. Minimum temperatures recorded 1 to 2 feet above the ground, at the Arizona Experiment Station date orchard near Yuma for several years past, are as follows:

Minimum temperature record at experiment station date orchard, Yuma, Ariz.

Winter.	Record below 32° F.		Minimum record.	
	Number of frosts.	Date.	Degrees F.	Date.
1905–6	34	Nov. 29 to Apr. 3	20	Jan. 1.
1906–7	39	Oct. 21 to Mar. 29	21	Nov. 30.
1907–8	32	Nov. 17 to Feb. 15	23	Feb. 14.
1908–9	21	Oct. 29 to Mar. 13	24	Nov. 29.
1909–10	32	Nov. 8 to Feb. 19	17	Dec. 4.

These temperatures are too low for citrus culture and will occasionally damage the more tender winter truck crops. The adjoining mesas, however, are above the levels where the cold air collects, and are not subject to these low minima. The lowest record available from Blaisdell Heights, about 80 feet higher than the date orchard, is 26° F., and frostless winters have been recorded there. The bench or mesa lands, adjoining the Colorado bottoms, are suitable for citrus and other slightly frost-resistant crops, but are not adapted to such distinctly tropical crops as pineapples, bananas, or cocoanut palms. Maximum field temperatures under shelter, during June to September, range from 110° to 116° F., but are relieved to some extent by daily breezes coming from the Gulf of California. These temperatures permit of an all-year growing season for a succession of crops consisting largely of forages and fruits in summer and of grain

and vegetables in winter. The rainfall is usually light, though occasionally much damage to fruits and hay is done by unexpected downpours in July and August.

WATER SUPPLY.

The water supply is in excess of the land and it is only necessary to bring it under control. The quality of these waters is usually good, ranging from 21 parts soluble salts in 100,000 of water in June floods to as high as 125 parts observed in one small October flood coming from a salty watershed.[1] In character the salts are white alkaline containing a large proportion of calcium sulphate, which is a chemical antidote for black alkaline lands.

The sediments of the Colorado River, considered chemically, are beneficial to the soils upon which they are carried by irrigation. These sediments have been observed to range from 0.45 to 28.2 tons per acre-foot of water, and often contain considerable organic matter which is of especial value on light, sandy soils deficient in humus and nitrogen. The deposition of sediments in irrigating ditches, however, necessitates frequent ditch cleaning. Settling sluices with which to partially clarify the supply are a necessary feature of irrigation works on this stream.

SOILS.

The river-bottom lands of the Colorado Valley range from dense, sticky adobe to light sands, the lighter soils predominating. These warm sandy soils, draining and working readily, are especially suited to intensive cultivation. The heavy soils, which take water slowly and bake and crack readily, are more difficult to handle, especially when charged with alkali salts.

The higher mesa soils are for the most part rather coarse sands, less fertile than the valley soils and considerably in need of the addition of river sediments and of organic manures and the benefits of leguminous green manuring crops. The mesa lands are quite rough and the river bottoms are diversified with dunes and old river channels. Leveling of such lands is necessary in preparing for irrigation. Alkali salts are generally present, but not usually in injurious amounts, except where ground waters wet the soil surface and there evaporate, leaving alkali crusts. Good drainage conditions should be assured in connection with irrigation in the region, so that soluble salts may be kept under control. The character of the alkali is sometimes "black," containing sodium carbonate; sometimes "white," consisting chiefly of sulphates and chlorids. The tendency of the river waters, containing calcium sulphate, will be to ameliorate the black alkaline lands and convert the more harmful sodium carbonate to sulphate.

[1] Arizona Sta. Bul. 44, pp. 202, 203.

YUMA PROJECT AND OTHER IRRIGATION WORKS.

The Mohave, Chemehuevi, Yuma, and Cocopah Indians g
crops by crude methods in the Colorado flood plain. Millets, c
sorghum, melons, squashes, beans, and other crops are planted in
wet ground as the summer flood waters recede, maturing before
ground dries out. Without means of controlling the Colorado, h
ever, these people can not make use of the valuable spring and e
summer season, which is the flood time of the river. White irriga
have made a number of attempts to operate pumping plants and c
struct ditches alo
the stream, in so
cases with fair succe
but in most instan
with failure due
floods, changing c
rents, sand bars, a
inadequate engine
ing devices.

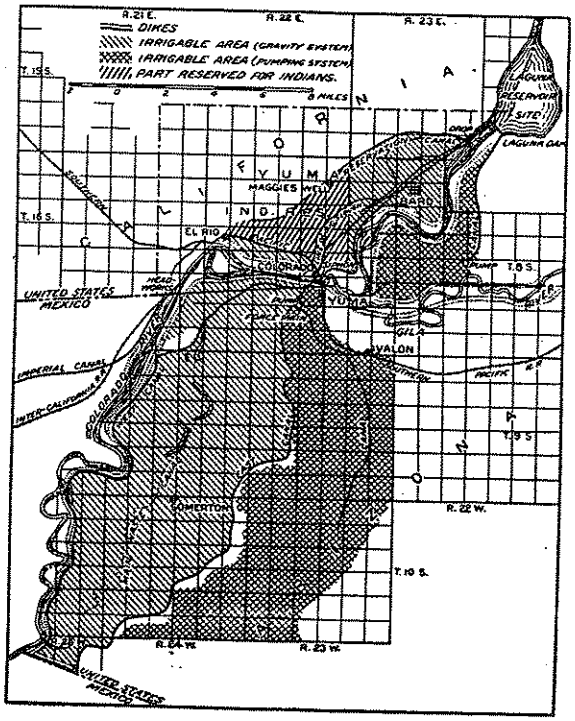


FIG. 6.—Yuma, or Laguna, project.

The principal i
gating plants now
stalled are:
pumping plant of
Camp Mohave Indi
School Reservati
the Rio Colorado La
and Irrigation C
gravity canal syst
below Camp Moha
Indian School Res
vation; the pumpi
plant of the Colora
River Agency, Park
Ariz.; the pumpi
plant (10-inch centr
ugal) of the Cibola Canal, Cibola, Ariz.; the centrifugal pumpi
plant of the United States Reclamation Service, at Yuma, Ariz.; t
scoop wheel; and the gravity canal of the United States Reclamati
Service, at Yuma.

The United States Reclamation Service has entered upon the co
struction of engineering works of the Yuma project near Yum
adequate for the control and utilization of the Colorado River on
large scale. The principal features of the work are:

(1) Laguna Dam, crossing the river 14 miles upstream from Yum
(fig. 6). This dam, completed in March, 1909, is 4,780 feet lon

250 feet wide, up and down stream, and 19 feet high. This bro ow structure raises the minimum river level about 10 feet, assuring an irrigating supply at all stages of flow of the river.

(2) The reservoir above the dam and the sluiceways at either end, which are designed to clarify the irrigating supply of a portion of its sediments, thus lightening the burden of ditch cleaning.

(3) The main canal, running from the west end of the dam to Yuma, where it will cross under the Colorado River to Arizona by means of a 14-foot inverted siphon. This is now nearing completion (March, 1911).

(4) Levees 73 miles in length along the Colorado and Gila Rivers, which are required to prevent untimely flooding of cultivated lands. These have been largely completed.

(5) Drainage, by means of low-level canals and water-elevating apparatus, to be provided in order to prevent swamping and accumulation of alkaline salts in the soils.

(6) Pumping stations, operated in part by power generated at a drop in the main canal, which are to elevate water to the bench or mesa lands.

(7) A temporary water supply, which has been provided by means of the old Ives and Colorado Valley Pumping and Irrigation Co. equipments, and by one of the scoop wheels which is to be used finally for drainage work.

As shown by this outline, the Yuma project provides for every contingency incident to a complicated situation. It will soon make possible the irrigation of 130,000 acres, as follows:

Lands to be irrigated under the Yuma project.

	Acres.
In Arizona:	
Gila bottoms	20,000
Yuma Valley	53,000
Yuma mesa	40,000
In California:	
Reservation lands	17,000

Of this area, 6,179 acres were in crops January, 1910.

The cost of the project will be about $55 per acre, payable in ten annual installments, without interest, beginning after the project is declared open.

FARM PRACTICE.

Leveling of the land is usually necessary because of the old river channels and wind-blown dunes of silt and sand. The buck scraper is one of the most effective tools known for moving dirt by horse-power, and is well adapted to smoothing land, building levees, and constructing the wide ditches necessary to carry water in a region of

suc gradient as the Colorado Valley. The cost of leveling and constructing the necessary head ditches with a buck scr man, and four horses at $5 per day is rarely less than $20 an ac

The main crop is alfalfa, which is started easily on new lands, prompt returns, and enriches the soil. Seven cuttings are harve and with proper care should yield 7 to 12 tons of hay, salable far at $10 to $15 per ton. Crops of seed averaging 400 to 500 po per acre may be harvested. This seed is worth 12 to 17 cent pound.

Barley and corn also are grown, especially on new land, and remunerative crops. Eucalypts and date palms are among trees adapted to the district. Following alfalfa, orchards, f and vegetables can be grown to excellent advantage under inte cultivation. The rotation of alfalfa with other crops will renew soil, enable the salts, which tend to accumulate with ridge and fu cultures, to be flooded out, and arrest the plant diseases and incident to certain of these crops. The whole range of prod enumerated on page 19 is possible in the Colorado Valley region time has not sufficed to settle the details of agricultural practice

The markets at Yuma have been strong thus far, and a good ping trade with Arizona and California points is possible. Du three years of mixed alfalfa and truck farming at the Arizona Ex ment Station date orchard, the following acreages were cultivated crops having the following gross values produced:

Acreage and gross values of alfalfa and truck products produced at the Arizona Expe Station date orchard.

Year.	Acres.	Gross value of crops.
1906-7	4.73	$928.09
1907-8	5.46	1,483.43
1908-9	5.10	852.08

The amount of labor used each year was such as could be furn for the most part by an industrious family of five.

Alluvial lands below Yuma are mostly owned privately and ca purchased for $50 to $250 per acre, according to their characte distance from a railroad. A smaller area of bottoms and a area of mesa lands will be available, probably in 40-acre homest under the United States Reclamation Service restrictions whe project is complete. This district offers excellent opportuniti the homemaker having capital sufficient to purchase a small ac and the necessary horses and tools. In addition, he should have or the means of earning $500 to $1,000 the first year. The follo is a statement of expenses and income derived from the first years' operations on the station garden mentioned above.

Expenses and income for the first two years' operations on a small intensively cu ced farm.

EXPENSES.

Land, 7.2 acres, at $100 per acre	$720.00	
Survey and papers	20.00	
Leveling, by contract	124.00	
Fencing, headgate, pump, drive point, small 2-room cottage, and shelter for horses	271.00	
Team, wagon, plow, harrow, garden tools, mowing machine	615.00	
Total preliminary outlay		$1,750.00
First year: Cash for seed, water, crates, etc	127.92	
Second year:		
Seed, water, crates, etc	226.19	
Improvements	59.28	
Hired labor	72.00	
Total operating expenses for two years		485.39
Total cost		2,235.39

RECEIPTS.

Cash for produce first year	928.09	
Cash for produce second year	1,483.43	
Total		2,411.52

IRRIGATION IN THE SALT RIVER VALLEY.

Salt River Valley is at this time the largest irrigated district within the Territory. Beginning in 1867 irrigation increased rapidly, until 20 years later the unregulated stream was overtaxed by the demands made upon it in times of shortage. Since that time the most important problem of the valley has been the adjudication and management of the water supply. This problem has been solved through the operation of the reclamation law, and, with 561,024 acre-feet of water now (April, 1911) in the Roosevelt reservoir, its efficiency is demonstrated.

CLIMATE.

The climate of Salt River Valley resembles that of the Colorado Valley at Yuma, but both its frosts and summer temperatures are slightly more extreme, consequent upon a 1,000-foot higher altitude, and the absence of tempering gulf winds. The rainfall is sufficient to necessitate the protection of hay and other perishable crops, and in summer often interferes with the drying of such fruits as figs and raisins.

The severest frosts are at the lowest levels. The slopes adjacent to the Phoenix and Salt River Mountains and the high ground near Mesa are, however, so mild in winter as to admit of citrus culture. Mini-

m temperatures at the station farm, 1,090 feet altitude, take
in above the soil surface, have been observed as follows:

Minimum temperatures at the experiment station farm in the Salt River Valley.

Winter.	Records below 32° F.		Minimum record.	
	Number of frosts.	Season.	Degrees F.	Date.
1900–1901	51	Oct. 30 to Apr. 9	14	Dec. 31
1901–2	64	Dec. 8 to Mar. 27	15	Dec. 14
1902–3	70	Nov. 16 to Mar. 23	18	Feb. 16
1903–4	72	Nov. 17 to Apr. 22	14	Jan. 29
1904–5	33	Nov. 12 to Feb. 14	20	Dec. 29

Maximum temperatures, under shelter, of 111° to 117° F. in Ju
and July, were recorded at the same place each year during the ye
1904–1909. At Ingleside (1,265 feet altitude) in one portion of
citrus district, the minimum winter temperatures for the years 189
1902 were 22°, 21°, 20°, and 29° F., respectively. Hardy vegetabl
grow all winter, but the planting time for spring crops averages abo
two weeks later than in the Colorado Valley.

WATER SUPPLY.

The surface water supply, with storage, as shown on pages 43 a
44, may be developed finally to irrigate 210,000 acres, with occasion
runs of flood water in excess of this estimate. Ground waters, main
south of the Salt River, are assumed sufficient at this time to irrig
50,000 acres, and seepage waters are now utilized for the irrigati
of about 14,000 acres in the Buckeye and Arlington districts west
Salt River Valley proper.

The quality of this supply has been observed to vary from 52
157 parts of soluble salts in 100,000 parts of upstream water,
larger amount being associated with the low summer flow. T
reservoir will equalize the quality of the irrigating supply as well
its flow, a fact of advantage to localities where conditions favor
accumulation of soluble salts in the soil. Seepage waters have be
observed to contain from 118 to 182 parts in 100,000 of salts, increa
ing downstream. Ground waters pumped for irrigation have be
found to contain as high as 509 parts in 100,000 of soluble solid
The writer believes that under conditions favorable to the rise of
alkali, 100 to 150 parts of soluble solids in an irrigating water
accumulate harmfully in the course of a few years, but that with go
drainage, abundant supply, and correct cultural methods where
the rise is prevented, it is possible that even the seepage waters me
tioned above may be used without harmful effects. The extreme
509 parts is, however, dangerous in the average situation, and usual

within a few years will result in an overcharge of soluble salts in the soil. The waters of Salt River usually carry white alkali and contain calcium sulphate, which tends to neutralize the originally slightly black alkaline soils of Salt River Valley. Rare floods have been observed, however, evidently from black alkaline watersheds.

The amount of sediment is much less than in the Colorado waters, 0.05 to 12.95 tons per acre-foot of water having been observed during one year. The Roosevelt reservoir, which will retain the sediments from the Salt River proper, will lessen the amount carried upon valley lands by so much. Salt River, because of its protected watershed and its reservoir, always will afford the clearest large water supply in Arizona.

SOILS.

The soils of Salt River Valley range from heavy adobe to gravelly river wash. Loess and sandy loam soils of great fertility constitute more than half the area, while less fertile gravelly loams and sands and less easily cultivated clay soils make up the remainder. The chief need of all these soils is organic matter and nitrogen, both of which are supplied by the principal crop, alfalfa.

Alkali salts, originally slightly black in character, have been concentrated in certain localities where drainage is poor to an injurious extent through the action of irrigating waters. These salty districts, however, are all susceptible to drainage, either by sumps and pumping or by lines of tile, and will be reclaimed ultimately.

SALT RIVER PROJECT.

All of the Salt River Valley canals have been acquired by the United States Reclamation Service as a part of the Salt River project, with the exception of the Tempe and part of the Utah systems. To these three main systems using upstream waters should be added the Buckeye and Arlington canals, which water a westerly downstream extension of the main Salt River Valley with water that has returned to the river channel as seepage.

The main features of the Salt River project, concerning which full information may be obtained from the United States Reclamation Service, may be described briefly as follows:

(1) A watershed drained by the Salt and Verde Rivers, a large portion of which is protected and conserved as National Forests.

(2) Roosevelt Dam and reservoir on Salt River, with a capacity of 1,284,000 acre-feet. The dam is now complete and the reservoir has been in service since February, 1910. The McDowell and Horseshoe reservoir sites on the Verde River, with a combined capacity of 485,000 acre-feet, possibly may be developed as a part of the project

at so. .uture time. Figure 7 gives a general view taken when t dam was nearing completion. Plate III is a view of the complet dam.

(3) Electric power, already developed through a power canal, an further to be developed at the dam and at various sites in river an canals below.

(4) Pumping plants operated by electric power at points whe ground waters are economically near the surface. The excess power possible under the project may be sold for industrial purpose thus contributing to the repayment of the project.

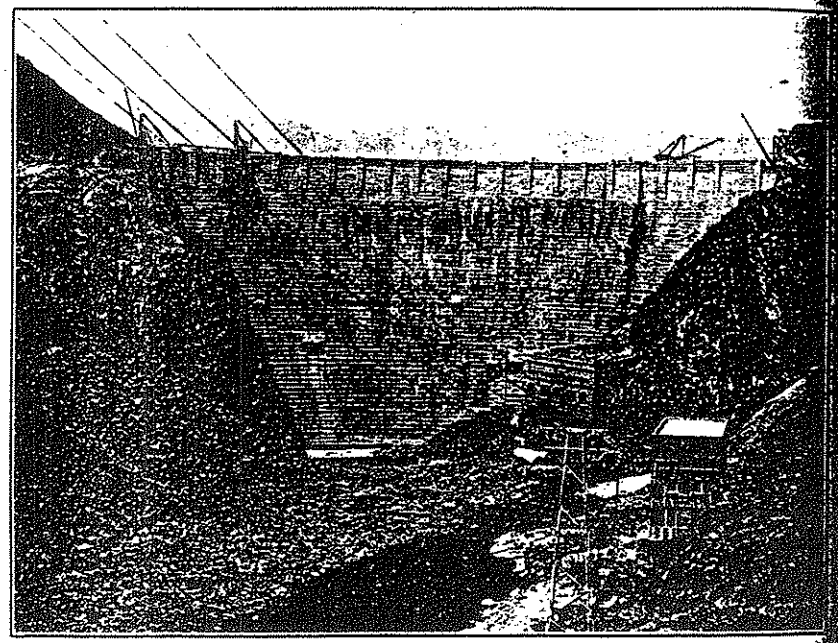


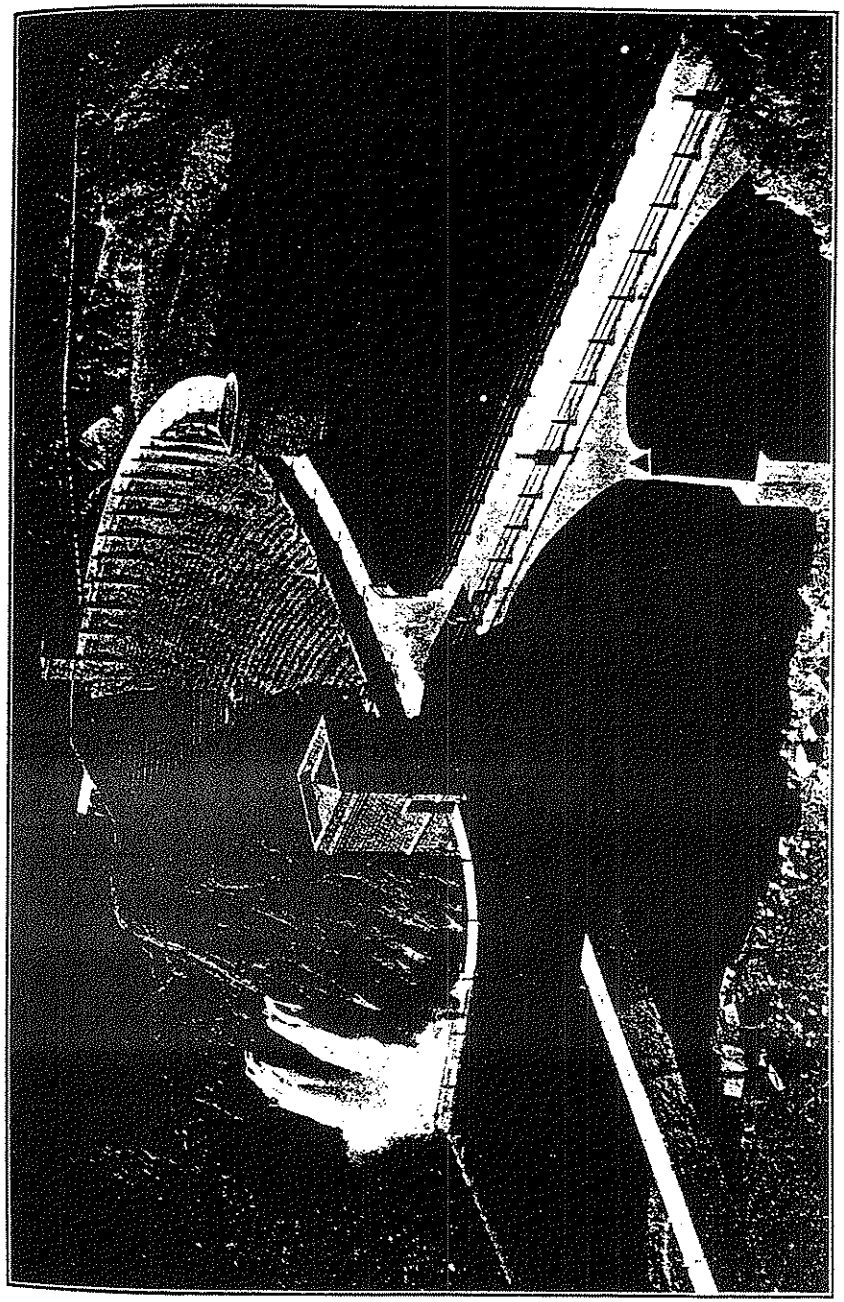
FIG. 7.—The Roosevelt Dam, nearing completion, May 10, 1910.

(5) Drainage plants operated by electric power in cultivated di tricts where ground waters have risen injuriously near the surface.

(6) Granite Reef diversion dam at the head of Salt River Valle making sure the diversion of regular river flow and storage waters irrigated lands. Temporary diversion dams, destroyed by floods an causing loss of irrigating waters at critical times, have been a serio drawback heretofore to the region.

(7) Distributing canals and laterals on both sides of Salt Riv These now (March, 1910) include main canals as follows (fig. 8):

North of Salt River: Arizona, Crosscut, Grand—appropriator Maricopa, and Salt River Valley Canals. South of Salt River: Easte and Mesa Consolidated Canals.



VIEW OF COMPLETE ROOSEVELT DAM.

This project, as outlined above, will secure the irrigation of 240,000 es, of which about 190,000 acres will be irrigated with surface ter, and not less than 50,000 acres with pumped water.

The Salt River project, as now outlined, will cost about $45 an re for the lands subscribed to the undertaking, or a total expendi- e of about $8,000,000. The income from the sale of surplus er from Salt River, however, will contribute materially to the eyment of the project and will lighten the burden of the 10 annual yments upon the shareholders.

Adding the McDowell and Horseshoe reservoir sites to the project uld make possible the irrigation of 20,000 to 30,000 acres addi- nal with surface water. The ground-water supply also, which can

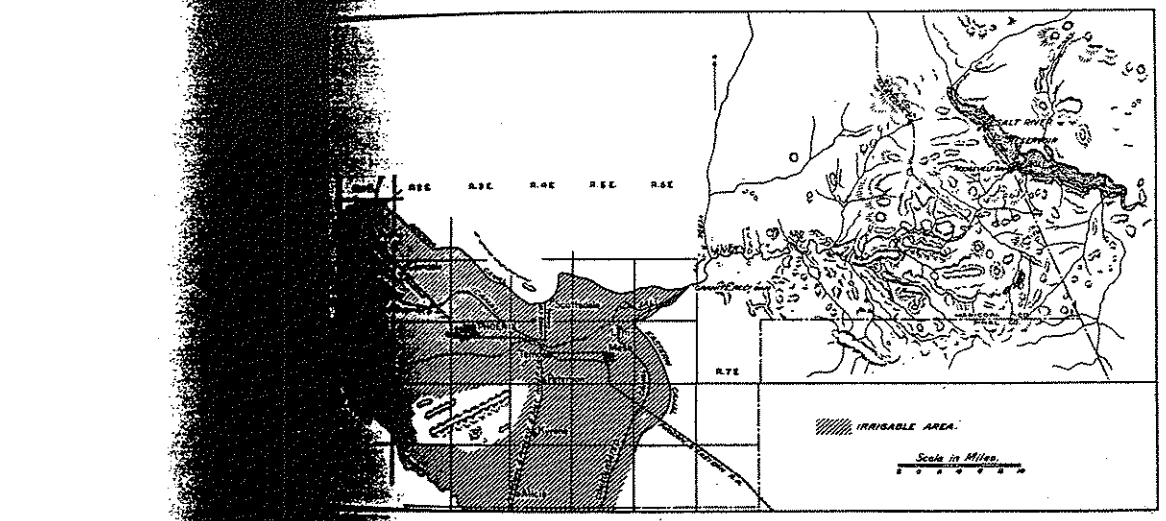


FIG. 8.—Salt River project.

y be roughly estimated at this time, is likely to prove adequate the irrigation of a greater area than that now planned. The keye and Arlington districts, while not within the Salt River oject, are benefited indirectly, as extended irrigation on upstream as will tend to increase their supply of seepage waters.

FARM PRACTICE.

Land surfaces in Salt River Valley are very smooth, requiring tle leveling, and slope from less than 10 to as much as 20 feet to mile. Such slopes afford excellent gradients for ditches, and cilitate irrigation. The average cost of bringing land under irriga- n in Salt River Valley is therefore minimum.

Alfalfa, as elsewhere in southern Arizona, is thus far the most portant crop. It yields five to six cuttings of hay, or, if desired,

produces profitable crops of seed; affords two or three months' pasturage, convertible into mutton, beef, and dairy products; endures well both extremes of temperature and periods of drought, and, above all this, enriches the soil for other crops, and therefore is peculiarly adapted to the conditions and needs of the region. Following is a fair statement of profits per acre from well-farmed alfalfa:

Cost of raising alfalfa hay and profit per acre.

COST.

Labor—making and stacking five cuttings—6 tons of hay	$9.00
Water	1.50
Labor irrigating	1.00
Incidentals	.50
	$12.00

RETURNS.

6 tons loose alfalfa in stack	42.00
2 months' pasture for two animals	6.00
	48.00
Net gain on 1 acre of hay, not deducting interest on investment	36.00

When fed to beef cattle, allowing 2 acres for three animals, the statement becomes as follows:

Cost of producing alfalfa and profits per acre when fed to steers.

COST.

Making 3 tons of hay for winter feed	[illegible]
Water	[illegible]
Labor irrigating	[illegible]
Incidentals	[illegible]

RETURNS.

900 pounds increase in weight of steers, not deducting shrinkage or allowing for loss by accident, at 4.5 cents	[illegible]
Net gain on 1 acre, not deducting interest on investment	[illegible]

Because of high prices for baled hay, often ranging to $1[illegible] in Salt River Valley in early spring, much alfalfa is sold in this form, although a considerable portion of the crop is fed and sold in the form of beef. Dairying is profitable also, and several creameries and one condensed-milk factory afford markets for the product. Range sheep are prepared for market in increasing numbers on alfalfa; bees forage upon it for honey, and even ostriches are reared with it as their main food staple.

An important, though recent, feature of agricultural [illegible] Salt River Valley is developing from the successful operation of a beet-sugar factory at Glendale. Sugar beets for the [illegible]

planted from December to February, inclusive, and harvested from June to early in August. Cowpeas may then follow the sugar beets in time to make a summer crop of 1 to 3 tons of cowpea hay, which may in turn be followed by another crop of sugar beets. Meantime the waste products from the initial crop of sugar beets may be utilized in various ways. The leaves and crowns may be piled with pulp from the factory and this carbohydrate ration fed to cattle in a balanced combination with cowpea hay from the same ground. The molasses waste may be combined also with alfalfa meal and used as a concentrated feed. The land may be cropped in this manner throughout the year, and the fertility of the soil may be maintained by the cowpeas, the irrigating sediments, and manure from the feeding pens. Incidentally, the climate makes possible the preservation of sugar-beet pulp in piles or pits in the open air, and facilitates the drying of the coarse cowpea hay. In this seemingly perfect combination of crops and conditions nothing, theoretically, is removed from the land but the sugar and the meat, the elementary constituents of which are inexhaustably available, without depletion of the soil, from the air and irrigating sediments.

Citrus culture, prospectively the most important fruit-growing industry of the valley, is confined to the slopes where orange-killing frosts do not occur. The early ripening of oranges in the region is a very favorable circumstance, the first shipments often reaching eastern markets in time for the Thanksgiving trade. The bright color and excellent quality of the fruit, due both to climatic conditions and the absence of citrus pests, is another reason for the high prices which have been received for this product. The culture of oranges and pomelos, with an assured water supply under the Roosevelt reservoir, will expand considerably in those parts of Salt River Valley where winter temperatures permit. Cantaloups are an established and remunerative crop and are marketed mainly in eastern cities through growers' associations. Ostriches are an interesting and profitable novelty of recent development. In brief, with assured water supply, a remarkable diversity of profitable crops possible, and a scientific and intensive agriculture already well under way, Salt River Valley is certain to make rapid advancement in agricultural practice and development.

Lands are nearly all in private ownership, and under the project are purchasable at $75 to $250 an acre, according to condition, character, and locality. The present tendency is toward small farms and more intensive cultivation. Reservoir water is, in fact, limited to 160 acres for any one user.

The Buckeye and Arlington districts immediately west of Salt River Valley resemble it in climate, soil, and water supply, but there

are no railroads. This fact tends to limit the people to those p
ucts which can be transported easily to market. Alfalfa seed is
of these, the yield and value of which are expressed in the follo
estimate:

Cost and profits per acre of raising alfalfa seed.

COST.		
2 tons alfalfa hay sacrificed, at $6 per ton	$12.00	
Water, 3 months' supply	.25	
Cutting and hauling	1.75	
Thrashing, 400 pounds of seed, at 3 cents	12.00	
Sacking, at 15 cents per hundred pounds	.60	
Hauling, at 25 cents per hundred pounds	1.00	
		$27.60
RETURNS.		
1 ton alfalfa straw	4.00	
400 pounds seed, at 14 cents	56.00	
		60.00
Net gain on fair average seed crop, not deducting interest		32.40

In addition to the seed crop, two cuttings of hay and winter pas
age are obtained. Much of the crop is fed to beef steers which
then driven to Gila Bend or Phoenix for shipment. Land values
moderate, ranging from $60 to $120 an acre. Being outside
Salt River project this district will not share in its cost, althoug
will be benefited by the seepage waters escaping from the u
valley. Two canals, the Buckeye and the Arlington, cooperati
owned by the farmers, serve these lands which, at present prices, w
out reservoir payments to be made, and with railroad transport
at hand, still offer excellent opportunities to incoming farmer
moderate means.

IRRIGATION ALONG THE GILA RIVER AND ITS TRIBUTARIE

The lower Gila River from Florence to Yuma is very simila
climate and soils to the Salt River Valley, but the uncertain sur
flow, the lack of storage, and a want of knowledge concernin
ground waters have thus far nearly prevented agricultural deve
ment, except under the Florence Canal.

The upper Gila River near the eastern boundary affords a w
supply adequate for the irrigation of about 23,000 acres bet
Duncan, on the Arizona-New Mexico line, and San Carlos.
district, with an altitude between 2,500 and 3,700 feet, is distin
less subtropical than the Colorado and Salt River Valleys. Wi
temperatures range as low as 8° F., a temperature which exclu
Eucalyptus and citrus trees. The hardier vegetables, such as oni
beets, and cabbage, grow through the winter season. Killing fr
for tender vegetation cease usually early in April and begin la

tober. The climate of the artesian belt, on the north slope of
raham Mountain, is somewhat milder than that of the valley
ottom.

Soils here, as in other Arizona valleys, subject to the sorting action of
ood waters, range from light sands to heavy clays. Much of the land
this district is steep and rough, and to reduce expense of leveling
ften is irrigated through furrows deep enough to carry water across
neven ground. For this purpose a homemade furrower or drag is
uch used, consisting of a heavy beam, to the underside of which are
xed four or five shovel blades or similar parts, which furrow the soil
the tool is dragged broadside across the field. The steep gradients
this district necessitate waste ditches at the lower sides of fields
carry off surface waters for use on adjacent lands.

The irrigating waters are somewhat less saline than those of Salt
River, ranging from 39 to 120 parts in 100,000 of water during one
ear's observations. Through the action of irrigating water, alkaline
alts have accumulated to an injurious extent in some localities, but
most cases these accumulations may be washed out by flooding
nd drainage.

Immense quantities of sediments are carried by Gila River floods,
ue to the eroded condition of the watershed. These sediments have
een observed to vary from 0.11 ton per acre-foot of water at a time
low flow to 128 tons during high water. Such amounts of sediment
pped in ditches necessitate expensive cleaning operations and
quire attention when deposited on irrigated fields. If allowed to
cumulate upon alfalfa or other uncultivated crops they will blanket
e soil gradually with a more or less impervious layer, which hinders
cess of water and air to the roots of the plants. Thorough cultiva-
on of soils irrigated with muddy waters is therefore an especially
portant item of farm management in the region.

IRRIGATION WORKS.

Most of the irrigating ditches of the district are small, and are owned
nd operated by individuals and by companies of farmers. The fol-
owing is a partial list of existing canals named in order from the New
exico line downstream:

Canals from the Gila River.

Duncan Valley canals.[1]—In New Mexico: Telles, Rucker, Hughes, Martin, Wilson, Hill, Schriver, Johnson.

In New Mexico and Arizona: Casper and Windham, Valley, Owen, Franklin, Model.

In Arizona: Day, Ward & Courtney, Duncan, Black & McCloskey, Waters.

[1] U. S. Geol. Survey, Ann. Rpt. 1899–1900, pt. 4, p. 336.

Solomon Valley canals:[1]

	Acres irrigated.		Acres irrigated.
Brown	100	Smithville	1
Sanchez	400	Bryce	
Mejia	320	Dodge	
Fourness	260	Nevada	
San Jose	3,000	Curtis	
Michelena	450	Kempton	
Montezuma	3,750	Reid	
Union	2,900	Fort Thomas	
Sunflower	400	Thompson	
Graham	962	Military	
Central	2,675	Saline	
Oregon	1,100	Zeckendorf	

Between San Carlos and Florence: Shields Canal, Winkleman Canal, Brannam Canal, Florence Canal.

The United States Reclamation Service has no project under construction on the Gila River and the Carey Act is not in operation in Arizona, so that water developments in this district are wholly a matter of private enterprise.

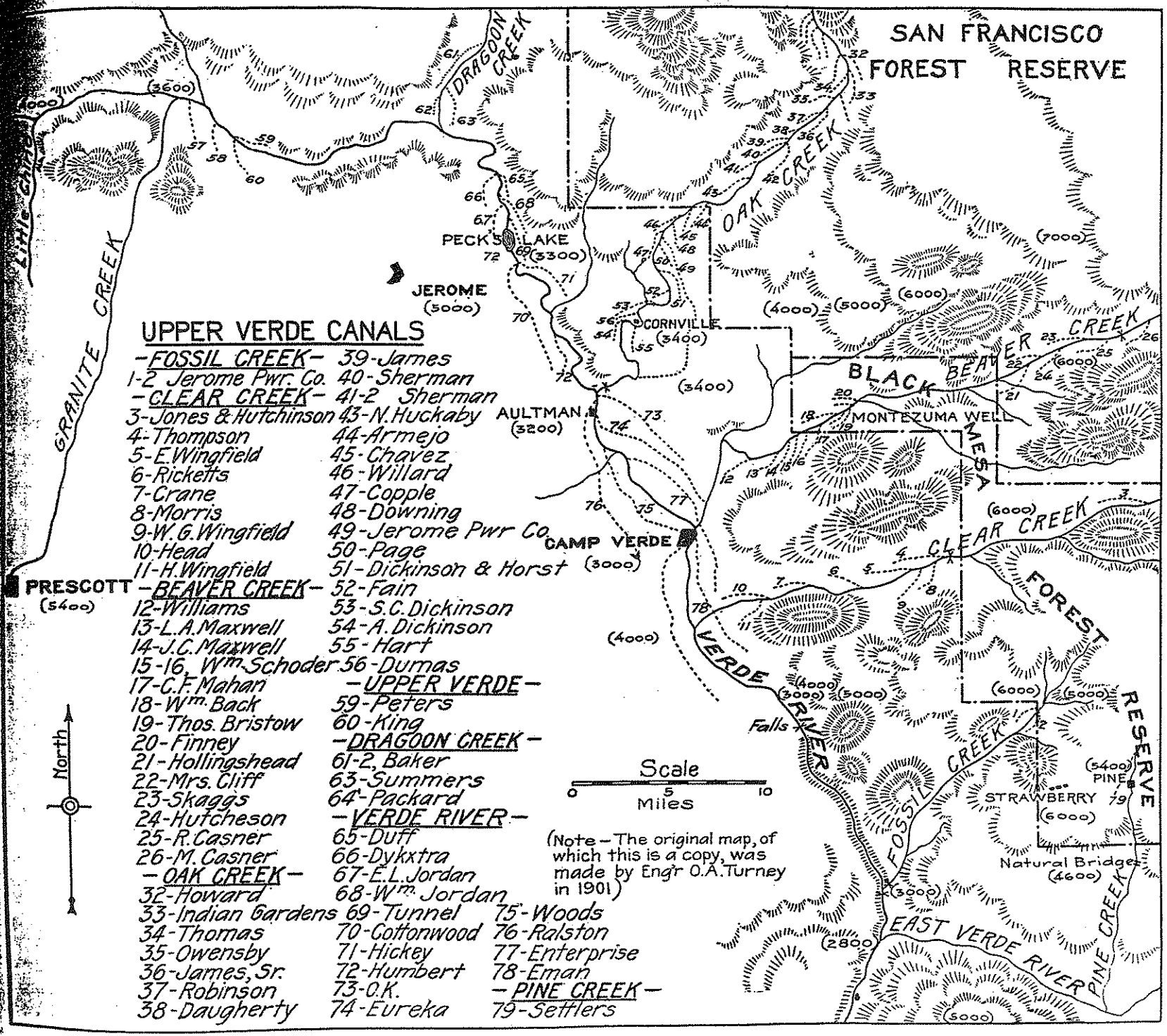
FARM PRACTICE.

Alfalfa hay is the principal crop of the district, bringing high prices in the several surrounding mining towns. Four to five cuttings are harvested, with additional pasture, and in early spring hay usually reaches $14 a ton baled, at the cars. The culture of alfalfa is developed highly on the upper Gila River. Renovators are used to break up silt accumulations and make the soil surface receptive to irrigating waters, and hay loaders, improved stacking machinery, and gasoline power balers are used. By reason of the high price of hay and the convenience with which it is made, dairying is but little followed, although with good cows it is more remunerative than the raising of hay. Other important crops in this region are oats, wheat, and barley. Deciduous fruits produce well, especially pears, peaches, and apples. Where the codling moth is under control apples of superior quality are grown and marketed in the near-by mining markets of Globe, Clifton, Morenci, Douglas, and Bisbee.

Land values are high by reason of excellent markets, high prices and limited areas under cultivation, ranging from $100 to $2[illegible] per acre. The farms are small, and the people, largely of the Mormon faith, incline toward intensive methods of farming. The Arizona & New Mexico and the Gila Valley, Globe & Northern Railroads traverse the district.

The San Pedro and Santa Cruz Valleys resemble the upper Gila agriculturally. St. David on the San Pedro, watered both by streams

[1] Fifth judicial district court decree, Feb. 10, 1906.



UPPER VERDE CANALS

—FOSSIL CREEK—
1-2 Jerome Pwr. Co.

—CLEAR CREEK—
3-Jones & Hutchinson
4-Thompson
5-E. Wingfield
6-Ricketts
7-Crane
8-Morris
9-W. G. Wingfield
10-Head
11-H. Wingfield

—BEAVER CREEK—
12-Williams
13-L. A. Maxwell
14-J. C. Maxwell
15-16, Wm. Schoder
17-C. F. Mahan
18-Wm. Back
19-Thos. Bristow
20-Finney
21-Hollingshead
22-Mrs. Cliff
23-Skaggs
24-Hutcheson
25-R. Casner
26-M. Casner

—OAK CREEK—
32-Howard
33-Indian Gardens
34-Thomas
35-Owensby
36-James, Sr.
37-Robinson
38-Daugherty
39-James
40-Sherman
41-2 Sherman
43-N. Huckaby
44-Armejo
45-Chavez
46-Willard
47-Copple
48-Downing
49-Jerome Pwr Co.
50-Page
51-Dickinson & Horst
52-Fain
53-S. C. Dickinson
54-A. Dickinson
55-Hart
56-Dumas

—UPPER VERDE—
59-Peters
60-King

—DRAGOON CREEK—
61-2, Baker
63-Summers
64-Packard

—VERDE RIVER—
65-Duff
66-Dykxtra
67-E. L. Jordan
68-Wm. Jordan
69-Tunnel
70-Cottonwood
71-Hickey
72-Humbert
73-O. K.
74-Eureka
75-Woods
76-Ralston
77-Enterprise
78-Eman

—PINE CREEK—
79-Settlers

(Note—The original map, of which this is a copy, was made by Engr O. A. Turney in 1901)

ow and by wells, is a place of gardens, the produce from w
ads a ready market in Bisbee and vicinity. The Santa Cruz Va
less developed than the San Pedro, partly because railroad con-
ctions have not been so good until recently. Summer flood
aters are utilized on both these streams for a quick-growing crop
corn planted in July and harvested in October, while in similar
nner the winter rains afford water for crops of wheat and barley
rvested in May.

About 45 small canals take water from the San Pedro River, and
obably 60 draw upon the Santa Cruz and its tributaries. The
Paso & Southwestern and the Southern Pacific Railways in the
n Pedro, and the Southern Pacific in the Santa Cruz Valley afford
nsportation facilities. Ground waters in considerable quantity
derlie both these valleys and are being developed in considerable
antity by artesian wells on the San Pedro and by pumping plants
ong the Santa Cruz.

RRIGATION ALONG THE VERDE RIVER AND ITS TRIBUTARIES.

The upper Verde River, including Clear, Beaver, Oak, and Dragoon
eeks, is distinctly a deciduous fruit-growing district, producing
finest apples, peaches, pears, and other temperate-region fruits
own in Arizona. The altitude is 3,500 to 5,500 feet; the winters
sharp, with occasional snow, and the summers milder than in the
er, lower irrigated valleys. The farms are small for the most
t, being situated in the nooks and angles of comparatively narrow
k valleys. The numerous small ditches are owned by individuals
mall companies of farmers. Alfalfa, corn, and grains are con-
erably grown under some of the large canals in the main Verde
ley. Jerome and Flagstaff afford markets for fruits and vege-
bles, and the United Verde and Pacific Railway at Jerome affords
her outlet for fruits to more distant points. (Pl. IV.)

There are a number of small tracts throughout central and south-
ern Arizona where altitude and limited water supply combine,
able for deciduous orchards and market gardens. These are
very remunerative when situated convenient to mining towns.

IRRIGATION ALONG THE LITTLE COLORADO RIVER.

The northeastern plateau, drained by the Little Colorado River, has
ltitude of 5,000 to 7,000 feet. The climate is temperate in char-
with cold winters and a summer season similar to that of
s or Kentucky. Rainfall ranges from 8 to 20 inches, but the
shed is favorable to the rapid loss of storm waters, and without
ge the irrigated area must remain small. Railroad facilities are
d to the Santa Fe, which does not connect immediately with the
irrigated settlements.

Alfalfa yields two to three cuttings a year. Winter wheat, barley are grown, and summer crops of corn. Vegetables and deciduous fruits are also successful, sometimes without irrigation, higher elevations. Farming in this district is combined with ranging of sheep and cattle. Cattle formerly predominated, in recent years sheep have become the main industry. The follow statement of operations of a representative sheep owner for year will afford an insight into expenditures and profits of business:

Beginning with November 1, 1908, with 4,000 ewes, the own account for one year is as follows:

Expenditures and profits of sheep raising.

EXPENSES.

Wages of 4 men, November to May	$1,200	
Wages of 6 men, May to November	1,800	
Wages of 8 extra men, 1 month in lambing time	400	
Buck herding	150	
Dipping once	160	
Shearing	280	
Chuck wagon and team	50	
Salt	100	
Renewal of bucks	300	
Miscellaneous items	100	
County taxes	250	
Forest reserve tax	360	
Total expenses		$5,150

RETURNS.

26,600 pounds of wool, at 16 cents per pound	4,256	
2,450 lambs, at $3 each	7,350	
		11,606
Profits, not deducting interest or owner's time		6,456

The net increase of lambs, after deducting 15 per cent taken coyotes and wildcats, was 70 per cent, or 2,800. Three hundred fifty of these were required to replace ewes lost during the se Conditions were favorable and profits high for the period st Forest Service restrictions limit the number of sheep permitte reserves and have in a measure secured the industry against l incident to overstocking.

Water storage is essential to increase of agriculture in this di which, during the 35 years since its first settlement by Mo farmers, has been developed to the full extent of its depend water supply.

In those portions of Arizona having 10 or more inches of nfall annually so-called dry-farming methods, supplemented by irrigation at critical times, will often mature crops successfully. During occasional wet seasons, as the winter of 1905, sufficient moisture falls to make crops without unusual effort on the part of the farmer, but rainfall in the Southwest is too variable in both time and amount to be depended upon. It is essential, therefore, in the average year, for the dry farmer to have available a supplementary supply, perhaps to bring up seed in a dry soil, or to mature a crop which otherwise would be lost through a failing rainfall. In practice, as it now begins to take form, this supplementary supply is secured either by small water storages possible on many sites in swales and little valleys near the crests of our watersheds or by pumping from the somewhat extensive areas of our valley bottoms, where ground water is found at 50 feet or less from the surface.

One of the largest supplies of supplementary ground water for pumping is that of Sulphur Springs Valley, which will serve as an illustration. In May, when corn, beans, melons, etc., may be planted to the best advantage, the soil usually is dry because of the preceding rainless months. A single irrigation in the seed furrows will cause germination and carry the plants until the rains begin in July. This single supplementary irrigation, therefore, even if costly, is of great value in securing an early start and a matured crop. The seeding time for wheat, barley, etc., in this valley is October, which usually is a dry month also. Supplementary irrigation at this time is similarly useful, and in many cases irrigation is required again in the spring to bring the crops to maturity. The rainfall of this and similar valleys, although in itself inadequate and untimely for the sure maturing of crops, may be utilized with the help of ground waters within easy reach of pumps.

In the ways suggested above—by conserving the rainfall, supplementing it with flood, reservoir, and ground waters, and by employing varieties suited to arid regions, considerable areas will be reclaimed gradually. This expectation is encouraged by the fact that for portions of Algeria, with similar climate and a rainfall of 10 to 16 inches per annum, recent statistics give the following productions of different kinds:

Yield of crops in Algeria.

Crop.	Production per acre.	Total product.
Wine.....gallons..	1,000	175,000,000
Wheat.....bushels..	10	24,500,000
Corn.....do....	8	58,000,000

E[illegible] at the beginning of operations in comparable locatio[illegible] sout[illegible]ern Arizona, part crops of beans, corn, sorghum, and m[illegible] indicate final success by the methods above suggested.

GRAZING RANGES.

Springs and deep wells throughout the grazing sections o[illegible] Territory are of great value, since they are the key to the adjo[illegible] range. A Hereford steer will travel about 8 miles between [illegible] and feed, so that the strategic value of occasional springs i[illegible] more arid districts is evident. For the same reason heavy ex[illegible] is incurred sometimes to secure water where there is a des[illegible] range. An instance is the Fresnal well, 786 feet deep, southw[illegible] Tucson.

The range country for the most part is used as a breeding gr[illegible] and the increase is shipped as yearlings and 2-year-old stock t[illegible] irrigated valleys of Arizona and southern California, to be fin[illegible] on alfalfa. Under the old conditions of free range without go[illegible] mental control the cattle business was a very uncertain one, [illegible] very profitable in years with abundant and timely rainfall, [illegible] disastrous in years of drought when feed and even stock wate[illegible] short. It is difficult to make a fair statement of income ava[illegible] from range cattle at this time, conditions being generally [illegible] with an outcome varying each season from serious loss to fa[illegible] easy profit, according to local circumstances affecting the o[illegible] operations.

THE AGRICULTURAL PRESENT AND FUTURE.

On the basis of present agricultural practice, of an approxim[illegible] known water supply, and of irrigation history in older State[illegible] possible to outline roughly at this time the future of irriga[illegible] Arizona.

AREAS NOW UNDER CULTIVATION.

The area actually cropped in the Territory during the yea[illegible] as ascertained by exact data for United States Reclamation S[illegible] projects, and by personal reconnaissance and correspondence f[illegible] districts, is about as follows:

Areas cultivated in 1909.

Yuma Valley, United States Reclamation Service project (January, 1910)	[illegible]
Colorado Valley, Camp Mohave to Laguna	[illegible]
Salt River Valley, United States Reclamation Service project (January, 1910)	12[illegible]
Buckeye and Arlington districts	[illegible]

	Acres.
Gila Valley from Monument to San Carlos, including Indian reservations	12,7[illegible]
Gila Valley from San Carlos to San Jose	21,000
Gila Valley from San Jose to the New Mexican line	2,700
San Francisco, Blue, Eagle, and Pinal Creeks	820
San Pedro Valley, excluding artesian waters	5,800
Santa Cruz River and tributaries	6,000
Upper Verde River and tributaries	7,650
Little Colorado River and tributaries	10,650
Miscellaneous small streams and springs	3,050
Indian lands not included above	5,000
Irrigation from mine waters	700
Artesian irrigation at St. Davids, San Bernardino, Lebanon, and Artesia	1,450
Total irrigated area	227,770

Certain of the areas included in this statement are not farmed the ear around owing to fluctuating water supply, but for irrigated nd that is actually cropped at least once a year the above total is robably within 5,000 acres, or 2 per cent, of being correct.

There are limited additional areas on higher mountain slopes d in the northern parks which are farmed on rainfall, but these robably do not exceed 10,000 acres actually cropped, even including beginnings in dry farming now under way in Sulphur Springs alley.

ESTIMATED AREA POSSIBLE TO CULTIVATE.

With a possible water supply of 4,000,000 to 5,000,000 acre- annually, the limit of intensive irrigation in Arizona may be set 00,000 to 1,000,000 acres, divided among different watersheds, proximately as follows:

	Acres.
The Colorado Valley between Camp Mohave and the Mexican line	350,000
The Little Colorado Valley	100,000
The Salt and Verde Rivers	280,000
The Gila and tributaries	140,000
Small streams and wells	30,000
Total	900,000

The use of a portion of the ground-water supply to supplement nfall will result in the cultivation of additional areas of less inten- y cultivated land of unknown extent. For gardens in towns and favorable locations, for stock water supply, and for an increasing mber of summer homes at higher elevations, there are also being veloped numerous small waters of large aggregate value. Reckon- that each two irrigated acres will, directly or indirectly, add one the population, and including those interested in range and forest dustry, the future agriculture of Arizona may easily support a

population of 500,000 people, outside of those connected
and transportation industries.

The valuation of irrigated crops produced in 1907 on abo
acres in Arizona was about $9,000,000. Allowing for
methods in large part employed, it is fair to say that unde
conditions intensive farming will result in probably twice
from irrigated lands. Five times the present area of doub
tive land will yield an annual product worth $90,000,000,
a possible output of $20,000,000 annually from grazi
would give a total for the agricultural industries of over $1
annually. This is well in excess of the mining output of th
at the present time and suggests the possibility that
Arizona, as in the once mining States of California and
agriculture will become the leading industry.

LINES OF PROGRESS.

The lines of progress along which such outcome is poss
to the legal, to the scientific, and to the social aspects of

In a region of limited water supply a thorough understand
principles of law relating to the use of water is absolutely e
harmony among irrigators and to the integrity of farm
Fortunately, the two water users' associations in the Salt
Yuma Valleys, working in cooperation with the United St
mation Service, are schools of irrigation law for those whos
included within these projects. These associations are or
compliance with the principles of beneficial use of water on
particular shares of water shall be appurtenant to specific
land; and that priority of appropriation gives the better
use of water, etc. They therefore provide for the enfor
these necessary but hitherto much neglected features of
torial law. With a constant influx to the Territory of settle
nothing of the principles governing irrigation, sustained
needed on the part of the associations of irrigators, those
for legal advice, and educational institutions, to the end th
of water may understand and observe willingly these mo
equities in the use of water.

Along scientific lines progress is variously possible and
Water conservation and development is a fundamenta
calling for engineering, mechanical, and general scientific
beginning with the watersheds and ending only when the
delivered to the irrigator. The beneficial and effective
not only requires scientific study of climate, soils, and
expertness in the irrigation and culture of crops by
Rotation of crops and advantageous methods of farm

importance in a region capable of an all-year succession of
intenance of fertility, control of alkali salts and plant
and the management of domestic animals are all factors in
ice in the region. The introduction and breeding of new
eties is of the highest importance in a region originally in
of an extremely meager agricultural flora. Almost all
forages, fruits, and vegetables of the Territory originated
ions, and the breeding of varieties especially adapted to
ons is necessary to the best use of the limited water resources.
ypes of animals, as Algerian sheep, ostriches, and white
wls, are favored to some extent also by the subtropical
nditions.

tive social development is another necessary feature of
the Southwest. The first act of an irrigator usually is to
himself with others for the purpose of constructing a ditch
priating water. Cooperation can not stop, however, with
elopment. It is equally necessary, by reason of distance
populations, to associate for the purpose of marketing
and to this end there is now a small but increasing number
rs' associations within the Territory which standardize,
ccount to their members for oranges, cantaloups, and bee
nt to distant markets. This cooperative spirit is favored
siveness of the agriculture and the consequent smallness
and the nearness of neighbors. Such communities, with
lines of travel, good roads, rural delivery of mail, and the
eetings necessitated by their canal, shipping, and other
will necessarily attain a degree of social development
e of that possible to a country of large farms without the
organization existing in an isolated irrigated region.

ion, it may be said that the Arizona farmer is fortunate:
possession of water resources adequate, when developed,
bout 1,000,000 acres and support probably a half million
an immigrant population, which, coming from every
nion and most of the countries of the world, brings with
ordinary assortment of knowledge and every phase of
and social training; (3) in the operation of State and
stitutions which are actively engaged in the development
sources and in the solution of many agricultural prob-
by this newly settled and unique region; and (4) in
n of incentives to industrial and social cooperation which
high type of rural society.

DAM THAT RIVER!

Ecology and Mormon Settlement in the Little Colorado River Basin

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UNIVERSITY PRESS OF AMERICA

Lanham • New York • London

4720 Boston Way
Lanham, Maryland 20706

3 Henrietta Street
London WC2E 8LU England

Printed in the United States of America
British Cataloging in Publication Information Available

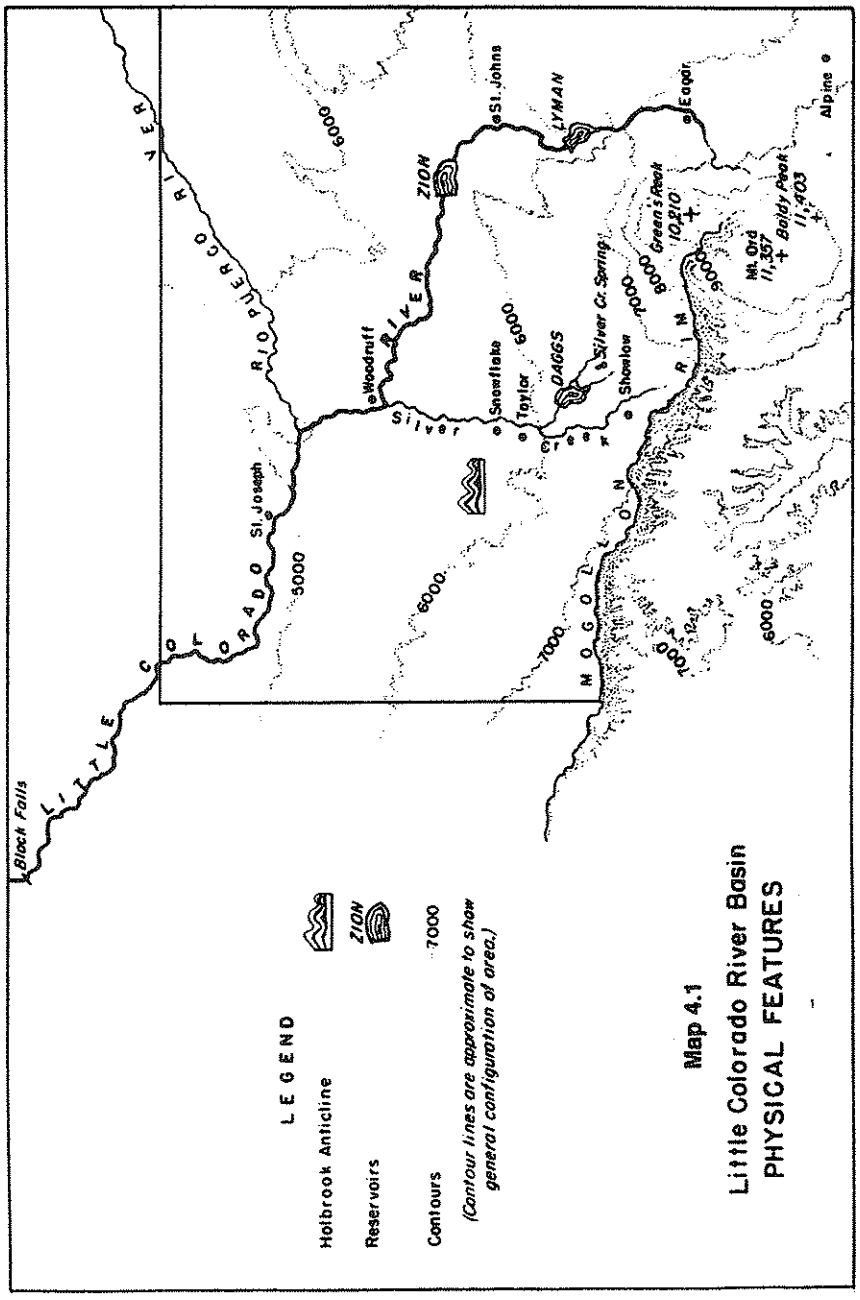
Library of Congress Cataloging-in-Publication Data

Abruzzi, William S.
Dam that river! : ecology and Mormon settlement in the Little Colorado River Basin / William S. Abruzzi.
p. cm.
Includes bibliographical references and index.
1. Mormons—Colonization—Little Colorado River Region (N.M. and Ariz.)—History. 2. Ecology—Little Colorado River Region (N.M. and Colo.) 3. Land settlement—Little Colorado River Region (N.M. and Colo.)—History. 4. Little Colorado River Region (N.M. and Ariz.)—History. I. Title.
F817.L5A25 1993 979.1'33—dc20 93–17051 CIP

ISBN 0–8191–9126–4 (cloth : alk. paper)

The paper used in this publication meets the minimum requirements of American National Standard for Information Sciences—Permanence of Paper for Printed Library Materials, ANSI Z39.48–1984.

This book is dedicated to my children,
Matt, Geof, Emily and Brian,
and to my father-in-law
William H. Reith, Sr.



has been accurately described as "a plateau which has been dissected by a major stream and its tributaries" (Harrell and Eckel 1939:28).

Climate and Weather

Topographical differences have resulted in significant spatial variation in climate throughout the study area, as altitude represents the single most important variable affecting mean annual temperature and precipitation. Because the storms which provide the major sources of precipitation enter the Little Colorado River Basin from the south, the White Mountains act as "orographic triggers" (Jurwitz 1954:12) and receive the lion's share of the moisture which these storms yield. Acting as "domes of cold air" (*ibid.*), the mountains to the south force the moist air in these storm systems to ascend; this rising air cools until the condensation point is reached and precipitation results. Since all of the Little Colorado River Basin is located on the leeward side of the White Mountains (at least with regard to the predominant southerly storm systems), specific locations within the basin receive lesser amounts of precipitation as their elevations decrease and as their distances from the mountains to the south increase (see Table 4.1). Consequently, a close association exists between altitude and precipitation along any particular longitudinal gradient. St. Johns and Springerville, located further to the east than most of the other towns under investigation, deviate from the general trend presented due to the northeastern slope of the region. However, precipitation figures at these two towns are consistent with the relation between altitude and precipitation elsewhere in the region.

Precipitation occurs within the basin primarily during the months of December through March and July through September. For many locations the remaining months may produce little, if any, precipitation. This seasonal variation in precipitation derives from the fact that weather conditions in this region (and throughout most of Arizona) result largely from two distinct storm systems that affect the region at different times of the year.

Winter precipitation is primarily determined by a high pressure system originating in the Pacific Ocean near the Hawaiian Islands.[3] This largely unstable air mass pulsates periodically, transposing its axis between a north-south and an east-west orientation. As a result, it alternates from extending eastward over the Pacific Northwest--and at times even to the Great Basin--to retreating to over 1000 miles from the continent. The recession of this "southwestern" storm systems permits the entrance of "northwestern" storms which deposit lesser amounts of precipitation.

Summer rainfall results primarily from the "Bermuda High" located off the coast of Florida which experiences pulsations similar to those described for the Pacific air mass. Beginning in the latter part of June, the Bermuda air mass moves westward, traveling great distances over warm tropical waters in the Caribbean and in the Gulf of Mexico. As this storm system crosses land, its "moist river of air is exceptionally deep, at times extending to the fifteen and twenty thousand foot levels" (Jurwitz 1954:12). Much of this moisture is released upon contact with the White Mountains.[4]

Table 4.1

Elevation and Precipitation for Selected Locations in the Little Colorado River Basin

Month	Mean Precipitation (in inches)						
	Winslow (4850')	Holbrook (5075')	Snowflake (5582')	St. Johns (5725')	Showlow 5331')	Springerville (6965')	Lakeside (7054')
January	.56	.62	.69	.67	1.78	.50	1.99
February	.40	.61	.84	.57	1.38	.53	1.97
March	.47	.60	.85	.78	1.81	.49	1.98
April	.46	.54	.68	.53	.79	.46	1.37
May	.26	.27	.45	.42	.49	.46	.61
June	.36	.40	.62	.45	.46	.57	.56
July	1.62	1.85	2.39	2.27	2.47	3.23	4.36
August	1.71	1.42	2.57	2.23	2.38	2.84	2.98
September	.78	.94	1.35	1.30	1.73	1.33	1.72
October	.52	.69	.89	.66	1.23	.78	1.78
November	.52	.72	.61	.56	1.41	.62	1.39
December	.93	.59	.68	.75	1.71	.66	1.73
Total	3.59	9.25	12.62	11.19	17.64	12.47	22.44

SOURCE: Harrell and Eckel (1939).
NOTE: Since they are situated in the same valley and at similar elevations, meteorological information collected at Springerville is applicable to Eagar. Close proximity also results in comparable precipitation data for Snowflake and Taylor. Also, because St. Joseph and Woodruff are located near Holbrook, climatological data for Holbrook may be considered representative of that for these and other lower valley settlements.

Winter precipitation has been more significant than summer rainfall in terms of its contribution to agricultural productivity in the region, even though at the lower elevations the relative abundance of summer precipitation increases significantly (see Table 4.2). Summer precipitation generally occurs through brief, spotty and torrential thunderstorms which unleash a flood of water for short periods of time. However, due to the intense nature of these summer storms, soils quickly become saturated and unable to retain much of the moisture they receive. Consequently, most summer precipitation streams down well-worn arroyos, carrying with it soil particles which are then deposited into river channels. Prior to the introduction of farming, most of this silt either settled in riverbeds at lower elevations, or was deposited into the Colorado River. The remarkable scenic beauty of the Painted Desert (which is located along the northern perimeter of the Little Colorado River Valley) derives largely from the erosive impact of these summer storms. However, with the introduction of agriculture into the basin, much of this silt has accumulated in irrigation reservoirs or settled upon agricultural lands. In either case, the extensive silting of streams produced by summer storms has exacerbated the cost of farming in this region (see below).

Table 4.2

Relative Contribution of Winter and Summer Precipitation at Selected Locations in the Little Colorado River Basin

Location	Winter Precipitation (in inches)	Percent of Total	Summer Precipitation (in inches)	Percent of Total
Lakeside	10.43	46.5	12.01	53.5
Springerville	3.26	26.1	9.21	73.9
Showlow	8.88	50.3	8.76	49.7
St. Johns	3.86	34.5	7.33	65.5
Snowflake	4.35	34.5	8.27	65.5
Holbrook	3.68	39.8	5.57	60.2
Winslow	3.34	38.9	5.25	61.1

SOURCE: Table 4.1.

Winter precipitation contributes more to the regional ecosystem than its relative abundance would suggest. While approximately 50% of the annual rainfall over much of Arizona is received during the months of December through March, runoff into reservoir systems due to winter storms accounts for nearly 85% of annual values (Jurwitz 1954:10). Because winter precipitation is deposited more

Both juniper and piñon are short, woody types of vegetation which, due partially to their shallow root systems, dominate in rough, broken country with shallow soils (Harrell and Eckel 1939:27). Density of tree cover increases with precipitation, as does the proportion of piñon in the juniper-piñon woodland community. Thus, both plant density and the relative proportion of piñon increase along a southerly gradient until a transition occurs near 6,000 feet to the montane forest community dominated by ponderosa pine. Due to variation in precipitation, an east-west gradient also exists in woodland density and in the proportion of piñon pine. While tree density in the St. Johns area averages only 10 trees per acre, 30 trees per acre is the mean near Snowflake (Salt River Project 1974 [section 3]:79, 99), which is located at the same approximate latitude and elevation as St. Johns.[8]

Table 4.4

Area and Relative Proportion
of the Four Principle Plant Communities
in the Little Colorado River Basin

Plant Community	Area (in acres)	Percent of Total
Northern Desert	169,200	3.6
Grassland	1,922,027	41.2
Juniper-Piñon Woodland	1,797,004	38.5
Montane Forest	776,401	16.6
Total	4,664,632	99.9

SOURCE: Little Colorado River Plateau Resource Conservation and Development Project (1972).
*Total does not equal 100% due to rounding error.

The montane forest community begins as juniper-piñon woodland gives way to ponderosa or yellow pine. The transition from woodland to forest occurs quickly as elevation in the southern highlands increases sharply. Ponderosa pine is the dominant species in this community up to an elevation of about 8,000 feet, after which aspen and Englemann spruce dominate at succeedingly higher elevations. Alpine meadows occur over extensive areas above 9,000 feet.

The ponderosa pine community in this region is part of the largest continuous stand of ponderosa pine in the United States. Beginning north of the Grand Canyon, this forest stretches in a southeasterly arc through the area under investigation and into western New Mexico. Because of its particular suitability for lumber, the local ponderosa pine community is presently the center of an active lumber and wood-related industry. While logging and lumber production have always been important economic activities locally, most of the large-scale lumber-related activities post-date World War II. As late as 1936, 96% of the ponderosa pine in the study area was estimated to be virgin timber. Several towns in the region have depended significantly upon the lumber industry.

The alpine meadows which dot the higher elevations have continuously provided an integral link within the agricultural cycle of communities in the region. These meadows have been employed for the summer grazing of cattle (and previously sheep) at least since the initial settlement of the area by Mormon pioneers. The availability of summer pasture at higher elevations (which is currently regulated by the National Forest Service)[9] ultimately determines the number of livestock which the region can support. Dependence solely on the grassland and juniper-piñon woodland communities would not permit economically viable animal densities.

These four biotic communities account for nearly 100% of the surface area in the Little Colorado River Basin.[10] While the grassland and juniper-piñon woodland communities together account for nearly 80% of the total land area, each of the four zones has had its unique impact on the history and development of communities in the basin.

Soils

The complex geological history of the Little Colorado River Basin has produced a diverse variety of soils in the region (see Kester, *et al.* 1964; Miller and Larsen 1975). Because considerable micro-regional differences exist in soil composition, generalizations have only limited applicability. However, with this caveat in mind, soils within the basin may be grouped according to their physiographic position, including: (1) soils of the flood plains and low alluvial fans, (2) soils of old alluvial fans and terraces, and (3) soils of the uplands (Kester, *et al.* 1964:7). Except for soils in the flood plains (which do not normally extend for more than a mile on either side of the Little Colorado River) and those at higher elevations (within the montane forest community), soils throughout most of the basin are thin and loamy. The productive capabilities for individual crops of the specific soil types discussed are presented in Table 4.5.

The soils of Joseph City (Jocity soils) are primarily alluvial in origin and lie north of the Little Colorado River on nearly level to moderately sloping alluvial fans and river terraces (see Kester, *et al.* 1964:22-23). Originating from the Moencopi formation (Bureau of Reclamation 1950:3), these soils have also received parent material derived from alluvium washed down from the deposits of Chinle shales located in the badlands of the Painted Desert, as well as from beds of fine gravel, sand and loam (Kester, *et al.* 1964:22). Jocity soils are deep, and their profile is characteristically clay loam throughout. Due to the important silt and clay composition of these soils, they provide low permeability, and are thus particularly susceptible to flooding during intense summer precipitation.

Having developed under dry climatic conditions, these soils are also typically low in organic matter and are deficient in nitrogen and phosphorus. Furthermore, since both the Moencopi and the Chinle formations contain large concentrations of alkali salts, soils in the vicinity of Joseph City (St. Joseph), particularly those which have been irrigated, contain sodium in quantities sufficient to inhibit--even preclude--healthy plant growth (Bureau of Reclamation 1950:3-4). The increased salinity and silt deposition caused by irrigation has only aggravated problems inherent in Jocity soils prior to human exploitation (see Abruzzi 1985:261).

Table 4.5

Average Estimated Optimal Yields of Principal Crops
Grown on Selected Soils under Prevailing Management Conditions

Soil Type	Wheat (bushels)	Barley (bushels)	Oats (bushels)	Corn (tons)	Alfalfa (tons)
Bagley	45	50	50	17	6.5
Clovis	60	--	70	23	6.0
Eagar	25	--	36	17	2.0
Jocity	--	45	--	11	5.0
Luth[a]	--	--	--	--	---
Navajo	--	--	--	10	4.0
Showlow	22	--	50	10	3.5

SOURCES: Kester, *et al.* (1964:61-62); Miller and Larsen (1975:39).
NOTE: No entry indicates that the crop listed is either not suited to the soil or is not commonly grown on it.
[a]No figures are given by Miller and Larsen for any of the crops listed on Luth soils. The only harvest data provided for these soils is for wheat and oats produced for hay. These figures were 1.0 and 1.5 tons per acre respectively.

The predominant soils under cultivation at Woodruff are of the Navajo series. Navajo soils comprise reddish-brown, calcareous clay reaching a depth of more than 60 inches. Located on nearly level to gently sloping flood plains along the Little Colorado River, these soils derive from a parent material consisting of alluvium washed from shale, sandstone, limestone and basalt. Navajo soils are typically low in fertility, moderately well-drained and very slowly permeable. Navajo soils in the vicinity of Woodruff were apparently moderately saline prior to the introduction of irrigation. However, the continued application of clear water

from Silver Creek has leached much of the salts contained within the root zone of most crops (see Kester, *et al.* 1964:28-29).

The soils in the gently sloping floodplains near Snowflake and Taylor are primarily of the Bagley series (see Kester, *et al.* 1964:11-13). Derived mainly from sandstone, limestone, shale, basalt, volcanic cinders, sand and gravel, these soils are well drained. Brown to light brown in color, the surface soil is either clay loam, loam or sandy clay loam in most places. Kester, *et al.* (1964:11) describe these soils as follows:

> The Bagley soils are among the most fertile and productive in the Area. They are well-drained, are moderately permeable, and have a high water-holding capacity. Runoff is very slow to slow. All except Bagley loam have an extremely stable, granular structure in the surface soil and do not erode easily.

Soils in the vicinity of Snowflake and Taylor are also generally free from harmful accumulations of soluble salts even after a century of continuous irrigation. (Bureau of Reclamation 1947:42; Salt River Project 1974 [section 3]:78).

Soils in the vicinity of St. Johns are of the Clovis series (see Miller and Larsen 1975:10-12). These are generally well-drained soils formed in sand and gravelly alluvium derived from quartzite, gneiss, schist, sandstone and limestone. The Clovis soils near St. Johns are sandy clay loam. Runoff in these soils is medium, as is the hazard of erosion. The topsoil, subsoil and underlying material are all generally categorized as of moderate alkalinity. (Miller and Larsen 1975:10). Permeability and available water capacity are also rated as moderate (*ibid.*).

Due to greater precipitation and denser vegetation, soils at higher elevations in this region are not characteristic of the arid Southwest. They resemble more closely soils found in the northeastern part of the United States than they do the neighboring soils at lower elevations (Greenwood 1960:39). Soils of the Showlow series are the most extensive soils in the region, and are found at many locations in the montane forest community (see Kester, *et al.* 1964:34-37). Showlow soils are deep, built upon a parent material of alluvium and contain large amounts of sand, gravel and cobbles. These soils are slowly permeable, well-drained and have a good water-holding capacity. Because of their greater organic content, Showlow soils are rated as moderately fertile, and on soils with less than a 3 degree slope the erosion hazard is slight.

The principal soils under cultivation in the vicinity of Eagar are of the Eagar series, which comprise well-drained soils formed in a gravelly alluvium derived from basic tuff (see Miller and Larsen 1975:12-13). The surface layer of Eagar soils is dark grayish-brown and dark gray gravelly loam about 9 inches thick (about 15 inches thick where the slope is less than 3 degrees). Permeability is moderate and the water-holding capacity is generally low in these soils. A temporary water table occurs in some irrigated areas during the growing season

due to overirrigation and normal ditch losses. Eagar soils are also moderately alkaline and calcereous throughout. Runoff is medium with a moderate hazard of erosion.

In Bush Valley, the location of Alpine, the primary soils are of the Luth series (see Miller and Larsen 1975:19). The Luth series consists of poorly drained soils that are formed in alluvium derived from basic tuff. These soils are generally found in narrow flood plains within mountain valleys. Their surface layer is typically dark gray clay loam and clay about 18 inches thick. The soils of this series are slightly acid in the surface layer, though mild to moderately alkaline in the underlying material. Permeability is high, as is available water capacity.

A final comment regarding the physiological structure of the basin is warranted. Perhaps the most important geological development within the region, at least from the perspective of establishing viable agricultural communities in the area, was the rise of the Mogollon Geanticline and the subsequent volcanic activity that occurred (see Harrell and Eckel 1939; Babcock and Snyder 1947; Greenwood 1960; Akers 1964; Dames and Moore 1973; and Salt River Project 1974 for discussions of the geological history of the region). This uplift created the higher elevations which form the southern boundary of the basin and which enhance the physical diversity of the region. By creating an "island of humid climate" (Greenwood 1960:19) in an otherwise arid environment, several distinct floral communities were established. More importantly, increased water supplies became available to both surface and sub-surface sources. In addition, the uplift and subsequent erosion produced deep narrow canyons in the southern portion of the basin which made the construction of storage reservoirs possible.[11] The topography of the southern half of the region contrasts markedly with that of the northern half, where few adequate sites exist for the storage of irrigation water. Consequently, settlements in the lower valley of the Little Colorado River had to rely exclusively on diversion dams rather than storage reservoirs as the principal infrastructural supports of their agricultural systems. In contrast to farmers at Snowflake, St. Johns and other Mormon towns to the south, those in the lower valley towns (such as St. Joseph and Woodruff) remained at the mercy of an unpredictable and highly variable river which regularly ceased flowing during a critical period in the agricultural cycle.

WATER

The role that variation in the abundance and distribution of suitable irrigation water played in the development of agricultural communities in this region cannot be over-emphasized. The availability of good-quality water functioned as a critical limiting factor governing the development of stable agricultural communities, and variations in the supply of usable water were closely associated with local fluctuations in population size.

Water presents itself to the basin in three forms: precipitation, surface flow and groundwater, and has provided in each form a distinct impact on community productivity and stability in the basin (Abruzzi 1985). These three water sources are necessarily interrelated. Precipitation is the ultimate source of water supply for the region as riverbeds and underground aquifers depend on rain and snow for their water. However, while the contribution of water in the form of precipitation is largely limited to its immediate area of deposition, that water which finds its way into river channels and into underground streams provides an impact far beyond the limits of its initial ingression. Due to the differential impact and local availability of these three forms of water, each should be treated independently as a distinct condition affecting community development in the region.[12]

Precipitation

The previous discussion has already demonstrated that considerable spatial and temporal variation exists in precipitation throughout the basin. However, two additional comments regarding precipitation warrant consideration at this time. First, the specific pattern of its temporal variation renders precipitation an inadequate primary source of water for the support of farming activities throughout most of the basin. The onset of the summer storms, which usually begin in July, occurs too late to autonomously support the agricultural cycle, because a substantial proportion of the annual irrigation requirements (about 45%) need to be applied to fields during the dry months of April, May and June (see Table 4.6). Thus, much of the growing season transpires during the spring dry season when insufficient precipitation occurs to facilitate the germination and growth of healthy crops.

Secondly, precipitation cannot provide a reliable source upon which to base an agricultural system, because most summer rainfall occurs in the form of scattered, torrential and unpredictable storms. Such precipitation finds its way either into the various river channels or into underground aquifers. Since most of the water which enters the basin as precipitation is ultimately lost to the local system,[13] any attempt to establish agricultural communities dependent primarily upon precipitation would be doomed to failure.

Surface Water

Surface-water flow throughout the basin, being a function of precipitation and ambient air temperature, follows a generally regular annual cycle (see Figure 4.1). Due to the existence of substantial snowpacks in the upper watershed (see Table 4.7), intermittent warming intervals, combined with precipitation, produce moderate runoff in most river channels during the months of January, February and March. Gradually, this flow subsides as the snowpacks disappear, and by late May and early June most streambeds throughout the basin are dry.[14] With the onset of summer storms in July, the volume and velocity of water flow in the river beds increases dramatically.[15] The passing of summer storms and the consequent

decline in precipitation throughout the region causes runoff to subside again until snow re-accumulates at the higher elevations and is once more deposited in streambeds through sporadic intervals of mild temperatures.

Table 4.6

Monthly Distribution of Diversions
from Daggs Reservoir
1946

Month	Percent of Annual Water Diverted from Silver Creek
January	2
February	2
March	5
April	13
May	15
June	17
July	16
August	12
September	9
October	5
November	2
December	2
Total	100

SOURCE: Bureau of Reclamation (1947:72).

Due to the marked eccentricity of temperature and precipitation in the basin, significant deviations from the described cycle may occur during any particular year. For example, monthly discharge in the Little Colorado River at Holbrook for the years 1905-07 displayed significant variation for the same month during different years (see Table 4.8). Similarly, Lyman Dam and Reservoir, which is located 4 miles south of St. Johns and which contains a storage capacity of 20,600 acre-feet, received an average annual discharge of 18.7 cubic feet per

second (approximately 13,540 acre-feet per year) for the years 1940-1957 (Akers 1964:7). Analysis of surface water discharge into Lyman Reservoir revealed that during this period actual discharge ranged from 16,000 cubic feet per second to at times no discharge at all. Furthermore, storage within the reservoir ranged from an overflowing 25,500 acre-feet in May of 1941 to several occasions when reservoir was completely dry due to the discharge being below the amount of water expended for irrigation (*ibid.*).

Because surface water flow in the region varies in direct response to precipitation, the volume and velocity of water flowing in a riverbed may change dramatically from one week--indeed, one day--to the next. Several streams, most notably the Little Colorado at lower elevations,[16] have been transformed within hours from dry sandy riverbeds to raging torrents, destroying bridges, dams and other obstacles in their path.[17] While the mean seasonal flow of water in the Little Colorado River near Holbrook is 309 cubic feet per second (Dames and Moore 1973 [section 4]:143), the U.S. Corp. of Engineers has calculated that during the peak flood of September 19, 1923 the discharge was 60,000 cubic feet per second (*ibid.*). Similarly, the maximum flow at Holbrook during the flood of 1915, when Lyman Dam above St. Johns burst,[18] is estimated to have been as high as 189,000 cubic feet per second (*ibid.*).

The responsiveness of surface-water flow to the vagaries of precipitation in the basin is also illustrated by the extreme variation in annual discharge in the Little Colorado River at specific locations in the region. While the average annual discharge of the Little Colorado at Woodruff for the period 1940-1947 was 86,000 acre-feet, during 1944 annual water flow at this location totaled only 20,000 acre-feet. During 1944, however, the volume of water discharged near Woodruff was 280,000 acre-feet, or nearly 15 times the 1944 figure, (Bureau of Reclamation 1950:7). Similarly, discharge figures for the Little Colorado River at Holbrook (a few miles downstream from Woodruff) for the years 1950-1969 show a range of variation from less than 16,000 acre-feet during 1950 to nearly 200,000 acre-feet during 1968 (see Dames and Moore 1973:Plate 4.4.3-4; see Figure 4.2). Streamflow figures at St. Johns for the years 1930-1944 exhibit the same pattern of variation.[19] The average annual discharge during this period was 8,430 acre-feet.[20] This average, however, masks a variation of between 2,790 acre-feet for 1942 and 50,010 acre-feet during 1941. Averages, thus, have little meaning where variation is both so pronounced and so pervasive.

Because most streams in the region (including the Little Colorado at lower elevations) are ephemeral and flow largely in response to rainstorms, most contain considerable quantities of sediment, especially during periods of heavy flow. Heavy sediment concentrations are particularly characteristic of streams in the northern portion of the study area. At these lower elevations with their alkaline soils, sediment loads may account for as much as 20% of stream low (Bureau of Reclamation 1950:3). Even Silver Creek, which originates from a clear mountain spring, acquires an increased sediment content as it descends towards the Little Colorado and receives water from its own tributaries along the way (see Map 4.3).

Table 4.8

Monthly Discharge of the Little Colorado River
at Holbrook, Arizona
March 1905 - April 1907
(in acre-feet)

Month	1905	1906	1907
March	25,700[a]	38,200	27,300
April	54,400	14,600	23,900
May	- - -	3,320	- - -
June	4,290	244	- - -
July	4,180	1,530	- - -
August	10,000	4,400	- - -
September	18,000	4,090	- - -
October	3,120	1,640	- - -
November	69,000	672	- - -
December	6,950	11,100	- - -
January	27,800	17,000	- - -
February	9,440	9,780	- - -

SOURCE: LaRue (1916:108-109).
[a]Discharge for March 17-31 only.

Due to their intimate association with the founding and development of most early Mormon settlements in the basin and with the history of the region as a whole, two streams deserve specific consideration. These are the Little Colorado River and Silver Creek, its principal tributary in the study area.

The Little Colorado River

The Little Colorado River begins as two small mountain streams created by snowmelt originating on Mount Baldy. This water, sparkling clear and cold, flows rapidly as it descends the steep slopes of the White Mountains. At this elevation, salt and other sediment concentrations in the river are practically nil (Greenwood 1960:85). Before reaching Springerville and Eagar, the river flows through a channel which alternately widens and narrows and contains several locations

suitable for irrigated farming were the growing season of sufficient average duration.

Between Springerville and St. Johns the Little Colorado flows in a narrow, shallow channel bordered by willows, cottonwoods and saltgrasses with an average gradient of 37.6 feet per mile (Harrell and Eckel 1939:29).[21] A perennial flow exists in the Little Colorado south of St. Johns, being sustained by several large springs in this area (Akers 1964:8).

Below St. Johns the river changes dramatically. The gradient declines sharply to around 10 feet per mile (*ibid.*:28) as the Little Colorado changes direction and begins its northwesterly flow, bisecting the basin. At this point, the river opens into a flat and sandy channel. Surface flow becomes intermittent, with most of the flow during the late spring being confined to subsurface channels. The Little Colorado retains this appearance until well after it leaves the region. The river channel near Holbrook and Joseph City has been described as

> broad and alluviated. Typical of such streams, it continually abrades its channel and redeposits the transported material downstream. As a result, the channel conditions change from time to time, such that there is no stable relationship between the stage of the river and its discharge. At present, the channel is over 100 feet wide...and is 5 to 10 feet deep. The banks are lined with riparian plants, such as salt cedar and mesquite. (Dames and Moore 1973 [section 4]:41)

Water quality in the Little Colorado south of St. Johns is quite good. However, as this water flows downstream, traversing high salt-bearing formations and acquires additional water from numerous tributaries originating in these saline strata, its purity is quickly lost. Water quality in the Little Colorado River is of questionable value below St. Johns, where the concentration of both suspended and dissolved solids (particularly soluble salts) renders it largely useless for domestic, agricultural or even industrial use (see Tables 4.9[22] and 4.10).

Located some 15 miles downstream from St. Johns are Zion Dam and Reservoir. Originally built between 1902 and 1905, Zion Dam was reconstructed in 1908 with a reservoir capacity of 12,896 acre-feet and a surface area of 2,048 acres (Akers 1964:8-9). By 1952, 22,700 acre-feet of sediment had been deposited behind the dam, reducing its storage capacity to 760 acre-feet (*ibid.*). Continued silting has terminated the use of this reservoir.[23] Sediment buildup has even significantly reduced the storage capacity of Lyman Reservoir, 5 miles south of St. Johns.[24]

Stream flow variability in the Little Colorado becomes more pronounced downstream, as the quality of its water deteriorates, because the river drains an increasingly larger area, and a greater proportion of its flow derives from tributaries originating to the north. Most of the water emanating from these less desirable northern tributaries enters the Little Colorado during intense summer storms and, thus, predominates in the stream at the height of the irrigation season.

These waters almost always contain excessive amounts of sodium salts and other sediment, with a large portion being particularly fine-textured silt derived from shale (Bureau of Reclamation 1950:9).

Table 4.9

Suspended Sediment Concentration
in the Little Colorado River
at Cameron, Arizona
1969

Date of Sample	Suspended Solids Concentration (mg/l)[a]
January 30	27,800
March 27	19,700
July 22	99,500
August 26	56,800
X	51,000

SOURCE: Dames and Moore (1973 [Section 4]:151).
[a]Milligrams per liter.

The sediment load carried in the Little Colorado River near Holbrook and Joseph City is always high, prompting its description as "red, turbid and unaesthetic" (Dames and Moore 1973 [section 4]:149). Dissolved solids normally exceed 500 mg/l during average discharge conditions. During periods of high evaporation, however, dissolved solids increase to values greater than 1,000 mg/l (*ibid.*:149). Such water is only suitable for irrigating salt-tolerant crops in well-drained soils.

Silver Creek

While not necessarily providing perennial abundance, Silver Creek, in marked contrast to the Little Colorado River and other local streams, presents at least a picture of persistent moderation. It does not portray the regionally-distinctive extremes of excess and privation. In addition, chemical analyses have consistently determined the waters in Silver Creek to be relatively pure and free from the heavy concentration of salt and other solids which plague the Little Colorado and its other tributaries.

Table 4.10

Chemical Concentrations at Selected Sites
along the Lower Valley of the Little Colorado River

Site Location	Total Solids Concentration (mg/l)	Sodium (Na)[a] Concentration (mg/l)
Holbrook	868	185
Penzance 1	507	98
Penzance 2	682	130
Havre 1	2,340	728
Havre 2	877	200
Winslow 1	3,060	984
Winslow 2	2,340	719
Winslow 3	2,030	610
Winslow 4	2,080	636

SOURCE: Dames and Moore (1973[section 4]:148).
NOTE: Site locations are as follows:

Penzance 1 and 2 are two miles west of Holbrook.
Havre 1 and 2 are twelve miles west of Joseph City.
Winslow 1 and and 2 are four miles east of Winslow.
Winslow 3 is two miles east of Winslow.
Winslow 4 is five miles north of Winslow.

[a]Figures for sodium concentration also include Potassium (K). However, a chemical analysis of Little Colorado River water near Woodruff shows the concentration of potassium to be quite small, 3.48 mg/l on the average.

Originating from a spring located about 10 miles southeast of Snowflake and Taylor, Silver Creek comprises the only fully-perennial stream in the Little Colorado River Basin. Silver Creek Spring, which actually discharges water from several neighboring locations, is the largest spring in the entire region, with a rate of flow estimated at 11 second-feet (cubic feet per second; Harrell and Eckel 1939:67) and ranging between 8 and 13 second-feet (Bureau of Reclamation

1947:13). The average annual discharge in Silver Creek downstream from Snowflake for the 21 year period between October, 1950 and September, 1971 was 11,600 acre-feet (Salt River Project 1974 [section 3]:283).

More significant than its annual discharge is the stability displayed by Silver Creek Spring. Harrell and Eckel (1939:30) reported an inability to locate even one account of failure in the flow of water from this spring, "even in the most severe drought." A Bureau of Reclamation (1947:50) study of the Snowflake area corroborates the finding of Harrell and Eckel, stating that "local information covering a period of nearly 50 years indicates that there is little variation in the flow" of Silver Creek Spring. This same report (*ibid.*:87) alludes to a sworn statement dated August 25, 1904 (at the end of a six-year drought in the basin) that the flow of water in Silver Creek was 13.5 second-feet, and concludes that

> although lower flows of Silver Creek have been recorded in recent years, it is evident that the springs feeding it provide a base flow relatively unchanged by drought.

One important consequence of the stability of Silver Creek Spring from the perspective of establishing viable agricultural communities has been the reliability of available water in the stream that it produces. While Silver Creek, like all other streams, is responsive to variations in snowmelt and precipitation, an ostensible lower limit of water availability exists in its channel, making Silver Creek a substantially more dependable source of surface water than any other stream in the Little Colorado River Basin (see Table 4.11). The degree of variation displayed by the flow of Silver Creek into Daggs Reservoir differs sharply from that of the Little Colorado River either at St. Johns or in the Lower valley, in both its monthly and annual discharge figures. While the relative stability of annual discharge in Silver Creek has provided sufficient predictability upon which to base agricultural activities from one year to the next, the stability associated with its monthly discharge has resulted in a reliable flow of water during the critical dry months of April, May and June. No report exists which indicates that Daggs Reservoir has ever been completely dry due to insufficient flow in Silver Creek.

Downstream, near Woodruff, the picture of Silver Creek changes. Because much of Silver Creek's water is expropriated by Snowflake, Taylor and Shumway,[25] and because its drainage area increases markedly at lower elevations, annual and monthly differences in discharge become more pronounced, approaching the fluctuations characteristic of the Little Colorado River (see Tables 4.12, 4.13 and 4.14). While annual discharge in Silver Creek for the years 1942-1944 averaged 13,000 acre-feet at Daggs Reservoir, runoff near Woodruff averaged only about 8,100 acre-feet. On the other hand, the annual discharge in Silver Creek near Woodruff in 1941 was over 35,000 acre-feet, and in 1932 the discharge exceeded 59,000 acre-feet. Such increased intensity of water flow, rarely experienced near the head-waters of Silver Creek, places considerable stress upon the physical structures underlying irrigated agriculture and adds significantly to the cost of maintaining agricultural systems.

Table 4.11

Monthly Discharge of Silver Creek into Daggs Reservoir
1942 - 1944
(in acre-feet)

Month	1942	1943	1944	$\bar{X}$	Percent of Total
January	713	763	683	713	6
February	1,194	1,734	654	1,194	11
March	2,024	2,762	3,528	2,771	25
April	961	531	1,017	837	8
May	788	533	654	659	6
June	750	513	642	635	6
July	729	522	691	647	6
August	931	521	708	720	6
September	802	585	670	686	6
October	816	644	704	721	7
November	791	662	676	710	6
December	801	738	652	730	7
Total	11,300	10,508	17,279	11,023	100

SOURCE: Bureau of Reclamation (1947:54).

Table 4.12

Streamflow Summary for Silver Creek near Woodruff
1929 - 1946
(in acre-feet)

Water Year	October	November	December	January	February	March	April	May	June	July	August	September	Total
1929-30	698	484	323	508	1,710	5,830	676	56	42	3,930	6,980	440	21,677
1930-31	284	629	740	940	3,930	1,250	393	377	292	3,060	3,850	3,240	18,985
1931-32	986	1,090	1,220	1,370	37,800	12,700	613	248	61	2,230	912	250	59,480
1932-33	1,110	825	730	732	1,320	5,380	42	181	507	5,380	3,180	4,470	23,857
1933-34	---	---	---	---	---	---	---	---	---	---	---	---	---
1934-35	---	---	---	---	---	---	---	---	---	---	---	---	---
1935-36	1,030	639	795	760	2,280	1,010	1,020	93	126	3,490	3,200	1,500	15,943
1936-37	623	484	371	448	9,730	9,400	294	151	272	511	477	282	22,683
1937-38	85	101	151	103	76	2,750	117	0	4	143	2,840	1,190	7,560
1838-39	52	75	79	331	383	1,670	807	4	0	141	1,680	462	9,884
1939-40	204	375	226	428	476	175	117	0	91	6,850	3,010	3,690	15,642
1940-41	895	349	1,780	3,850	3,520	16,170	3,810	165	180	841	1,650	2,060	35,270
1941-42	1,890	153	605	1,130	307	791	325	114	39	4	372	55	5,785
1942-43	456	254	448	325	375	1,310	294	54	15	798	3,720	1,000	9,049
1943-44	472	189	436	670	662	4,460	835	112	33	542	679	501	9,591
1944-45	188	226	357	363	426	3,370	93	1	12	2,270	5,280	160	12,746
1945-46	480	177	309	417	341	189	3	0	0	2,200	4,220	6,140	14,456
X	629	402	573	825	4,125	4,430	629	100	112	2,159	2,803	1,696	18,840
%	3	2	3	4	22	24	3	1	1	11	15	9	98*

Source: Stubblefield (1953:22).
*Total does not equal 100% due to rounding error.

Table 4.13

Annual Discharge at Selected Locations
in the Little Colorado River Basin
1930 - 1944
(in acre-feet)

Year	Little Colorado River at St. Johns	Little Colorado River at Woodruff	Silver Creek at Woodruff	Silver Creek at Snowflake*
1930	5,280	42,700	21,700	7,700
1931	3,120	64,200	19,000	9,300
1932	15,600	117,000	59,500	16,200
1933	5,050	51,600	23,900	7,400
1934	- - -	- - -	- - -	8,000
1935	- - -	- - -	- - -	9,600
1936	4,350	42,710	15,940	8,700
1937	3,540	46,100	23,040	19,600
1938	4,110	15,110	7,560	8,800
1939	2,460	10,370	5,680	7,900
1940	9,750	46,100	23,040	10,100
1941	50,010	115,400	35,270	19,900
1942	2,790	14,560	5,790	11,300
1943	2,080	20,250	9,050	10,500
1944	1,460	14,850	9,590	11,300
X	8,430	46,230	19,360	11,080

SOURCE: Bureau of Reclamation (1947:58); Colorado River Commission of Arizona (1940[section 4]:1).
NOTE: Figures are rounded to nearest tenths.
*Figures for Snowflake comprise runoff into Daggs Reservoir, and those from 1930 to 1942 are estimates of actual runoff at this location. All figures for Snowflake are rounded to nearest hundreds.

Besides providing a reliable quantity of water, Silver Creek differs significantly from the Little Colorado and its other tributaries by furnishing excellent quality water most of the time as well. Except for the periods of peak flow associated with heavy rains, the concentration of suspended solids is

generally below 25 parts per million, and even during periods of heavy flow this figure is normally exceeded only in the lower stream near Woodruff (see Table 4.15). A Bureau of Reclamation (1947:66-67) analysis of the chemical quality of Silver Creek water concluded:

> Results of analyses of Silver Creek waters, sampled near Woodruff. indicate the quality to be suitable for irrigation use. Complete discharge data for the stream at the point sampled were not available, so weighted averages of the concentration of waters could not be determined. The highest concentration of waters sampled, however, was but 440 parts per million, and the percent sodium exceeded 38 in only one instance. indicating the water to be of good quality. Water stored in Daggs Reservoir and that in Silver Creek above the reservoir is of excellent quality. The water in the reservoir at the close of the 1942 irrigation season had a concentration of 160 parts per million and a sodium percentage of 12, while that in Silver Creek above the reservoir has an average concentration of 119 parts per million and an average sodium percentage of 25.[26]

As the report itself points out (*ibid.*), the best proof of the superior quality of Silver Creek lies in the fact that, (in contrast to Joseph City), continued irrigation with Silver Creek water for nearly 70 years had produced no noticeable soil deterioration in the Snowflake-Taylor area. Thus, in both the quantity and the quality of its water, Silver Creek offers an abundant and reliable resource base upon which to establish an agricultural community.

HUMAN IMPACT ON THE LITTLE COLORADO RIVER BASIN

It would be incorrect to assume that current environmental conditions in the Little Colorado River Basin represent those encountered by the early pioneers settling this region. Due to the fragility of this largely arid environment, important changes have resulted from the impact of human resource exploitation. Two major impacts will be discussed--overgrazing and irrigation--in order to more fully appreciate the condition of the natural environment prior to Mormon immigration. The discussion that follows bears directly on the issue of differential community development during the settlement period.

Overgrazing

Several years ago, Colton (1937) published an account which clearly illustrated the devastating impact of overgrazing on one location within the Little Colorado River Basin.[27] While excavating a house which he believed to be a prehistoric pit house--the floor of the house was 30 inches below the existing level of the river bank--Colton discovered that, in fact, the house had been built in either 1878 or 1879. Through subsequent interviews, he further discovered that the house in question was still in perfect condition as late at 1884. At that time, the flat lands on either side of the river supported a fine stand of both old and young cottonwoods, while gama grass covered most of the surrounding hills. The house then stood about 100 feet from the river, and beaver were known to inhabit the stream, living off the cottonwood trees. However, in 1884 several thousand head of sheep were imported into the valley. These sheep were apparently maintained without noticeable range deterioration until the drought of the early 1890's. At this time, Navajos reportedly entered the area to cut down the cottonwoods and feed them to their starving herds. When the rains resumed in the mid-1890's with no grass to hold the water, disastrous floods ensued. Because the riverbed was narrow at this location and could not carry much flood water, the river overflowed its banks and deposited 30 inches of silt by 1935. When Colton returned to the excavation site in 1937, the river had widened another 14 feet and only the back wall of the house was still standing.

Table 4.14

Variation in Monthly Discharge in Silver Creek
1942 - 1944

	Daggs Reservoir	Woodruff
Months included	36	36
Mean monthly discharge	919.1	623.6
Standard Deviation	633.661	915.028
Coefficient of Variation	.689	1.461

SOURCES: Tables 4.11 and 4.12.

Widespread grassland deterioration has occurred throughout the region as a result of the persistent overstocking of ranges.[28] Cattle and sheep numbers on ranges in the basin were quite high between 1885 and 1925. Apache County assessment rolls registered an average of 35,119 head of cattle and 117,762 head of sheep for the years 1916 through 1925, compared to 19,630 cattle and 3,882 sheep for the years 1958 through 1967 (see Table 4.16).[29]

Recovering from the Depression of 1873, the cattle industry throughout Arizona expanded rapidly. "Ranges that for permanent and regular use would have been overstocked with one cow to every 100 acres were overloaded until they carried one cow to every 10 acres" (Spencer 1966:21). Range deterioration within the Little Colorado River Basin began in the 1880's when the Aztec Land and Cattle Company purchased over 1 million acres and imported more than 60,000

Table 4.15

Water Quality in Silver Creek at Woodruff and at Daggs Reservoir
(in parts per million)

	Woodruff		Daggs Reservoir	
Date of Sample	Total Dissolved Solids	Sodium	Total Dissolved Solids	Sodium
June 23, 1942	374	31	---	10
September 30, 1942	340	23	160	5
November 9, 1942	na	na	116	11
November 25, 1942	316	17	na	na
April 27, 1943	324	29	na	na
May 1, 1943	na	na	122	10

SOURCE: Bureau of Reclamation (1947:68, Table 17).

head of cattle onto this range (see Chapter 7). While the extended drought of the early 1890's forced the Aztec Company into bankruptcy, the overstocking of ranges had already radically altered existing range conditions.[30]

Overstocking of ranges is still a problem in the region. Due to the unpredictable nature of precipitation throughout the region, ranchers experience great difficulty in adjusting cattle numbers to changing moisture conditions. They, therefore, stock their ranges for conditions intermediate between high and low extremes (Salt River Project 1974 [section 3]:42). Given the extensive overstocking that occurred previously, this prevailing management strategy (see also Underwood 1970) has preserved the deteriorated condition of the range. Consequently,

> the once almost pure stands of winter fat on the heavy alkaline-free soils have been virtually eliminated and replaced by snakeweed and rabbitbush. The broad expanse of grass that once covered most of Navajo and Apache Counties has deteriorated under heavy grazing pressure and become overrun with snakeweed and pinque. (Salt River Project 1974 section 3:76)

Several indicators signify the existence of overstocked ranges. One is the relative predominance of non-palatable perennial grasses. As already indicated, the herbaceous class of vegetation accounts for only a small fraction of either the grassland or woodland communities. Palatable shrub species are similarly scarce, and the frequency of unpalatable grasses such as ring muhly is high. Galleta, the most commonly occurring grass, is practically useless for grazing when dry --indeed, it can be lethal if consumed by livestock in sufficient quantities while in a dry state (see Schmutz 1968).

Another indication of overgrazing is the expansion of juniper trees into the grassland community. The grazing habits of livestock provide the conditions which facilitate juniper expansion (see Nichol 1937:191). Juniper seeds germinate only after they have passed through the alimentary tract of an animal. Livestock, thus, facilitate the dissemination of juniper seeds at the same time that they remove the competing grasses which inhibit juniper expansion. Controlling juniper expansion has been a major concern of ranchers in recent years. As one drives though that portion of the region in which juniper predominate (most notably near Snowflake), extensive stands of juniper may be seen uprooted as a result of widespread bulldozing--"chaining" as it is called--in an effort to control their spread and to increase the number of palatable grasses available for cattle.[31]

Extensive range deterioration has significantly reduced range productivity. Rangeland in the Joseph City area is producing 225 pounds of forage per acre per year, which is only 45% of the 500 pounds of forage per acre per year estimated as the potential for this location (Dames and Moore 1973 [section 4]:225). Consequently, only between 6 and 7 animal units can be supported per section in the Joseph City area (*ibid.*:235).[32] Estimates of the number of animal units supportable on a section of rangeland in the Snowflake and St. Johns areas are 3.5

and 9.9 respectively (Salt River Project 1974 section 3:85, 105). These figures represent, according to local authorities, perhaps one-third to one-half of the number of animal units supportable prior to the 1880's.[33] A 40% reduction in current grazing level has been suggested as the requirement necessary to restore the ranges to their productive potential (Dames and Moore 1973 [section 4]:225).

Table 4.16

Number of Cattle and Sheep Registered
in Apache County
1916-1925 and 1958-1967

Year	Cattle	Sheep	Year	Cattle	Sheep
1916	25,093	107,197	1958	22,472	5,202
1917	30,701	143,961	1959	20,939	5,129
1918	37,778	144,177	1960	21,291	4,716
1919	33,550	145,846	1961	20,241	5,121
1920	38,362	132,494	1962	19,731	5,733
1921	35,351	113,108	1963	19,083	2,530
1922	38,413	120,432	1964	18,489	2,769
1923	41,386	114,772	1965	16,688	2,425
1924	38,440	80,603	1966	18,488	2,447
1925	32,114	75,031	1967	18,881	2,747
X	35,119	117,762	X	19,630	3,882

SOURCE: Apache County (n.d.).

Besides reducing livestock productivity, over-grazing has had a deleterious impact on surface water quality in the basin and ultimately on the production of those crops which depend on surface water for irrigation. The reduction of biomass caused by excessive grazing pressure (particularly the high proportion of bare surface produced by overgrazing) has enhanced soil erosion and added considerably to the silt-bearing quality of the Little Colorado and other streams in the basin. One U.S. Department of the Interior report (1946:152) suggests that in one year the Little Colorado River transports "the equivalent of nine inches of topsoil from an entire township." Overgrazing within the region, as well as that

which has occurred on the Navajo Reservation to the north, has contributed substantially to the deterioration of the Little Colorado River at lower elevations and of farming operations which employ this water source (see Abruzzi 1985).

Irrigation

Although continuous irrigation has not caused any appreciable soil deterioration among settlements at higher elevations, the same cannot be said for towns situated in the lower valley. Joseph City has suffered the greatest dependence on the poorest quality soils and surface water of any Mormon settlement in the region. Marked differences in soil and surface-water quality existed prior to the advent of farming and ranching within the basin. However, these differences increased as the water available to farmers in the lower valley deteriorated following Mormon settlement of the region in the 1870's. Other settlements were established upstream which eventually acquired prior use of waters flowing in both the Little Colorado River and Silver Creek. Thirty direct irrigation rights exist on the upper Little Colorado River which have been amalgamated into two irrigation companies: The Round Valley Water User's Association and the St. Johns Irrigation Company. Many separate irrigation rights have also been incorporated into irrigation companies serving the towns of Snowflake, Taylor, Shumway, Showlow and Woodruff along Silver Creek. In addition, several small, private water rights exist on other tributaries to the Little Colorado. By 1930, when all existing storage reservoirs in the Little Colorado River Basin had already been completed, 37 reservoirs impounding 72,795 acre-feet of water had been constructed (Bureau of Census 1930).

As a result of the prior appropriation of water, settlers at St. Joseph had to cope with a greater proportion of their irrigation water originating in the Rio Puerco and other northern tributaries to the Little Colorado. Because this water has particularly high concentrations of salts and other dissolved solids, its continued use in irrigation has significantly reduced the productivity of soils in the vicinity of this town. Through capillary action, continued irrigation has also increased the surface accumulation of salts already present in these alkaline soils. It is not an uncommon sight to see fields in the Joseph City area blanketed with a white layer of fine silt particles which have coated the surface of the soil and baked dry in the hot summer sun. Due to its exceptionally fine texture, this silt produces a clay-like layer as it dries which is highly impervious to water. The result, in addition to salt stress on crops, has been both poor drainage and inadequate soil aeration, which further inhibit agricultural productivity.

CONCLUSION

During their colonization of the Little Colorado River Basin, early Mormon pioneers occupied several distinct and widely separated local habitats. Due to the marked variability associated with key features of the natural environment in this

basin, each habitat presented a unique set of material conditions to which specific local populations had to adapt. The precise combination of subsidies and drains present within each habitat ultimately determined the return upon labor invested there and, thus, the success of local agricultural activities undertaken. Exploiting whatever subsidies were available, the early settlers frequently had to bear the costs of heavy drains upon their meager resources due to a frequently demanding and highly variable natural environment. While certain constraints proved surmountable, others remained beyond the control or the adaptive capacity of these small populations with their limited resources. Already containing important differences with respect to those conditions influencing agricultural productivity, local habitats diverged further in their agricultural potential throughout the settlement period. The key to understanding the differential development displayed by these early settlements, thus, lies in comprehending the configuration of environmental diversity within the basin--indigenous and derived--and the distinct adaptive demands which this placed on the maintenance of specific local populations. Significantly, similar developmental patterns emerged within broad sub-regions of the basin.

Because climatic conditions remained beyond human control, these conditions ultimately circumscribed agricultural productivity in the region. The existence of an arid climate throughout most of the basin absolutely precluded the viability of substantial farming operations existing outside of a few river valleys, and the numerous, abandoned settlements dotting the basin testify to the costs incurred by individuals flaunting this imperative.[34] Similarly, the inverse relation between altitude and length of the growing season and the greater variability of the length of the growing season at higher elevations combined to severely constrain agricultural productivity among settlements located in the southern highlands. Alpine, and to lesser extent Showlow,[35] consistently displayed among the smallest and most variable population size and annual productivity (as reflected in tithing collected) of any Mormon settlement in the basin during the nineteenth century.[36]

Although aridity and an inadequate growing season decisively restricted the number of suitable locations for establishing viable agricultural settlements in the basin, other considerations, somewhat less categorical in their impact, determined the viability of farming settlements at remaining locations. For those settlements beyond the pale of immediate climatic constraints, the availability of suitable surface water for irrigation was the most pressing limiting factor governing agricultural productivity. For most settlements in the basin, extreme variation in surface-water flow posed the dual problem of exceeding both the minimum and maximum tolerance limits endurable by early Mormon agricultural systems. While an insufficient supply of silt-free water precluded healthy plant growth, an excessive flow frequently placed an unbearable stress on the frail irrigation structures erected by the early pioneers, precipitating their collapse. For several reasons, however, the drains imposed by fluctuations in surface water flow

weighed most heavily on settlements in the lower valley of the Little Colorado River.

Unlike towns at higher elevations to the south which were able to construct storage reservoirs and, thus, offset seasonal shortages in surface water availability, St. Joseph, Woodruff and the other early settlements in the lower valley were relegated to the use of diversion dams. Consequently, despite a heavy investment in irrigation systems, the lower valley settlements remained subject to the pervasive instability imposed by the highly variable and frequently insufficient flow of water in the Little Colorado River.

The physical stresses imposed by heavy stream flow were also most clearly experienced by the lower valley irrigation systems. Because the drainage area near St. Joseph and Woodruff is considerably larger than that near any other settlement in the basin, the absolute magnitude of water impacting the dams of these two towns during periods of heavy stream flow was considerably greater than that sustained by similar structures elsewhere in the region. At the same time, the deep, alluvial composition of the lower Little Colorado River bed aggravated the difficulties attending dam construction and increased the vulnerability of these dams.[37]

The problems of excess and privation which characterized the flow of water past St. Joseph and Woodruff were soon exacerbated by flooding upstream on both the Little Colorado River and Silver Creek. The prior appropriation of streamflow by these later settlements amplified the shortage of suitable irrigation water available to the lower valley settlements during periods of low flow.[38] Conversely, during periods of particularly heavy flow, dam failures upstream increased the destructive force of an already swollen river, frequently destroying irrigation systems and inundating fields throughout the lower valley.[39] Drought and flood conditions frequently added to the stress imposed on crops and soils in the lower valley--for the reasons already stated, but also due to the higher silt burden which both situations provided.

The lower valley settlements also suffered from lower quality soils than those found elsewhere in the basin. Lower in quality initially, the suitability of these soils for agricultural purposes declined further as a result of continued irrigation with water reduced in purity by overgrazing and by the prior appropriation of clear water upstream.

Although settlers occupying the river valleys at intermediate elevations experienced constraints upon their productivity as well, the restrictions which they encountered were not nearly as extreme as those imposed upon populations located at either higher or lower elevations in the basin. Possessing a sufficient and reliable growing season, each of the remaining settlements--Snowflake, Taylor, St. Johns and Eagar--benefitted from a dependable, and silt-free stream flow, suitable locations for storage reservoirs, a relatively mild seasonal climatic shift and about 4 inches of precipitation more than that available in the lower valley. At the same time, all of these settlements are located in broad valleys containing relatively fertile soils. Significantly, these are the same four towns

described in Chapter 2 as ranking highest regarding the size and stability of their populations and agricultural productivities, and in the complexity of their community organization.

As already indicated, a principal factor contributing to differences in productivity and population size among the agricultural settlements in this arid river basin during the nineteenth century was the fluctuation that occurred in the availability of water for irrigation purposes. Integrally related to this variation in water supply--both as cause and effect--were the systemically important dam failures, which in some settlements occurred with frustrating regularity. Irrigation systems comprised the principal infrastructural investment sustaining agricultural productivity in the basin. Consequently, a dam failure imposed a severe drain on a settlement's resources and jeopardized its very survival. For this reason, the following chapter will examine the history of dam constructions and failures in greater detail.

NOTES

1. The term, Four Corners, refers to that general region surrounding the intersection of the boundaries of Arizona, New Mexico, Utah and Colorado.
2. The region under consideration actually comprises only the southern portion of the Little Colorado River Basin. The northern part of the basin consists principally of badlands located within the Navajo reservation. This latter region will be considered only as it impinges on populations inhabiting the Little Colorado River Valley along the northern periphery of the study area. For convenience sake, however, the term Little Colorado River Basin will be used to denote the region investigated.
3. The following discussion of the meteorological conditions underlying precipitation in the Little Colorado River Basin derives from Jurwitz (1954). The purpose for presenting this discussion is to underscore the unpredictability of precipitation and, therefore, the potential for instability that precipitation poses for agricultural communities in this basin.
4. So arid is the environment in the basin during late spring and early summer that as the initial storms enter the region, much of the precipitation is reabsorbed back into the clouds through evaporation prior to its reaching the ground. Also, many of the summer storms, particularly those that occur early in the season, represent localized cloud systems which may be viewed depositing enormous amounts of water along specific paths while locations immediately outside a cloud's line of travel remain completely untouched.
5. One hundred and twenty days represents the average growing season needed to support most crops.
6. Only fragmentary data exist on the length of the growing season at Showlow, not enough to warrant inclusion in Table 4.3. The information which does exist suggests that the growing season at Showlow is considerably less than that at Snowflake and possibly less than 120 days on the average.
7. See the section below on overgrazing for a discussion of permissible animal densities.
8. Figures on the proportion of piñon pine at different locations in the juniper-piñon woodland community are not available, but variations in their relative abundance are visibly noticeable. Because the region under investigation forms an undulating plain, rising with an increasing gradient, changes in vegetation cover occur over shorter distances as one proceeds southward through the area. Furthermore, since vegetation within an arid climate is particularly responsive to minor shifts in precipitation, which in this area is a function of altitude, visible differences occur in plant density within localized segments of the juniper-piñon community. Even slight variations in elevation associated with the undulating character of the topography produce noticeable, localized differences in plant density between contiguous higher and lower sections of the rolling landscape. The 200% increase in plant density which occurs between St. Johns and Snowflake is associated with less than a 1 1/2 inch increase in mean annual precipitation.

9. National forests were established early in this century and eventually included a significant portion of the montane forest community. The Forest Service currently controls about 962,000 acres within the basin, most of which is located above 6,000' elevation. The Forest Service alone controls about 20% of all the land within the region, while total government administration regulates nearly 50% of the land in the basin (see Little Colorado River Plateau Resource Conservation and Development Project 1971:12).
10. The remaining land area consists largely of isolated riparian communities, such as those within the narrow river valley associated with Silver Creek. Such communities display little areal extent in relation to that of the total region.
11. The formation of the Holbrook Anticline (northwest of Snowflake) resulted in extensive faulting throughout the basin. Although several towns in the region, including St. Johns (see Salt River Project 1974 (section 3):291), have encountered problems of water storage in reservoirs due to faulting, the greatest difficulty has been experienced by Snowflake and Taylor which are located closest to the anticline formation (see Chapter 5, footnote 34).
12. Although of primary developmental importance to the communities in this basin during more recent years, groundwater played a relatively insignificant role in the adaptation of early populations. While shallow wells were dug for domestic purposes, extensive use of sub-surface water for irrigation did not begin until the 1920's (at Joseph City; see the *Snowflake Herald*:3/21/1924) and did not become widespread until after World War II. The most intensive exploitation of groundwater sources has taken place since 1960 with the introduction of large industrial enterprises into the basin. For this reason, a discussion of the variations in quantity and quality of sub-surface water will not be included here. See Abruzzi (1985) for a discussion of the relationship between community development and the exploitation of groundwater resources.
13. Greenwood (1960:4) refers to estimates which claim that over 98% of all precipitation in the Little Colorado River Basin is "used by plants, evaporated, or lost to underground tables".
14. While a sufficient supply of water generally exists in the Little Colorado River near Joseph City prior to and at the very beginning of the irrigation season, one Bureau of Reclamation study reported that from April to June, stream flow in this area is "usually inadequate to meet irrigation requirements, with no flow at all in June during 6 of the 8 years of the period studied" (Bureau of Reclamation 1950:7).
15. It was precisely those freshets associated with the advent of summer storms which wreaked so much havoc on the dams built by early pioneers in the lower valley of the Little Colorado River (see Chapter 5).
16. The intensity of variation in water flow increases as one proceeds downstream in the Little Colorado River, since the size of the drainage area increases with greater distance

from the river's point of origin on Mount Baldy. While the Little Colorado drains only 747 square miles near St. Johns, the drainage area in the vicinity of Holbrook and Joseph City increases dramatically to 17,600 square miles.

17. This capacity of the Little Colorado and other streams in the basin to rapidly transform themselves is illustrated by the predicament of the settlers throughout the lower valley during 1876 and at Woodruff during 1878 (see Chapter 2). In these two instances, crops were lost to both drought and flooding during the same agricultural season. Such occurrences, which were not uncommon, underscore the intensity and unpredictability of environmental variation within the basin.

18. See Chapter 5, footnote 28.

19. Because the different gauging stations are part of the same river basin, the pattern of variation in water flow is correlated from one station to the next. Thus, the discussion presented here, illustrating annual variations in water flow for distinct locations during different time periods, underscores the pervasiveness of surface water variability throughout the region.

20. The Salt River Project (1974 [section 3]:290) indicates that the average discharge of the Little Colorado River above Lyman Dam over a 32-year period was 14,420 acre-feet.

21. The river channel at this point is less than 50' wide and less than 5' deep (Akers 1964:8).

22. Cameron is actually located over 70 miles downstream from the study area and much further to the north. At this location, the Little Colorado River receives most of its water from the heavily sedimented tributaries originating in the badlands north of the study area. The figures for Cameron, therefore, are not representative of the region between St. Johns and Joseph City; rather, they are presented to illustrate the extent of sediment concentration typical of tributaries such as the Rio Puerco, which enter the Little Colorado from the north.

23. One figure quoted for the annual silt discharge in the Little Colorado River is 27,500 acre-feet (Porter n.d.b.:8). Early pioneers complained often of the poor quality of water obtained from the Little Colorado, both for domestic use and for irrigation purposes. One story relating to the original pioneers in 1876 and retold frequently is particularly revealing.

> A 7-gallon kettle was filled when they camped for the night with water from this stream and set by for use the next morning after it had "settled" --there was about an inch at the top of the kettle of fairly "clear" water; but soluble matter in the water was still so much in solution that the water was of poor quality. (Porter, n.d.b.:7-8)

24. Leone (1979:92-93) discusses the problem of silt accumulation in reservoirs along the Little Colorado and argues that dam washouts in the 19th century were essential to successful farming in this region. He Maintains that once permanent dams were constructed in the 1920's, they accumulated silt and became useless--even dangerous. Due to silt accumulation and the consequent raising of the river bed for miles behind a dam, water was more likely to spill over the dam and flood surrounding fields. Holbrook, which is located 10 miles above the Joseph City dam at Penzance, is continuously threatened with flooding as a result of silt aggradation behind that dam.

25. Shumway is a small town of approximately 100 persons located a few miles south of Taylor.

26. As measures of chemical concentration in water, parts per million and milligrams per liter may be considered equivalent below concentrations of 5,000 ppm.

27. While the situation described by Colton occurred at a location several miles downstream from the town of Winslow, and thus outside the study area, the forces which contributed to the massive erosion that he discovered have been ubiquitous throughout the Southwest, including that portion of the Little Colorado River Basin under consideration here.

28. Range deterioration has been greatest in the grassland and juniper-piñon woodland communities.

29. If the figures for the years 1924 and 1925 are discounted, the average number of sheep during the earlier period becomes 127,748 head. The sheep industry has completely disappeared from the study area (see S. Peterson 1978).

30. Overgrazing, in conjunction with the drought of the 1890's, had a devastating impact on the grassland community and the towns depended on it. This impact is reflected in the following statement made by an early settler in the region.

> When we came to Arizona in 1876, the hills and plains were covered with high grass and the country was not cut up with ravines and gullies as it is now. This has been brought about through overstocking the ranges. On the Little Colorado we could cut hay for miles and miles in every direction. The Aztec Cattle Company brought tens of thousands of cattle into the country, claimed every other section, overstocked the range and fed out all the grass. Then the water, not being held back, followed the cattle trails and cut the country up. Later tens of thousands of cattle died because of drouth and lack of feed and disease. The river banks were covered with dead carcasses. (Quoted in McClintock 1921:191)

31. The "chaining" of junipers has been extended into areas where they are indigenous in order to increase the productivity of this rangeland as well.

32. One animal unit consists of a cow an its calf; a section comprises 1 square mile or 640 acres.

33. The extent of overgrazing by the Aztec Company is clear. Grazing 60,000 head of cattle on 2,000,000 acres, the Aztec Company maintained animal densities of nearly 20 animal units per section.

34. Due to their present ability to exploit underground water sources, several contemporary farmers have been able to circumvent this principal limitation and establish farming operations outside of traditionally inhabited river valleys.

35. Eagar is situated at a higher elevation than Showlow. However, due to the northeastern slope of the basin, the climatic and physical conditions encountered by early settlers in Round Valley compared more closely to those experienced by settlers in towns at lower elevations than Showlow within the western portion of the basin.

36. Alpine, the most highly-situated settlement under consideration, registered the highest proportion of non-heads of households declaring farming as their principal occupation in the 1900 census. While only 13 heads of households listed farming as their primary occupation at Alpine, 21 non-heads of households did so. This ratio contrasted sharply

with most other settlements, such as Snowflake and Taylor where the comparable figures were 34 and 6, an 27 and 2 respectively. Even Showlow registered only 2 non-heads of households compared to 14 heads of households declaring farming as their principal occupation in the same census. Nutrioso, a small farming settlement approaching the altitude of Alpine, displayed a ratio of 16 non-heads of households to 20 heads of households reporting farming as their primary occupation. Of equal significance is the young age of many of the non-household heads declaring farming as their principle occupation at Alpine. Five were between 10 and 15 years of age. The comparable figure for Nutrioso was 4. This marked disparity displayed by Alpine and Nutrioso regarding the ratio of dependents to heads of households employed in farming suggests that forcible demands were placed on farming at this altitude. Very likely, all available labor was needed to complete the full complement of agricultural operations within the restricted growing season provided. Given the variability associated with an already short growing season at this elevation, poor harvests were likely a regular occurrence for farmers at Alpine, Nutrioso, and other mountain settlements.

37. While the depth of this alluvium does not exceed 30 feet in most places (Babcock and Snyder 1947:7), its thickness in at least one location near Joseph City has been measured at 180 feet (Danes and Moore, 1973 [section 4]:155).

38. See Chapter 5.

39. See Chapter 5, footnote 28.

Dam Construction

Of the several environmental conditions that imposed themselves on the early agricultural communities in the Little Colorado River Basin, none exerted a more profound impact on the productivity and stability of specific settlements than did the variation displayed in the abundance and distribution of suitable water for irrigation purposes. Significant, recurring and frequently unpredictable fluctuations in precipitation and stream flow made it imperative that each Mormon town construct viable water control systems immediately upon settlement, and that such structures be continually maintained--often at great individual and community expense.

Irrigated agriculture needed to overcome serious limiting factors before it could provide a reliable productivity from which stable communities might evolve. Because surface water flow is a function of the larger climatic regime, the availability of water for irrigation has been markedly irregular, and annual, seasonal and daily variations in water flow have combined to make the Little Colorado and most of its tributaries unreliable sources upon which to base agricultural systems. Since stream runoff figures for the basin are highly variable, storage reservoirs must be employed to impound water during periods of high runoff which can then be released during periods of low flow. By "smoothing out fluctuations in input" (H. Odum, 1971:16), such storage structures enhanced the stability and predictability of a principal environmental condition affecting agricultural productivity and community development in this variegated basin.[1]

The lower valley settlements were continually plagued by the problem of a variable water supply. As already indicated, geological limitations dictated that only diversion dams could be constructed in this subregion.[2] Agriculture along the upper Little Colorado River and near the headwaters of Silver Creek, on the other hand, was very early based on the use of storage reservoirs due to the existence of suitable geological conditions at these locations. Consequently, unlike St. Joseph, Woodruff and the other lower valley settlements, the more southerly towns were better able to adapt to the seasonal shortage of streamflow during May, June and July. They were, therefore, better poised to overcome a critical limiting factor constraining agricultural productivity and community development in the region.[3]

The continued deposit of silt in the stream bed of the Little Colorado River throughout the lower valley over many thousands of years also contributed to the difficulties encountered by lower valley settlements in their quest for viable irrigation systems. Nineteenth century Mormon irrigation system in the lower valley all suffered from the same problem: the lack of a firm foundation upon which to found diversion dams. Commenting on the difficulties experienced in

labor on this dam and its attending ditches demanded that nearly its entire adult male population (about 50 men) work for nearly 2 1/2 months, during which time 1,208 man-days and 354 team-days labor were consumed. This dam was destroyed with the very first freshet that came down the river.

During the subsequent winter and spring, settlers at St. Joseph constructed a new dam two miles further upstream from the site of 1876 dam. They, therefore, had to add two miles to the ditch system (in addition to repairing existing ditches). Labor on the 1877 dam and ditch placed considerable stress on the settlers at St. Joseph as the entire project had to be completed by only 18 to 20 men (Porter n.d.a.:355). Despite their strenuous efforts the settlers produced only a modest harvest. When freshets finally arrived late in the season, they cut a new channel in the river around the dam, "rendering it wholly useless" (Tanner and Richards 1977:42).

The 1878 agricultural season was characterized by especially high floods, capped by an excessively wet harvest (Porter n.d.a:358), and the flood of August 22 that year remains among the highest on record. Most settlements along the Little Colorado lost their dams that year, and St. Joseph was no exception. The settlers there struggled determinedly to save the dam which they had built the previous year, but to no avail. As Nuttal (1878b) reported during his stay at St. Joseph,

> Their dam cost about $3,000 in labor, is 300 feet long, 40 feet wide, 4 feet high; also a levee at ends of dam 400 feet long, 8 feet wide and from 3 to 5 feet high. During the late floods the river changed its course, so that the dam and levees are now worthless; the water ditch from the dam is some 9 miles long and much damaged by the late rains.

Eight hundred additional man-days of labor, not counting the use of team labor, were consumed by the settlers at St. Joseph while attempting to save their dam (see Little Colorado Stake:9/31/1878). Yet, by the close of the 1878 season, "both dam and ditch were in worse condition than when work commenced on them the preceding February" (Porter n.d.b.:5).

In 1879, work proceeded on a new dam which was located an additional mile up the river. The ditch extending from this dam was very expensive. Not only was it a mile longer, but it also required several deep cuts through protrusions in the landscape. This dam lasted for two years. The cost of dam and ditch maintenance for 1880 was recorded at only $300 (Porter n.d.a.:360), was considerably less than the amount expended during any previous year.

The next dam, constructed in 1881, was located back downstream at the site of the original 1876 dam. While no clear reasons are given for investing in a new dam at the original location, the costs of the longer ditch (both in terms of the labor expended on maintenance as well as the water lost through shrinkage and evaporation) may have proved excessive. In any case, the 1881 "high-dry" dam was a radical departure from previous structures.

> The idea was to build a large enough earth dam across the river channel to force the stream over its banks and form a new channel on a rocky area. The earthen dam would have to be high enough to turn aside the largest flood, and would need to be protected on the exposed end where the water would pass so it would not erode away. To protect the face of the exposed earthen dam a crib was built of logs bolted together and filled with rock. If the settlers were successful in turning the stream on to the solid rock, it would not be too difficult to control it, since there would be a solid base. All the settlers believed that their failures in the past were due to the sandy bottom of the river. (Tanner and Richards 1977:43-44)

By March 16th, work had progressed far enough to begin closing the last gap in the dam which had been left open to permit water to pass through during construction. By three that afternoon this last gap was closed and the dam completed. On March 20th, just four days later, a freshet of muddy water originating from northern tributaries swept down the Little Colorado and carried the dam away (Tanner and Richards 1977:44). The estimated cost of this destroyed dam was $6,000 in man and team labor (Porter n.d.c.:83).[7] A second dam was apparently constructed that same year, because on November 26, 1881 St. Joseph was reported to have lost another dam (*ibid.*).

After the devastating loss of such an expensive dam, the settlers at St. Joseph tried to minimize their investment the following year. The 1882 dam was constructed further downstream than any of its predecessors and was viewed as a temporary structure which would wash away with the duration of the summer rains. While the dam's downriver location allowed for a shorter irrigation ditch, a completely new canal had to be constructed from this previously unused site which ultimately consumed more labor than the dam itself. Labor on the new dam and ditch was supplemented by workers from as far away as Snowflake and St. Johns. Although many came as volunteers,[8] a total of $1,000 was paid in compensation (Tanner and Richards 1977:45).

While the 1882 dam was of simple construction compared to its predecessors, the ditch was another matter. Because the downstream location of the new dam required that the attending ditch cross several washes before reaching the fields, troublesome wooden flumes had to be incorporated into the ditch's construction. The 1882 ditch ruptured on several occasions and demanded considerable repair. One early pioneer noted that "the 4th of July passed without any celebration because of so much work" (quoted in Porter n.d.b.:6). Despite their indefatigable efforts, the settlers at St. Joseph could only boast a "below average" harvest (Tanner and Richards 1977:45). At this time the local bishop estimated that the town had expended a cumulative total of between $30,000 and $35,000 in labor on dams without arriving any closer to a solution (Porter n.d.c.:84; see also Tanner and Richards 1977:45).

No record exists of any expensive irrigation construction during 1883, perhaps because this was not a particularly wet year (see Porter n.d.c.:86).

However, during March of 1884, heavy floods inflicted extensive damage, including the complete destruction of the 1882 dam. Construction of a new dam was begun almost immediately. Fearing a total crop failure due to the late beginning of dam construction, some planting was also done in the mountains above Heber, a settlement founded by colonists from St. Joseph the previous year (Porter n.d.b.:6).

The 1884 dam represented another novel approach to dam construction on the part of settlers at St. Joseph. With the help of the Atlantic and Pacific Railroad, 22 pilings between 16 and 20 feet in length were driven in two rows across the riverbed at the location of the original 1876 dam, and a structure composed of timber, brush and rock was erected against these piles (see Porter n.d.b.:6). Dam construction began on April 8th and water was turned into the ditches on May 18th, making this one of the most rapidly completed levees on the Little Colorado (see Tanner and Richards 1977:46). While the pilings themselves withstood the ravages of the river, the materials adjoining this foundation were chronically torn loose by heavy flooding, and major repairs were required each spring. Rejuvenated by annual repairs, the 1884 dam served the settlement until it was entirely swept away by the heavy flooding which occurred during the fall of 1887. Survival for four complete agricultural seasons made the 1884 dam the most successful St. Joseph dam to date.

Little information exists on the dams used during 1888, 1889, and 1890, indicating that they were not very substantial structures. Porter (n.d.c.:89) claims that while they were superior to sand dams, they were constructed with an expectation of surviving only one season. Located at the site of the 1882-1883 structure, these dams shared the problem of troublesome flumes and ditches which plagued the settlers previously (Tanner and Richards 1977:46). At the same time, "major sections of the dam, if not the entire structure, were taken away with disheartening regularity" (*ibid.*). Consequently, while not requiring the major initial expenditure associated with certain previous dams, the dams of 1888 through 1890 are not likely to have represented insignificant investments either.[10]

The next major dam construction was undertaken in 1891. It took three years to complete, and represented the most significant incorporation of total community effort since the days of the early United Order colonization. This dam marked a return to the "high-dry" type dam, and was built near the site of the original 1876 dam. At the existing wage rates, the final cost of this dam has been variously given as $5,000 and $6,000 (see Porter n.d.c.:91; McClintock 1921:142; Tanner and Richards 1977:47).[11] However, one cost not included in these figures was the relative neglect of farming that necessarily resulted during the three years in which this dam was under construction (see Porter n.d.b.:7).

So substantial was the undertaking initiated by this small settlement that an unofficial return to the United Order working and eating arrangements was established (see Tanner and Richards 1977:47). A "dam house" was erected for the men working at the construction site, and the women of the settlement took turns, two-by-two, cooking for the men working on the dam. Between 10 an 25

"men and boys" labored on the dam, supplemented by workers from Snowflake and St. Johns (*ibid.*). Porter (n.d.b.:7) describes the dam as follows:

> It was across...(the)...deep quicksand bed, where no substantial footing could be reached, that the high part of the dam of 1891 was built. A "crib", made of heavy timbers securely bolted together and to the underlying stone and sufficiently high to be well above the flood waters when they were turned over the stone table to the northward, was placed as near the edge of the quicksand-filled canyon as was deemed practicable. This crib was loaded with stone and gravel to give it weight and stability; and to the southward from it, the "high-dry" dam was constructed to the more elevated walls beyond the river. To the northward of the crib was the spillway, 191 feet in width, through which the flood waters were forced. Across part of this spillway, insufficiently high to turn a low river stream into the mouth of the canal, some heavy timber construction was placed, also securely pegged to the stone beneath, and reinforced by a sealing mass of stone, gravel, and earth along its upper edge.

By June of 1891, water was running in the canals. However, for the next three years the settlers at St. Joseph were forced to alternate between working on their farms and laboring on the dam, hoping all the while that no unusual flood would destroy the structure before it was completed. The dam was finally dedicated amid considerable celebration on March 10, 1894 (see Porter n.d.b.:7).[12]

The 1894 dam was not the final dam at St. Joseph. Although it withstood for 29 years, considerably longer than any of its predecessors, the entire structure was swept away in 1923 when heavy runoff caused the collapse of Lyman Dam above St. Johns and unleashed a torrent of water unlike anything ever released in this stream. A new and final dam was constructed at the same site in 1924. This dam was 200 feet long, 12 feet thick at the base, 10 feet thick at the top, 26 feet high and contained 12,500 cubic yards of earth plus considerable rock work (see Porter n.d.c.:93-95; Tanner and Richards 1977:48). The most significant feature of this new dam was the inclusion of cement, which because of its great expense had not been previously used in dam construction in the basin. Three hundred and twenty-five cubic yards of cement was used in the building of this final structure (*ibid.*), which was made possible through a $3,000 appropriation by church headquarters in Salt Lake City (Tanner and Richards 1977:50). The cost of the cement raised the total cost of the 1924 dam to about $16,000 (Porter n.d.c.:95).

As the expense, instability and generally poor returns associated with agriculture at St. Joseph have demonstrated, irrigated farming did not represent a viable adaptive strategy upon which to build a firm community base at this location during the nineteenth century. Continually plagued by limited resources, settlers at St. Joseph could barely surmount the drains imposed upon them by a variable and unpredictable environment. Consequently, they became increasingly dependent on strategic subsidies derived from external sources. The difficulties

inherent in attempts to establish viable agricultural settlements in the lower valley of the Little Colorado River are clearly illustrated by the fact that St. Joseph was the only original colony to survive. The point is made doubly clear by an examination of the history of dam construction at Woodruff, another well-documented sequence. Between 1878 and 1919, Woodruff built 13 dams and suffered the destruction of 12 (see Fish n.d.a.:34-37; Peterson 1973:185-191).

The Woodruff Dams

Unable to complete a dam across the Little Colorado in 1877 due to their limited numbers (see Chapter 2), the settlers at Woodruff expended considerable labor in dam construction the following year. Investing 390 man-days and 227 team-days labor,[13] the handful of settlers at Woodruff erected a dam which was 125 feet long, 50 feet wide and 22 feet high,[14] with expectations running high of turning water into the fields by early May. Before the structure was completed, however, a heavy flood swept the dam away (Little Colorado Stake:5/24/1878). With the loss of this dam and the subsequent failure of the 1878 harvest, only 3 families remained at Woodruff (Peterson 1973:187), and the spring of 1879 found the settlement nearly deserted.

During the summer and fall of 1879 several additional families settled at Woodruff, and in November of that year construction began on a new dam which was completed the following May. Owing to the generally low flow of water in the Little Colorado during the late spring and early summer, the increasing water level behind the Woodruff dam in 1880 threatened the crops downstream at St. Joseph. Following an urgent appeal by farmers at St. Joseph, a hole was cut in the Woodruff dam. "This was a damage of about $500.00 and blasted their hopes of a crop for that season" (Fish n.d.a.:35).

A flood during September of 1881 was reported to have destroyed a considerable portion of the 1880 dam (*ibid.*), and in January of the following year work was begun on the construction of a new dam (*ibid.*). Although the labor on this new dam was heavy, owing to the small size of Woodruff's population, 1882 displayed positive results, as Fish (*ibid.*) reports:

> The work was continued during the winter and spring with about an average of 7 men and in May the water was again brought out. A small field was fenced and about 70 acres of land put in mostly to corn and vegetables. This yielded well and the people were greatly encouraged.

During the winter of 1882-1883 the dam was reinforced and nearly 400 acres were planted, with the prospects appearing favorable that spring for a successful harvest (Fish n.d.a.:36). On July 26, however, another devastating flood swept down the Little Colorado destroying most of the dam in its wake. Fish (*ibid.*) reports that

> a leak started around the west end of the dam. This increased rapidly and not withstanding strong efforts being made to stop it, the breach soon widened and the bank and the end of the dam were soon cut away to a depth of 25 feet and 100 feet wide. This was a very heavy blow to the place and many turned away from the sight feeling to give up the enterprise.[15]

Construction began on the next dam on January 2, 1884 (*ibid.*) and continued to near completion when a freshet completely washed it away. A call was issued to members of the various wards at the next stake conference to donate one week's labor towards rebuilding of the Woodruff dam. Work on the second dam of 1884 commenced on June 2nd, very shortly after the destruction of the preceding structure. An average of 45 men labored on the dam at any one time, and $3,000 in labor is estimated to have been donated (*ibid.*). Just as this second dam was also nearing completion,

> a heavy body of water came down cutting over it and it soon went out leaving it about as it was one year before. This was a heavy blow to the people for the season had been quite dry and the little grain that had been put in had completely dried up and was not worth harvesting. (*ibid.*)

Settlers at Woodruff were able to survive the winter of 1884-1885 because of their participation in the construction of the new building to house the ACMI store there (see Chapter 6). Local church leaders awarded the contract for the construction of this two-story building to the residents of Woodruff so that they might be supported until a new dam could be completed. By the close of 1885, the Woodruff dam had been rebuilt and a permanent structure finally appeared to have been achieved. No dam failures were reported for several years.

On February 21, 1890 this growing optimism was quickly displaced as an extremely large flood on Silver Creek destroyed the Woodruff dam in a matter of minutes.[16] Church authorities in Salt Lake City appropriated $3,000 from local tithing funds to subsidize the reconstruction of the Woodruff dam (Fish n.d.a.:37).[17] At the same time, $1,500 in relief was appropriated to the residents of Woodruff by the Arizona Territorial Legislature (Peterson 1973:190). A small population (and thus a limited labor supply) caused work on the dam to proceed slowly. Although they were able to turn water into their fields late in the season, the settlers at Woodruff were forced to leave their dam in an unfinished condition. Consequently, when a second flood passed on November 8, 1890, all of their labor went with it, and several persons made plans to abandon the settlement (Fish n.d.a.:37).

Church leaders again assisted in directing the reconstruction of the Woodruff dam, and donated labor from the surrounding towns was forthcoming

(see Peterson 1973:188) as little of the previously extended provisions remained. This dam, flagged by stone slabs (Peterson 1973:185) and costing perhaps $11,000 (see Woodruff Irrigation and Recreation Project:i), held for 14 years until Zion's Dam above Hunt burst on August 26, 1904 under the pressure of heavy rains (Fish n.d.a.:37). So immense was the torrent of water released by the collapse of Zion's Dam that the residents at Woodruff were forced to abandon their homes and seek shelter at higher ground (*ibid.*).

During November of 1904, yet another appeal was made by the stake for assistance in reconstructing the disabled Woodruff dam. Church headquarters contributed $500 in cash and the Snowflake, Taylor, St. Johns and Showlow wards were asked to contribute an additional $1,500 jointly (*ibid.*). The settlers at Woodruff were forced to farm without irrigation water for two full seasons as they were unable to turn water onto their fields until August 2, 1906 (Fish n.d.a.:37). This twelfth and last dam on the Little Colorado was constructed entirely of stone, and lasted until 1915 when Lyman Dam (which impounded the largest reservoir in the entire basin) faulted under the pressure of heavy stream flow and released a flood of water which swept this dam away (see Peterson 1973:185-186).[18]

After repeated failures along the Little Colorado, the construction effort turned to Silver Creek. Winding its way through moderately deep canyons, Silver Creek possessed the rocky foundation upon which a permanent dam structure could more securely be built. Construction of a dam on Silver Creek also offered an escape from the "silts and minerals of the Little Colorado as well as its fierce floods" (Peterson 1973:186). A permanent diversion dam was finally completed in 1919, but only after the State of Arizona appropriated $10,000 and the Mormon Church contributed $22,500 towards its final cost of $85,000 (see Peterson 1973:188). This was an expensive irrigation system. Beyond the meager resources of this small settlement, it incorporated technical problems of ditching along canyon walls as well as the placing of flumes across canyon crevasses.

> At places, the canal was hung from the cliff above, at places it was chiseled through solid rock, and at other places it took the shape of flumes across the river or wash. (Woodruff Irrigation and Recreation Project n.d.:i)

Although Woodruff's struggle with water is locally viewed as ending subsequent to the completion of the 1919 dam, in fact, the struggle continued. The flumes leaked regularly, demanding constant repair, and water losses in the ditch became excessive (see Peterson 1973:186; Woodruff Irrigation and Recreation Project, n.d.:i). These heavy costs eventually led to the abandoning of irrigation by means of the Silver Creek dam. Farmers turned instead to the pumping of water from underground sources.[19]

The history of its struggle to control the Little Colorado River, like that of St. Joseph, reveals "the fineness of the balance in which Woodruff's existence hung. Closely circumscribed by natural conditions, it barely escaped joining the

Little Colorado roster of ghost towns" (Peterson 1973:187). Varying up to a peak of 30 families, Woodruff's population waxed and waned depending on the status of its dam. Each successive dam failure triggered an exodus of settlers searching for more optimal locations. Continually plagued with a labor supply inadequate to complete the construction of another dam, a core of a very few families persisted in recruiting settlers to augment their sparse numbers. However, each successive dam failure testified to the cost and unreliability of farming in this valley. In the final analysis, the settlers at Woodruff survived only because of externally derived subsidies which offset the failures of their agricultural system. Besides the numerous and substantial contributions of money, labor and produce received from nonlocal sources for the explicit purpose of subsidizing dam reconstruction, the continued occupation of this valley was largely made possible by individuals continually seeking employment elsewhere in the basin. An inventory of the population at Woodruff after the failure of the 1904 dam revealed that although 33 families inhabited this small valley, 10 were headed by widows or aged men while the men of 20 families were scattered in employment throughout the basin (see Peterson 1973:190). Settlers at Woodruff were unable to channel sufficient resources into agricultural production due to the drains imposed on them by an unstable river. They, therefore, operated a costly and largely ineffectual agricultural system. Consequently, like St. Joseph and the other lower valley settlements, Woodruff never achieved sufficient prosperity (i.e., a substantive and reliable surplus) from which to generate community development.

St. Johns Dams

Although dam failures did not occur at St. Johns with the regularity displayed at either St. Joseph or Woodruff, such infrequency was partially compensated for by the scale of the irrigation systems there and by the size of the losses caused by their destruction. The dams constructed by the settlers at St. Johns dwarfed all others in the basin. Consequently, when they collapsed they unleashed massive torrents of water that destroyed everything in their path--including, generally, the dams at Woodruff and St. Joseph which might otherwise have withstood the stresses of the swollen river.

The initial irrigation works at St. Johns antedated Mormon settlement at this location and, compared to subsequent structures, comprised very rudimentary water control systems (see Fish n.d.a.:49). Built in the early 1870's by the indigenous Hispanic population, the original irrigation system at St. Johns consisted principally of a small dam and three irrigation ditches designed only to conduct water upon land immediately adjacent to the Little Colorado River channel.[20] With the dramatic increase in population at St. Johns following the immigration of hundreds of Mormon settlers between 1880 and 1885,[21] irrigation by diversion alone could not accommodate the growing agricultural demands for water. Due to the generally diminished supply of water in the Little Colorado during the late spring and early summer, open hostility developed between Mormon settlers and the indigenous Hispanic population over conflicting claims

to Barth's rights to water from this stream.[22] In an attempt to overcome this seasonal shortage of water and at the same time accommodate the rapid influx of settlers, the Mormon population at St. Johns constructed two storage reservoirs during the early 1880's. One reservoir adjoined St. Johns on the north, covering an area of about 60 acres, while the second lay 1.25 miles south of the town and extended over 125 acres (Fish n.d.a.:51). The combined cost of these two dams with their attending canals exceeded $4,000 (see *ibid.*).

In order to enhance agricultural productivity, the St. Johns Irrigation Company was formed which undertook the construction of a large dam six miles south of the town.[23] Slough Dam, as this structure was named, was reported to be nearing a "Christmas completion" in August of 1894 (Jensen n.d.d.:8/9/1894), and during the following three years this finished dam was reported to have impounded a substantial capacity of water for irrigation purposes. Slough Dam apparently underwent substantial repair and expansion during most of 1900 and likely into 1901, as several reports included within the Minutes of the St. Johns Stake Conferences during this time period referred to a large dam under construction also located six miles south of the town. One report dated February 10, 1900 indicated that much work was in progress on a large reservoir six miles upstream which when finished would be 40 feet high, 150 feet long and 150 feet thick at the bottom, and which would flood 1800 acres of land.[24] This structure was built of rock on the lower side tied together with cedar, with the upper or inside facing the water made of dirt. It was expected to permit the cultivation of an additional 4,000 acres of land (*ibid.*). No such detailed descriptions are available for the original Slough Dam. Furthermore, Leone (1979:91) indicates a possible dam loss at St. Johns in 1899, which would account for such a large reconstruction effort being expended in 1900.

Work on this second Slough Dam required strong community involvement. Large numbers of people participated in its construction, and labor on the dam assumed a "united effort" (Jensen n.d.d.:12/1900). By December of 1900, the volume of water impounded behind the second Slough Dam was greater than that stored during any previous year at St. Johns, forming a lake nearly 3 miles long. Even at this volume, the water had an additional 10 to 15 feet to climb before it reached the top of the dam at its existing stage of construction (*ibid.*). However, this enlarged Slough Dam collapsed in 1903, producing several years of population decline and economic depression at St. Johns (see McClintock 1921:182).[25]

A renewed construction effort was begun in 1910 when the residents at St. Johns (in association with a Denver, Colorado development company)[26] jointly incorporated into the Lyman Irrigation Company for the purpose of building a large reservoir 12 miles south of the town (see Berry 1910). The Colorado company and the settlers at St. Johns each provided one-half of the necessary capital to underwrite this substantial project,[27] and the Mormon Church appropriated $5,000 to aid the residents at St. Johns in raising their share of the investment

(McClintock 1921:183). Completed only after an expenditure in excess of $200,000, the construction of this dam proved defective. In April of 1915 the structure collapsed, killing 8 persons and causing extensive damage to flooded farm lands throughout the region (*ibid.*)[28]

The Lyman Company was subsequently reorganized, and by 1918 another $200,00 was spent. However, St. Johns still lacked an adequate water storage facility. An appeal was then made to the State of Arizona. The State Loan Board advanced about $800,000 to the residents of St. Johns, holding mortgages on their land and on the dam as its security (*ibid.*).[29] This second Lyman Dam, which still stands, was completed in 1920.

While not experiencing the near-annual setbacks sustained by St. Joseph and Woodruff, St. Johns felt the devastation of successive dam failures. Moreover, the sheer size of the dams at St. Johns, the volume of water that they harnessed, and the substantial community investment that each represented made subsequent losses increasingly difficult for this community to endure. As in the cases of both St. Joseph and Woodruff, a final solution to St. Johns' water control problem was achieved only through the application of strategic subsidies received from external sources.

Irrigation at Snowflake and Taylor

When the early Mormon pioneers purchased Stinson's claim along Silver Creek, he had about 300 acres of land under cultivation (McClintock 1921:164). Mormon farmers were to increase the amount of irrigated land in this vicinity to about 2,200 acres.[30] While not without its setbacks and hardships, irrigated agriculture in the Snowflake-Taylor area experienced a steady amelioration through the expansion and consolidation of existing irrigation systems. Snowflake and Taylor did not suffer the continual stresses which drained St. Joseph and Woodruff; nor did they sustain the occasional devastations which haunted St. Johns. For the most part, each successive investment in the water control system serving these two interdependent settlements enhanced their future capacity for irrigation rather than merely allowing for the recovery of lost ground.

Irrigation at both Snowflake and Taylor was first accomplished through the direct diversion of water from Silver Creek. During 1878, five men built a dam with a ditch on the west side of Silver Creek at Taylor. A second canal was constructed on the east side of the river the next spring to accommodate the influx of settlers from Woodruff following the failure of their dam (see Fish n.d.a.:43). The settlers at Snowflake also relied solely on water diversion initially. In the spring of 1879 heavy work was reported being performed repairing ditches which had been severely damaged (in some places completely destroyed) by the heavy rains and high waters of the previous fall (see Fish n.d.a.:40; LeVine 1977:23). With increasing immigration, diversion alone quickly proved inadequate to meet the growing demand for water, and dissention developed between the settlers of Snowflake and Taylor regarding competing claims to irrigation water.[31] Except for

this early conflict, the development of irrigation along Silver Creek proceeded with the complete integration of the water control systems serving these two towns.

In an effort to enhance the farmable acreage within their adjoining valleys, farmers at Snowflake and Taylor constructed several small storage reservoirs prior to the early 1890's. One of these reservoirs, constructed in 1887, was described by Fish (n.d.a.:22).

> In the latter part of January a reservoir was surveyed (by Joseph Fish) between Snowflake and Taylor on the west side of the creek. This was made and completed (so far as intended for the present) before the first of March by the people of Snowflake. There is about 4550 (cubic) yards of earth work in the bank besides rock and brush which is put in for protection. It is estimated that this will hold enough water to irrigate 1,000 acres over once. (parentheses in the original)

Snowflake and Taylor each lost their dams during the heavy floods of 1890. However, construction began on the Flake Ranch Reservoir immediately following the formation of the Snowflake and Taylor Irrigation Company in 1894 (see Bureau of Reclamation 1947:2, 34). Two additional reservoirs were added to the system in 1898 (*ibid.*). Another dam, replacing the two extant Snowflake dams, was built between Snowflake and Taylor in 1899 (LeVine, 1977:113).

Finally, work began in 1906 on the Daggs Dam and Reservoir located 10 miles south of Taylor. Daggs Dam, which impounds 2,500 acre-feet of water, was built to replace several previous dams and provide the bulk of the irrigation requirements for farmers in the Snowflake-Taylor area. When finished, this dam stood 65 feet high, 230 feet thick at the bottom, 14 feet thick at the top, 60 feet long at the bottom and 330 feet long at the top. By 1909 Daggs Dam had reached a height of 33 feet, and construction was finally completed on May 23, 1914 at a total cost of $40,000 (*Snowflake Herald*:6/6/1914; see also Levine 1977:114),[32] with all of the labor performed by farmers working out their assessments (Bureau of Reclamation 1947:34). While future repairs, reinforcements and enlargements of Daggs Dam occurred,[33] the dam was never lost, and Daggs Reservoir served as the principal source of irrigation water for these two towns until it was converted to recreational use in the 1960's. At this time, farmers at Snowflake and Taylor turned to using water pumped from the Coconino sandstone (see Abruzzi 1985).

While irrigated farming along upper Silver Creek was not without its difficulties,[34] an examination of the history of dam construction along this tributary presents a very different picture from that along the Little Colorado. The most arduous and persistent demands imposed by irrigation in the Snowflake-Taylor area--and these were mentioned often--were those associated with the maintenance of irrigation ditches. One reference to problems with ditches has already been made. Fish (n.d.a.:67) indicates that ten years later ditch repair still presented a considerable drain.

> The labor on ditches in this stake has been enormous, at Snowflake this year the tax was a trifle over $3.00 per acre. Paying out this amount every year per acre on dams and reservoirs tells upon the people and they begin to think it is too much of a burden to carry.

The maintenance of dirt ditches was a constant problem, particularly during years of heavy rainfall. Added to this cost was the already mentioned loss through evaporation and seepage of nearly 30% of the water diverted for irrigation. Maintenance and seepage problems in Snowflake were never effectively solved until the 1960's when at least the primary canals were lined with cement (see LeVine 1977:118).

However, Snowflake and Taylor were not alone in their struggle to maintain irrigation canals or in the losses of water they suffered during transit. While the assessments for ditch repair in these two towns were high, they were comparable to those levied elsewhere in the basin (see Fish n.d.a.:67). Canal maintenance was equally problematic for other towns as well, especially those in the lower valley where the soil through which irrigation ditches traversed has been characterized as "sugary" (Peterson 1973:180; see also McClintock 1921:141). Furthermore, while struggling with their ditches the farmers at Snowflake and Taylor did not have to contend with the even greater drains imposed by repeated dam failures. Significantly fewer dam losses occurred at Snowflake and Taylor than at either Woodruff or St. Joseph, and the scale of these losses was insignificant compared to that endured by St. Johns.

CONCLUSION

The preceding pages clearly illustrate the extent of the drain imposed on those settlements which sustained recurring dam failures. The costs incurred encompassed not only the reconstruction of damaged or demolished dams, but also the destruction wrought upon ditches, crops and, ultimately, on the fields themselves. Successive, poor harvests in association with repeated dam losses imposed an extraordinary hardship on individual settlers, undermining their ability to continue the struggle with the Little Colorado. Population size in those settlements most subject to dam failures either fluctuated markedly or declined absolutely. Such instability derived from the persistent inability of these settlements to recruit and retain sufficient manpower to effectively counter the river's variability and power. Consequently, those settlements most affected by the difficulties attending irrigation in the basin were able to endure only because strategic inputs of labor and other resources were forthcoming from non-local sources.

Externally derived inputs of labor, produce, materials and money comprised indispensable subsidies without which certain settlements likely would not have survived. Without the judicious appropriation of such resources, St. Joseph and Woodruff (containing among the smallest populations in the basin and

enduring the most adverse conditions accompanying irrigation) would surely have followed their neighboring settlements to extinction. While the Mormon settlement at St. Johns is not likely to have dissolved in the absence of specific subsidies, the population of this town did wax and wane with the status of its dam, and the productivity of its agriculture was central to its regional pre-eminence.

Despite the fact that the problems attending irrigation were of central concern to all nineteenth century Mormon settlements in the basin, specific data relating to water control for individual towns has been unevenly preserved. While the quantity and quality of available information bearing on the costs attending successive dam failures and reconstructions at St. Joseph and Woodruff are quite impressive considering the frontier context in which they were recorded, this same level of reporting was not maintained at other settlements. Although at least a minimal amount of data is available regarding the irrigation systems at St. Johns, Snowflake and Taylor, almost no information has survived which illuminates the struggle with water control systems waged by the more remote settlements (including Eagar,[35] Showlow and Alpine) situated at higher elevations. This variation in data availability reflects, in part, the lesser direct involvement in the affairs of these more remote settlements of church leaders overseeing the colonizing effort (cf. Peterson 1973:36), as well as the different concern among individual settlers for recording the procession of their historical venture. However, such differential data availability also reflects the relative intensities of the struggles waged. Those settlements which preserved the most complete record of their labor on water control systems, attending to every detail, are precisely those towns for which the problems surrounding dam failures assumed the principal theme of their local histories and generated wider church interest. At the same time, those settlements which sustained the fewest dam failures have not been overly concerned with recounting the detail of these infrequent events.

One final comment regarding the frequency of dam failures needs to be made. Besides demonstrating a distinct difference in the incidence of dam failures among individual settlements, Table 5.1 testifies to the significant distinction that existed between settlements in the lower valley and those located elsewhere in the basin. The specific conditions outlined in Chapter 4 placed a substantially higher stress on irrigation systems in the lower valley, undermining the viability of agricultural settlements in this area. Indeed, of the six settlements founded along the lower Little Colorado between 1876 and 1878, only two survived the decade following their colonization. No other sub-region matched the extinction rate achieved in the lower valley; every town established in river valleys at intermediate elevations survived, and those highland settlements which were abandoned were deserted for reasons unrelated to irrigation.[36] Furthermore, while settlements in the lower valley displayed marked instability in both population size and agricultural productivity, towns at intermediate elevations, most notably Snowflake and Taylor, experienced the least fluctuations in these critical community variables.

As this and preceding chapters have stressed, the Little Colorado River Basin presented early Mormon pioneers with distinct spatial and temporal variation in resource availability. While temporal resource variability--most notably that associated with the availability of water and length of the growing season--imposed distinct productive restrictions within specific habitats, the region's spatial diversity offered Mormon settlers an opportunity to circumvent local habitat limitations. Although early Mormon pioneers quickly recognized the adaptive advantage of a multihabitat exploitative strategy, their attempts to integrate resource flows from distinct habitats into a unified resource-flow system were not equally successful. The initial United Order settlements' attempts at multihabitat exploitation failed. A successful multihabitat resource-flow system was only achieved at a later date with the development of a regionally coherent system of tithing redistribution. The failure of the conjoint enterprises underscores the difficulties that temporal resource variability imposed on the lower valley settlements. The differential success of these two systems complies with Ashby's (1956:206-212) Law of Requisite Variety and with the principles of energy flow in ecological systems. Because the development of an effective system of resource redistribution was central to successful Mormon settlement in the region, the following chapter will examine local Mormon efforts at multi-habitat exploitation and provide a substantive explanation for their differential success.

NOTES

1. Irrigation reservoirs constitute the passive storage of potential energy in agricultural systems (see H. Odum 1971:38).
2. St. Joseph did construct one supplementary storage reservoir in 1902 (see Tanner and Richards 1977:94). However, due to its small size and rapid silt accumulation, this reservoir never served as a significant component of this town's agricultural system.
3. Besides providing a reliable supply of water, reservoir storage serves to reduce the velocity of water flowing through irrigation ditches. By permitting the settling of suspended sediment in water during storage, reservoirs also serve to reduce silt deposition on irrigated soils. Whereas silt in the St. Johns area became deposited largely behind the Lyman Dam (gradually reducing its storage capacity), this sediment regularly found its way onto the fields at St. Joseph.
4. Leone's figures do not include dam losses at Sunset, Brigham City, Old Taylor and Obed prior to the dissolution of these settlements.
5. Actually this war lasted 48 years. Building their first dam in 1876, the settlers at St. Joseph did not obtain a permanent dam until 1924. However, the dam completed in 1894 lasted for 29 years and may be considered as a more or less permanent structure.
6. Claiming only 9 dam failures for St. Joseph significantly understates the demands imposed on this small settlement, as this figure only accounts for the complete washouts of irrigation structures. On numerous occasions destruction to the dam, while not constituting total devastation, was so severe that little difference can be discerned between the cost of repairs following such partial damage and those attending a complete collapse.

7. Following the ratio of human to team labor expended on the 1876 dam (see Chapter 2), the 1881 dam cost this small settlement of 110 persons 2,320 man-days labor and 906 team-days labor.
8. The use of voluntary labor from other towns to aid in dam reconstruction was a common feature among Mormon settlements in the region. The donation of labor in dam repair was an acceptable means by which inividuals in this cash-poor region could meet their tithing obligation to the Church (see Chapter 6). Access to voluntary manpower from neighboring Mormon towns was indispensable to the survival of settlements in the lower valley. Not only did they experience the most incessant dam failures, they also contained among the least adequate supply of labor.
9. The settlers at Woodruff were also plagued with ungovernable flumes in their attempt to obtain irrigation water from Silver Creek. The difficulty that this method of water conveyance posed underlay the perseverence that Woodruff residents displayed in their continued construction of dams along the Little Colorado (see below).
10. One pattern associated with the history of dam construction at St. Joseph is the vacillation between investments in major structures consuming considerable inputs of labor and the reversion to more disposable dams requiring increased annual repairs but only limited initial investments. While continual repairs were expensive, the lack of a large initial outlay represented less of a committment of a particular dam site and structure, thus maximizing the settlement's flexibility in its response to an unpredictable river. The switch to less costly dams followed the destruction of the 1881, 1884 an 1894 dam structures.
11. Porter states that the current wage rates were 22 2/9 cents per hour for a man an 16 2/3 cents per hour for a team. While no clear indication is given, 10 hours likely represents a full day's labor, making the man and team-day values $2.22 an $1.67 respectively. Assuming a ratio of human to team labor equivalent to that employed in the 1876 dam, at a total cost of $5,000, the dam completed in 1894 would have consumed 1,742 man-days an 678 team-days labor. At a cost of $6,000 the comparable figures would have been 2,090 man-days and 814 team-days labor.
12. Noting at the time that the population of this settlement consisted of only 15 families, Andrew Jensen, the Church Historian, named St. Joseph "the leading community in pain, determination and unflinching courage in dealing with the elements around them" (quote in McClintock 1921:142).
13. At the wage rates of $2.00 per day for human labor and $1.50 per day for team labor the 1878 dam cost $1,120.50. Consisting of rock, brush and dirt most early dams at Woodruff entailed labor investments of about $1,000 (see Woodruff Irrigation and Recreation Project n.d.:i).
14. The labor expended constructing the 1878 dam was invested by a population of only 15 men, 15 women, 25 boys and 20 girls (see Nuttall 1878b), comprising a total of 75 persons in 13 families. Of the 45 children listed, 23 were under 8 years of age.
15. Most settlers at Woodruff were able to remain at this location, having obtained the supplies needed to sustain them until the next harvest from the recently-opened Arizona Cooperative Mercantile Institution store. See Chapter 6 for a discussion of the ACMI.
16. The location of all but the last of Woodruff's dams (below the confluence of Silver Creek and the Little Colorado River) made them vulnerable to exceptional flooding on either stream. Being a particularly wet year, 1890 witnessed the collapse of dams at both Snowflake and Taylor, which in turn, precipitated the destruction of dams at Woodruff and St. Joseph.

17. Most of this tithing appropriation consisted of produce from the Snowflake and St. Johns stakes to provide food for the settlers at Woodruff while they labored on their dam.
18. So great was the flooding caused by the collapse of Lyman Dam that the town of Woodruff was also flooded (Woodruff Irrigation and Recreation Project n.d.:i) See footnote 28 of this chapter for a discussion of the damages resulting from the collapse of Lyman Dam in 1915.
19. Due to the increased pumping of sub-surface water in the basin during recent years, the residents of Woodruff have encountered problems with the water available in their wells. Both the level and the quality of this water have decreased significantly, generating a movement among them to solicit federal, state and county assistance to recondition the ditches leading from the Silver Creek dam (see Woodruff Irrigation and Recreation Project n.d.). However, this project must contend with a reduction in the flow of water in Silver Creek caused by the same increased exploitation of sub-surface water sources (see Abruzzi 1985).
20. Demand for irrigation water prior to the Mormon influx into St Johns was not great, as exploitation of the landscape was generally extensive in nature. Sheepherding was the principal productive activity of a majority of the Hispanic population, and Solomon Barth, who controlled most of the water rights at this location on the river, farmed only a few hundred acres of land (see McClintock 1921:178).
21. From the time of their settlement during the winter of 1879-1880 until the spring of 1885, the Mormon population at St. Johns increased to 672 persons, largely as a result of active church recruitment. Following the settlement of St. Johns, most of the subsequent Mormon immigration into the Little Colorado River Basin was directed to this location. Fish (n.d.a.:53) reports that by 1884 about 250 men had been called to settle at St. Johns, although only about 140 remained there. The difficulties experienced by Mormon settlers at St. Johns, including considerable political harassment (see Chapter 7), inhibited many from settling permanently at this location. From its peak in 1885, the Mormon population at St. Johns declined steadily throughout the remainder of the nineteenth century (see Table 2.6).
22. In 1886, arbitrators representing each group negotiated a compromise in which the Mormons were allowed 60% of the river's capacity, with the Hispanic population obtaining rights to the remaining 40%. This conflict was soon alleviated when the construction of large storage reservoirs generally eliminated the seasonal water shortage during May, June and July.
23. The exact year in which construction began on this dam is not clear. Fish does not mention the dam's construction at all, and its existence is not recorded elsewhere until the dam was nearing completion in 1894. Greenwood (1960:103, most likely using McClintock 1921:183 as his source) claims that construction was initiated in 1886. McClintock, however, only states that the St. Johns Irrigation Company was founded in 1886, and does not indicate how long after this date actual construction was begun on the dam.
24. The original Slough Dam was reported to have flooded only 500 acres of land (see Jensen n.d.d.:8/9/1894).
25. Between 1905 and 1910 the Mormon population at St. Johns declined from 566 persons to only 455. This decline did not reverse itself until the activities associated with the building of the subsequent Lyman Dam presented new opportunities.
26. The Denver company sold its interest in the Lyman Reservoir to the people of St. Johns in 1914 (see *Snowflake Herald*:4/16/1915).

27. Great expectations were focused on this joint venture. It was anticipated that the completion of such a large dam and reservoir would permit the intensive cultivation of 15,000 acres of land in the St. Johns area (see Berry 1910:18).
28. The *Snowflake Herald* (4/16/1915) reported that, in addition to its total destruction in 1915, the Lyman Dam, "the constant work of 12 years", was also washed out once during its construction.

The collapse of Lyman Dam in 1915 precipitated the destruction of dams downriver at Meadows, Hunt and Woodruff. While the dam at St. Joseph withstood the flooding, damage to this dam was estimated to be about $1,000 (ibid:4/23/1915). The collapse of the Lyman Dam was felt throughout the lower settlements. The following list of "direct losses" was included in the *Snowflake Herald* (5/7/1915):

Damage to Lyman Dam and canals	$ 90,000
Houses washed out at St. Johns	7,000
St. Johns Irrigation Company	3,000
Bridge at St. Johns	2,500
Bridge at Hunt	2,000
Crops and fences at St. Johns and Meadows	10,000
Meadows Dam	3,000
Udall Dam	18,000
Crops, fences, ditches at Hunt	8,000
Woodruff Dam	17,000
Crops, etc. at Woodruff	13,000
5-mile steel bridge	4,500
Holbrook bridge	5,000
Other (including livestock, etc.)	5,000
Total Direct Losses	$196,000

"Indirect losses" were listed as follows:

Crop loss at St. Johns	$60,000
" " " Meadows	5,000
" " " Hunt	12,000
" " " Woodruff	10,000
Total Indirect Losses	$87,000

Several of these estimates of losses proved too small, most notably the cost of repair to dams at both St. Johns and Woodruff. Moreover, as the article pointed out, "it is safe to say that other indirect losses will make the total up to a full hundred thousand (*ibid.*)." The loss of a dam at St. Johns was clearly a devastation imposed throughout a much larger proportion of the basin.
29. The *St. Johns Herald* (1/30/1919; 3/6/1919; 3/27/1919; 5/15/1919) inicated that the Arizona State Loan Board took over actual construction of the new Lyman Dam and pushed it to completion under the direction of their own engineers. As of May 15, 1919, 125 men and 70 teams were employed on the dam, and more were being sought. Expectations were that the dam would be high enough by June 15th to provide water for the coming season. Apparently, until the state took over, reconstruction of the Lyman

Dam had completely ceased (*ibid.*: 1/30/1919), placing agricultural productivity at St. Johns in a state of uncertainty for three or four years.
30. This figure represents all of the irrigated farmland within the boundaries of the Bureau of Reclamation's Snowflake Project Area, which included "the area adjoining the towns of Snowflake, Shumway and Taylor" (Bureau of Reclamation 1947:1). The project boundaries encompassed a total area of 27,500 acres, with most of the irrigated farmland in this territory located in the immediate Snow-flake-Taylor area.
31. Because the original residents of Taylor had settled in the valley with Stinson's approval prior to the sale of his property to William Flake, many members of this settlement disputed the extent to which succeeding settlers at Snowflake had prior claim to the waters of Silver Creek. This conflict was settled in 1883 when the following arbitrator's report was submitted to the farmers of both towns:

> That in order to make suitable reservoirs and water ditches Snowflake shall pay at the rate of three dollars per acre and Taylor at the rate of five dollars per acre for all their farming land and city lots watered or that may hereafter be watered out of the waters of Silver Creek....(Quoted in Fish n.d.a.:41; also quoted in LeVine 1977:112).

In 1888, the assessment rates were apportioned equally among the farmers of both settlements (*ibid.*), and a formal integration of the irrigation systems of the two towns was achieved in 1893 with the incorporation of the Snowflake and Taylor Irrigation Company (LeVine 1977:113).
32. The expenditures for surveying, legal fees and the purchase of headgates associated with the construction of Daggs Dam totaled $3,800 (LeVine 1977:113). The remaining costs covered the actual construction of the dam.
33. LeVine (1977:155) mentions that in 1916 Daggs Dam, as well as other dams at Snowflake and Taylor, needed repair due to the stresses of high water. The following year the Apache Railroad was granted permission to use the dam as a right of way for its roadbed (*ibid.*), which led to a strengthening of the dam by the railroad company. The Dam needed repair again in 1932, and the Apache Railroad dispatched a crew of 20 men to aid in this project (*ibid.*:116; see also *Snowflake Herald*:11/13/1931).
34. The most serious setback to farmers at Snowflake and Taylor with regard to their investment in an irrigation system was experienced long after the period under consideration here. In September of 1935, work began on the construction of the Lone Pine Dam, which was expected to increase irrigated acreage in the two valleys by about 4,000 acres. Completed in March of 1937 at a total indebtedness of nearly $300,000, this dam stood 95 feet high and was expected to impound 11,000 acre-feet of water (see LeVine 1977:116 for a discussion of the financial information and other specifics on the Lone Pine Dam). However, due to extensive faulting throughout the Snowflake-Taylor area (see Chapter 4, footnote 11), this dam proved incapable of storing water. Even after successive attempts to patch various leaks, the reliable storage capacity of Lone Pine Reservoir remains an insignificant 31 acre-feet. The failure of this dam might have resulted in a widespread loss of land by farmers in the Snowflake-Taylor area had the irrigation company not been successful in transferring its indebteness from the land bonded to finance the project to the power division of the irrigation district (see *Snowflake Herald*:5/10/1940).

35. Greenwood (1960:101) does indicate that the canal and reservoir system presently used by the Round Valley Water Users Association was constructed between 1880 and 1898 under the direction of the Mormon Church, which at various times furnished a subsistence pay of $1.25 per day as well as the necessary dynamite. No mention is made of any major setbacks in this construction process.
36. See, for example, Chapter 2, footnote 32.

Chapter 6

Exploiting Environmental Diversity

The little Colorado River Basin is composed of several widely distributed and structurally distinct habitats which are often differentially affected by the same environmental variation and which offer different productive potentials for agricultural populations. Any attempt by the nineteenth century Mormon settlers to exploit these diverse habitats within a single resource-flow system was likely to enhance local community stability. Stability would be increased by reducing each individual settlement's dependence on a specific habitat and by providing additional resources from other, independent habitats which were unlikely to suffer from the same schedule of variation. Several early Mormon adaptive strategies either manifestly or latently incorporated a multi-habitat adaptation within a single resource-flow system. To the extent that this occurred, specific settlements were more likely to weather potentially devastating environmental fluctuations and less likely to succumb to the stresses that such instabilities imposed.

The success of an adaptive response to environmental conditions depends in part upon the resources that a community is able to direct into appropriate channels. Accordingly, the size of their population, the technology which they commanded, and the organization through which they directed their labor and other resources determined the ability of the Little Colorado Mormon settlements to effectively exploit the opportunities presented by a multi-habitat adaptation. However, simultaneous demands upon a population's resources limited the amount of energy that could be directed into the expansion or integration of resource flows originating in distinct and widely separated habitats. Due to insufficient manpower and to the drains imposed on that manpower by fluctuations in the conditions defining their primary habitat, early settlements in the lower valley of the Little Colorado River were unable to effectively expand their exploitative activities into other, frequently more productive locations. The effective incorporation of diverse habitats into a single resource-flow system was only achieved at a later date when increased immigration and a regionally coherent church organization permitted the synchronization of resource flows from a variety of widely distributed habitats throughout the basin.

UNITED ORDER CONJOINT ENTERPRISES

Although their emphasis from the beginning was to establish viable agricultural settlements based on the flow of the Little Colorado River, early Mormon colonists quickly recognized the adaptive advantage in exploiting habitats away

American Anthropologist

Volume 91 Number 3 September 1989

Contents

Articles

Research Reports

 ISSN 0002-7294

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Ecology, Resource Redistribution, and Mormon Settlement in Northeastern Arizona

Successful Mormon colonization of the American West has largely been attributed to the adaptive advantage of cooperative Mormon values. This article shows that successful Mormon colonization of the Little Colorado River Basin had an ultimate ecological basis: the redistribution of surplus resources among settlements situated in dispersed and functionally independent local environments. Two systems of resource redistribution among 19th-century Little Colorado Mormon settlements are examined, showing that ecological considerations explain their differential success as adaptive mechanisms contributing to the success of this local colonization effort. The article concludes by suggesting that general ecology provides a useful theoretical framework for explaining successful Mormon colonization in this region and elsewhere.

MORE THAN TWO DOZEN MORMON AGRICULTURAL SETTLEMENTS WERE founded in the Little Colorado River Basin of northeastern Arizona as part of an ambitious 19th-century Mormon effort to colonize the American West. A demanding and highly variable environment threatened the success of this local effort by seriously limiting agricultural productivity and by imposing excessive demands on farming. High costs in the face of low and highly variable agricultural productivity yielded substantial emigration and population instability, and resulted in the failure of some half dozen settlements. The colonization effort succeeded, however, despite the difficulties encountered, and the basin today contains some 20 towns that originated during early Mormon colonization of the region. Significantly, agricultural colonization of the basin was largely a Mormon achievement, with Mormon settlements succeeding where others had failed (see Peterson 1973:1–2).

Historians and social scientists have long been interested in the impressive success of Mormon colonization and have largely explained this success in terms of the social and economic consequences of cooperative Mormon values (cf. Arrington 1958; Leone 1979; O'Dea 1957; Peterson 1973). While recognizing the role that cooperative values played as proximate causes underlying successful Mormon colonization, this article argues that successful Mormon colonization of the Little Colorado River Basin had an ultimate material basis: the judicious redistribution of surplus resources among individual settlements situated in separate and independent local environments. The article also argues that the adaptive advantage of Mormon resource redistribution conforms to expectations derived from general ecological theory.

Although considerable debate exists regarding the relationship between diversity and stability in ecological systems and the extent to which regulation occurs within complex ecological communities (see Abruzzi 1987:317–318; May 1973:37–40), research exists that suggests that complex ecological communities are better able to maintain population and community stability in the face of limited environmental variation (cf. MacArthur 1955; Rogers and Hubbard 1974). The key to maintaining community stability under

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variable environmental conditions lies in the degree to which redundancy exists in the flow of energy/resources through a community. Redundancy results when resource flows through a community originate in several functionally independent channels. Community stability and persistence can only occur if a community's resource flows possess sufficient redundancy to assure local resource availability during periods of increased environmental instability. Where sufficient redundancy exists, the destabilizing impact of environmental fluctuations can be offset by the existence of a complex network of overlapping energy/resource flows. Where sufficient redundancy does not exist, the negative consequences of environmental perturbations are likely to ramify throughout the community and reduce community stability, even among communities containing a high degree of diversity. This article suggests that Mormon values facilitated resource redistribution, and thus successful colonization of the Little Colorado River Basin, only when they underlay a multihabitat resource-flow system that contained sufficient redundancy to effectively counteract local environmental instability.

The relevance of material considerations and general ecological theory for explaining successful Mormon colonization in the Little Colorado River Basin is illustrated by the differential success of two systems of multihabitat resource redistribution developed by early Mormon settlers in the region. The first of the two systems was based on the joint operation of several productive enterprises by early United Order towns located along the lower valley of the Little Colorado River.[1] This initial system failed as a mechanism of environmental regulation despite its collective organization and its manifest ecological orientation because it lacked sufficient redundancy to withstand and offset the destabilizing impact of environmental instability. It depended directly on the surplus labor and productivity of fewer than a half dozen settlements situated in similar, highly unstable habitats. A system of tithing redistribution later emerged that provided the redundancy needed to offset local environmental instability. This later system succeeded because it was based on resource redistribution among nearly 20 settlements located in diverse, independent, and widely separated habitats. Significantly, this later system did not evolve as a conscious adaptation to physical environmental conditions, but largely as a response to competing non-Mormon business interests. In addition, while tithing redistribution emerged as part of the overall cooperative thrust of Mormon colonization, it depended fundamentally on institutions that enabled individual settlers to profit from participation in the system.

By showing that successful Mormon colonization of the Little Colorado River Basin can be explained by explicit reference to general ecological considerations, this article attempts to go beyond merely stressing the importance of environmental factors in the settlement process. Specifically, its goals are (1) to indicate the ultimate material basis for successful Mormon colonization, and (2) to suggest that general ecology provides a meaningful theoretical framework for explaining successful Mormon colonization and, potentially, the evolution of complex human communities.

Mormon Colonization of the Little Colorado River Basin

Mormon colonization of the Little Colorado River Basin began in 1873, when a well-equipped party of more than 100 individuals was dispatched by Church leaders in Salt Lake City to establish a single settlement along the lower valley of the Little Colorado River (see McClintock 1921:135; Tanner and Richards 1977:12). This initial effort failed, and a second attempt was made in 1876. This time, 500 settlers were organized into four companies and instructed to establish four settlements in the general location chosen for the previous expedition. These were Sunset, Brigham City, Obed, and St. Joseph (see Figure 1). Additional colonies were founded along Silver Creek and along the upper Little Colorado River during 1877–80.

Establishing and maintaining viable agricultural communities in this arid and climatically variable region proved exceedingly difficult. Annual precipitation for most of the

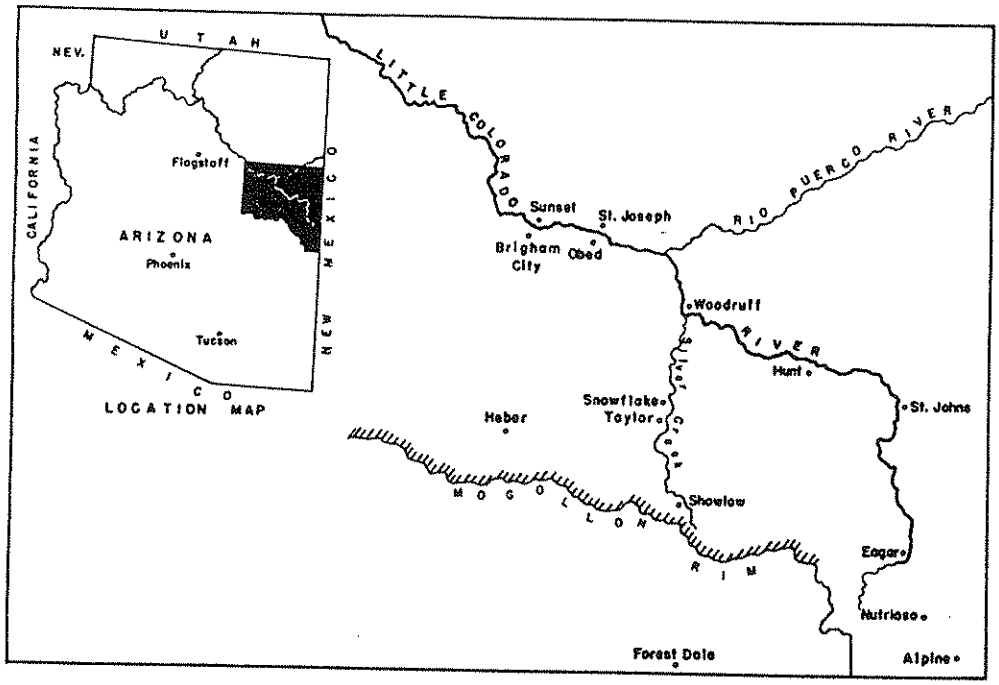


Figure 1
Little Colorado River Basin Mormon settlements. (Reprinted with permission of Plenum Press.)

basin averages less than 400 mm and varies substantially from year to year. Furthermore, little, if any, precipitation occurs during the critical months of April to June. Irrigation was, therefore, essential to successful farming in the region (see Abruzzi 1985). However, because surface water flows largely in direct response to precipitation, streamflow also fluctuates sharply, and most streambeds are dry during April to June, when 45% of annual irrigation requirements must be applied (see Bureau of Reclamation 1947:72). Mormon settlements also had to contend regularly with early frosts, high temperatures, droughts, flooding, hailstorms, insects, and high winds. In addition, two devastating droughts ravaged the basin for nine years between 1892 and 1905, killing thousands of livestock and causing widespread crop failure. Such pervasive environmental variation frequently resulted in individual settlements losing crops to several causes during a single agricultural season.

Hard work and cooperation did not, therefore, guarantee success. Settlements were frequently left with insufficient food to survive the winter, despite a heavy investment of labor and other community resources. For example, while Sunset produced 7,000 bushels of wheat and corn in 1879, this lone productive year was preceded and followed by three years of poor harvests. Likewise, Brigham City suffered continuous crop failures from 1876 to 1881, while St. Joseph sustained near-total crop failures for three of the seven years between 1876 and 1882. In addition, records indicate that generally poor harvests occurred throughout the basin during half the years between 1880 and 1900 (Abruzzi 1981:92–96). Total tithing collected displayed an annual variation of nearly 40% at St. Joseph and Woodruff, more than 30% at Showlow and Alpine, and about 20% among the relatively properous and stable settlements of Snowflake, St. Johns, Taylor, and Eagar (see Table 1).

Substantial variation in agricultural productivity persisted despite continued intensive labor investment. For example, St. Joseph constructed five dams between 1876 and 1884

Table 1
Total tithing by town, 1887–1905 (in dollar values).[a]

Year	St. Joseph	Woodruff	Snowflake	Taylor	St. Johns	Eagar	Showlow	Alpine
1887	611	570	2,334	1,004	—	—	364	—
1888	772	410	2,969	1,299	3,637	1,427	283	288
1889	862	602	2,855	1,573	4,413	1,838	418	425
1890	1,204	797	3,411	1,710	4,328	1,804	651	234
1891	590	681	2,851	1,414	4,479	1,743	489	388
1892	684	971	3,319	1,557	3,447	1,391	522	472
1893	734	581	2,865	1,130	3,029	1,901	263	491
1894	583	581	2,498	1,259	2,347	1,165	572	218
1895	772	655	2,341	995	2,391	2,021	330	470
1896	748	629	2,362	1,192	2,169	1,634	325	442
1897	952	774	2,578	1,147	2,541	1,975	389	454
1898	1,191	894	2,183	1,230	2,861	2,156	226	333
1899	1,543	1,324	2,880	1,479	3,482	2,029	453	594
1900	1,141	1,394	2,945	1,563	3,961	1,371	233	416
1901	1,677	1,246	3,882	1,567	4,200	2,485	—	523
1902	1,497	1,349	3,782	1,817	3,713	1,886	—	391
1903	1,907	1,578	4,142	1,857	4,542	1,863	554	860
1904	1,796	1,364	3,699	2,055	4,186	1,739	585	506
1905	2,094	1,047	3,589	1,847	4,361	2,155	667	583
X[b]	1,124.11	915.42	3,025.53	1,463.47	3,560.50	1,810.17	430.88	449.33
s	489.41	356.43	589.24	318.20	817.39	325.69	144.43	146.96
V	.435	.389	.195	.217	.230	.180	.335	.327

[a]Source: Abruzzi (1987:88).
[b]"X" denotes the mean; "s" denotes standard deviation; "V" denotes coefficient of variation.

for a total cost of nearly 9,000 man-days and 3,000 team-days labor valued together at over $40,000, all of which were destroyed by floods in the Little Colorado River (see Abruzzi 1981:169–177). Settlers at St. Joseph did not achieve a permanent irrigation structure until the construction of their final dam in 1924.

Each dam loss produced a crop failure which resulted inevitably in individuals emigrating from the affected community. Emigration, in turn, forced the remaining inhabitants of a town to recruit new settlers to rebuild the dam, repair ditches, and replant fields. Understandably, population instability was most pronounced among settlements located along the lower valley of the Little Colorado River, as these towns experienced both the greatest variation in agricultural productivity and the highest incidence of dam failures. St. Joseph and Woodruff, the two surviving lower valley settlements, sustained 13 and 10 dam failures, respectively, between 1876 and 1900. By comparison, only three dam failures occurred at Snowflake and Taylor, two at St. Johns, one at Showlow, and none at either Eagar or Alpine during the same years (Abruzzi 1981:191). As a result, the lower valley contained the greatest number of failed settlements. Brigham City was abandoned in 1881 and Sunset in 1883. A later settlement, known eventually as "Old Taylor," was both founded and abandoned in 1878 following the construction and loss of five dams during that single year. Obed was abandoned in 1877 due to persistent illness associated with its location.

Exploiting Environmental Diversity

As the previous discussion clearly indicates, local environmental variability threatened the survival of individual settlements in the Little Colorado River Basin, and thus undermined the entire colonization effort. However, the region's spatial diversity provided an opportunity for early settlers to overcome local environmental limitations. The basin contains numerous widely separated and structurally distinct local habitats which are often differentially affected by the same environmental variation and which offer distinct potentials for agricultural productivity. Consequently, a clear adaptive advantage existed for early Mormon settlements to integrate the productivities of several habitats into a single resource-flow system. A multihabitat exploitative strategy would diversify an individual settlement's resource base and thus increase local community productivity and stability. To the extent that a multihabitat strategy occurred among Mormon settlements in the region, it increased the probable success of their colonization effort.

Individual settlements could reduce their level of dependence on any single highly variable habitat by exploiting several distinct local environments. In this manner, the region's spatial diversity could be used to circumvent its temporal variability. Widely separated habitats generally displayed different schedules of variability. For example, while the particularly wet 1890 agricultural season increased agricultural production at most locations, it caused crops to rot at Alpine and led to the loss of dams at Snowflake, Taylor, Woodruff, and St. Joseph (see Abruzzi 1981:94, 174, 179, 188). Similarly, St. Johns and Alpine reported extensive damage to crops caused by grasshopper infestations between 1884 and 1891, whereas other settlements did not (see McClintock 1921:191).

Broad regional environmental forces also generally produced distinct impacts in different portions of the basin. For example, while abundant rainfall generally increased agricultural productivity at lower elevations, it increased flooding and crop damage at higher elevations and in other local habitats where soil permeability is low, such as in the lower valley of the Little Colorado River. Similarly, intense rainfall or heavy snow melt yielded more frequent dam failures at lower elevations because of the larger surface area drained here. While warm years generally provided more adequate growing seasons at higher elevations, they increased the likelihood of heat stress and higher evapotranspiration rates on crops at lower elevations. Conversely, while cooler temperatures reduced heat stress on crops in the lower valley, they increased the risk of early frosts throughout the southern highlands. Consequently, due to local differences in elevation, precipitation,

temperature, length of growing season, soil quality, and surface water quality and availability, agricultural productivity varied significantly within and between Mormon settlements throughout the 19th century. For this reason, no clear correlation exists in the pattern of annual agricultural productivity achieved among individual towns throughout the region (see also Lightfoot 1980:206–208).

The development of an integrated multihabitat resource-flow system thus offered a clear adaptive advantage for early Mormon settlements in the region. For those towns whose very survival was in perpetual jeopardy, the ability to withstand otherwise devastating crop failures and dam losses frequently meant the difference between extinction and continued survival. However, even the more prosperous settlements benefited from resource redistribution. Between 1887 and 1905, agricultural productivity varied more than 35% above and below its average at Eagar, and 28% above and nearly 40% below its mean at St. Johns. Even Snowflake, the most prosperous settlement in the entire region, experienced 30% variation in agricultural productivity during these years. By actively pursuing a multihabitat exploitative strategy, Church leaders more realistically shifted the focus of self-sufficiency away from individual settlements and onto a regionally coherent adaptive system.

The Little Colorado Mormon settlements developed two distinct multihabitat resource-redistribution systems during the 19th century. The first consisted of a series of productive enterprises jointly operated by the early United Order towns in the lower valley of the Little Colorado River. The second and later system operated through the collection and redistribution of the tithing resources among settlements dispersed throughout the river basin.

Conjoint Enterprises

Early Mormon settlements in the lower valley jointly operated four separate productive enterprises: a sawmill, a dairy, a grist mill, and a tannery. Unfortunately, almost no information exists regarding either the grist mill or the tannery. However, enough information exists for the sawmill and the dairy to indicate (1) that these enterprises provided important resources that supplemented agricultural production along the lower valley, (2) that they frequently provided these resources during the very years when farming along the lower valley failed, and (3) that the per capita productivity of these supplementary activities often exceeded that achieved through irrigated farming along the Little Colorado.

Established during November 1876, the sawmill was located about 60 miles southwest of Sunset. Production at the mill during November and December that year was 51,202 board-feet at a cost of 1,200 man-days labor (Porter 1923:65). By April of 1877, production at the sawmill had totaled 100,000 board-feet (Jensen 1935:4/10/1877), and during November of 1878 about 80,000 board-feet of lumber were produced (Little Colorado Stake 1878–87:11/30/1878). Most of this lumber was used by settlements in the lower valley to construct the initial buildings needed to establish these towns. However, in 1879 nearly 40,000 board-feet of lumber were charged to individuals at Snowflake (Porter 1923:65), and as early as September 1877, a delegation was sent to Prescott, Arizona, to determine the current market price for the sale of lumber (St. Joseph United Order 1887:9/6/1877).

The sawmill produced lumber for five years. However, it became increasingly difficult to maintain sufficient labor at the site. Travel to the sawmill from the Little Colorado settlements took nearly a week round-trip. Consequently, a more or less permanent population had to be stationed there. Following a heavy initial input of labor, the number of permanent residents at the mill steadily declined, and by the close of 1881 the mill was sold.

The most successful of the early conjoint enterprises was the dairy. Established in 1878, the dairy provided both substantial and critical provisions for the early colonies. During the first year, 48 men and 41 women tended 115 cows and produced 5,400 pounds of

cheese and 442 pounds of butter (McClintock 1921:154; Peterson 1973:111; see Little Colorado Stake: 8/31/1878). Production at the dairy during 1881 included 2,000 pounds of cheese, 1,300 pounds of butter, 1,100 pounds of pork, and 340 bushels of potatoes (Warner 1968:10). By 1882, a reported 200 cows were being milked there (Warner 1968:11).

Although the dairy was successful and substantially enhanced the aggregate productivity of the lower valley settlements, its productivity, like that of the sawmill, depended upon surplus labor available from the parent communities. Since the dairy was also located at a considerable distance from the Little Colorado, its efficient operation likewise required a resident population. However, as lower valley settlements suffered continuing hardship trying to maintain their fragile irrigation systems, they were increasingly unable to provide the labor needed to operate the dairy. Furthermore, as population size declined at Sunset and Brigham City, the Mormon dairy suffered. With the demise of these and other towns along the Little Colorado the dairy was abandoned in 1882, less than a year after the close of the sawmill.

Tithing Redistribution

Following the failure of the conjoint enterprises, Little Colorado Mormon settlements evolved a system of tithing redistribution that contributed substantially to the success of their colonization effort. Tithing was collected by individual wards, centralized into regional stake warehouses and then forwarded, less a portion granted for local use, to the General Tithing Office in Salt Lake City.[2] Most tithing collected within the Little Colorado River Basin during the 19th century was paid in kind, as cash was a scarce commodity on this remote frontier. Items were tithed as they became available, and tithing stocks were generally most abundant following the fall harvest.

Only a fraction of the tithing collected among Little Colorado settlements during the 19th century was actually forwarded to Salt Lake City. The majority remained within the region. While considerable tithing resources were exchanged among individual settlements in order to alleviate local shortages of specific commodities (see Leone 1979:74–77), most was used to subsidize specific projects deemed important by local Church leaders to the success of the colonization effort. The irrigation systems upon which agriculture in this arid region depended were the single most important public structures among Little Colorado Mormon settlements. Consequently, it was in subsidizing dam reconstruction that tithing redistribution performed its most critical adaptive function (see Abruzzi 1981:165–196; Leone 1979:43–110).

The destruction of irrigation systems threatened the survival of an entire community. Their immediate reconstruction was, therefore, essential, especially if a dam failure occurred during the agricultural season. However, such undertakings were generally beyond the resources of individual towns, especially the smaller ones. Through tithing redistribution local Church leaders provided produce and supplies that permitted endangered settlements to survive until the next harvest. They also used tithing funds to hire labor to help repair dams, and allowed individuals to offset their tithing obligation to the Church by donating labor on dam reconstruction and on other Church-approved projects. Tithing surpluses were also distributed to needy individuals and families within a town, even during years when the majority of that community prospered. Applied in this manner, tithing redistribution enabled surpluses collected at one spatiotemporal locus to offset production deficiencies at another time and place.

Tithing redistribution thus contributed substantially to the successful colonization of this arid and climatically variable river basin. It is highly unlikely that either St. Joseph or Woodruff would have survived repeated dam failures were it not for access to regional tithing resources. Individual settlements also benefited when losses occurred for reasons other than poor harvests or dam failures. For example, Mormon settlers at St. Johns and Eagar, both relatively prosperous communities, depended critically on tithing redistri-

bution during several years in which they endured intense and costly political harassment by non-Mormons (see Abruzzi 1981:43–49).

The effectiveness of tithing redistribution depended on several supporting institutions, including (1) a regional board of trade that established uniform prices among Mormon settlements in the region and made it economically advantageous for individuals to donate resources to the Church, (2) a network of church-affiliated mercantile institutions that provided the storage, transportation, and credit arrangements needed for effective tithing redistribution, and (3) a system of quarterly stake conferences at which representatives from every settlement exchanged information, assessed local needs, and determined appropriate resource allocations.

The Board of Trade among Little Colorado Mormon settlements was designed to encourage and direct cooperative production, marketing, and purchasing activities among Mormon settlements. This was done in order to regulate wages and prices paid in economic transactions with competing non-Mormon business interests (see Abruzzi 1981:215–217; Arrington 1958:342–349; Leone 1979:82–83; Peterson 1973:131–135). Local boards of trade were established throughout the Mormon settlement area that were administratively united with Zion's Central Board of Trade in Salt Lake City. By establishing specific prices charged to non-Mormons, the Board of Trade necessarily fixed the prices that prevailed among Mormons themselves. In addition, by establishing set prices for all commodities, items in greater abundance at one town might be more profitably converted through deposit in the Church's local marketing apparatus than in sale to non-Mormons. Both individuals and local Church leaders could, therefore, exchange surplus goods on hand for scarce commodities that were abundant elsewhere at prices that were not harshly responsive to market fluctuations. As a result, the Board of Trade's pricing policies facilitated resource redistribution among Mormon settlements and inhibited the expatriation of resources from the redistributive system.

The Arizona Cooperative Mercantile Institution (ACMI), like the Board of Trade, developed as a local component of an encompassing Church institution: Zion's Cooperative Mercantile Institution (ZCMI) (see Abruzzi 1981:217–221; Arrington 1958:298–322; Leone 1979:79–81; Peterson 1973:136–153). The ACMI was founded in 1881 with 11 local church leaders forming its initial Board of Directors. A central ACMI store was established with locally owned affiliates organized in most settlements. The ACMI was originally begun as a wholesaler for Mormon towns in the region, purchasing supplies at prices that individual settlements could not command. However, it quickly assumed an important credit function. Individuals and affiliated cooperative stores could obtain advances from stocks on hand, usually to be repaid following the next harvest. Applying liberal credit arrangements, the ACMI facilitated recurring investment in local agriculture, as it normally carried a heavy load of debtors from one year to the next.

The ACMI also performed a critical role in tithing redistribution. Local bishops could exchange goods from their tithing stocks for cash, and frequently stored tithing produce on credit with the ACMI. Individuals could deposit their tithing obligations to the Church at the local ACMI affiliate and either have the proper amount credited to their tithing account or banked against future need. Labor was also an important commodity that could be exchanged at the ACMI. A substantial number of individuals obtained temporary employment freighting for the ACMI or performing other duties necessary for its operation, and the entire settlement of Woodruff exchanged employment for food and supplies with the ACMI following the destruction of their dam in 1884 (Abruzzi 1981:179).

The effectiveness of the ACMI in resource redistribution was enhanced by its integration with the larger ZCMI. Deposits in local cooperative stores throughout the Mormon West could be credited to individuals and towns within the Little Colorado River Basin. Thus, by its various credit arrangements and through its intimate association with the local Church leadership, the ACMI effectively transformed an otherwise dormant sur-

plus into an active flow of resources that circulated between locations of relative abundance and those of critical need.

The responsiveness of tithing redistribution was assured by a system of quarterly stake conferences attended by representatives from each ward. Although they were ostensibly held for religious communion, the conferences served as a time during which considerable information was exchanged regarding the material circumstances of local settlements. The conferences occurred during critical junctures in both the agricultural and seasonal cycles: prior to the planting season (February–March), after the spring runoff (May–June), following the intense summer rains (August–September), and subsequent to the fall harvest (November–December). They therefore facilitated a rapid exchange of information and enabled a judicious response to local needs at the very times when environmental conditions were most likely to have a negative effect on local agricultural systems.

Discussion

As already indicated, the Little Colorado River Basin presented early Mormon settlers with a diverse yet highly variable environment that imposed severe limitations on agricultural productivity and community stability at the same time that it offered the potential for circumventing local environmental limitations. Early Mormon settlers clearly recognized the adaptive advantage of exploiting regional diversity and employed several specific strategies to integrate the exploitation of diverse habitats into a single resource-flow system. However, of the two multihabitat resource-flow systems that emerged—one based on joint resource exploitation and the other on tithing redistribution—only the latter system functioned as an effective mechanism of environmental regulation by circumventing environmental variability. It is argued here that tithing redistribution succeeded primarily due to the greater redundancy of resource flows it provided compared to the earlier system of conjoint enterprises.

The conjoint enterprises eventually failed because they never achieved functional independence from the lower valley settlements. Most activities performed at the sawmill and the dairy had to be completed during the summer and early fall due to the constraints imposed on these activities by the winter weather at higher elevations. However, agricultural labor was performed primarily during the summer and fall as well. Consequently, the effective operation of the conjoint enterprises competed directly for labor with farming in the lower valley. A record of the labor expended at St. Joseph during 1879 illustrates clearly the problem these early settlers faced (see Table 2). Of the 4,761 man-days of labor credited to 23 men, approximately 4,500 man-days, or 196 man-days per capita, had to be performed concurrently with the growing season.

Little time remained, therefore, to invest in other activities. Competing demands for labor in agriculture, dairying, logging, milling, and the numerous other operations needed to establish and maintain individual settlements strained the limited labor force of these small towns. During periods of critical labor shortages in agriculture, which occurred almost semiannually due to recurring dam failures, the drain of investing in supplementary productive activities far removed from the lower valley was a burden that became increasingly difficult, and eventually impossible, for lower valley settlements to endure. The instability and high cost of agriculture in the lower valley precluded the continued investment of limited resources in potentially productive yet supplementary resource flows.

Labor shortages among lower valley settlements were also aggravated by high dependency ratios (see Table 3). Settlements in the lower valley maintained consumer/producer ratios that reduced their productive capacity below that already imposed by their small size. This increased the already excessive drain on their limited resources. Furthermore, dependency ratios increased with time. At St. Joseph, the proportion of the population under eight years of age increased from 36.5% in 1877 to 49.5% in 1881, a year that witnessed a major dam reconstruction (see Abruzzi 1981:171–172). Signifi-

Table 2
Labor expended at St. Joseph during 1879.[a]

Work performed	Labor expended (in man-days)
Ditch	764.5
Farm	734
Garden	154
Stock	256.5
Herding cows	90
Herding sheep and shearing	326
Dairying	473
Freighting to Utah	128
Choring	234
Carpenter work	303.75
Shoemaking	82
Smith work	95
Building and sundry labor	710.25
Teaching school	95
Sawmill	315
Total	4,761

[a]Source: Porter (1923:375).

Table 3
Percent of the population under eight years of age among settlements in the lower valley of the Little Colorado River, 1877–86.[a]

Year	Sunset	Brigham City	St. Joseph
1877	25.0	34.0	36.5
1878	21.0	36.0	45.0
1879	33.8	40.2	43.0
1880	31.6	38.7	38.8
1881	34.5	—	49.5
1882	43.6	—	45.8
1883	52.4	—	43.6
1884	41.5	—	42.5
1885	42.3	—	23.3
1886	—	—	23.1

[a]Source: Abruzzi (1981:207).

cantly, children under eight years of age still accounted for 42.5% of the population at St. Joseph in 1884, another year requiring a major dam reconstruction (Abruzzi 1981:173). In 1883, the year of its dissolution, Sunset's population contained 52.4% children under eight years of age, the highest proportion of any town throughout the settlement period. In contrast, the proportion of the population under eight years of age in the Eastern Arizona Stake in 1879 was only about 31%, and at its peak reached only 36.7% in 1883, with children under eight years of age comprising only 26.2% of the population of Snowflake in 1880 (Abruzzi 1981:208). In addition, mean family size at St. Joseph between 1892 and 1897 was 7.3 persons, or nearly 30% greater than the mean family size of 5.8 persons recorded at Snowflake during the same years (Abruzzi 1981:209).

Thus, during the critical years when lower valley settlements struggled to establish their productive bases along the Little Colorado River and attempted simultaneously to

establish the institutions upon which a multihabitat resource-flow system could be based, they lacked the manpower needed to accomplish their goal. Lower valley settlements never seemed able to command enough resources to repair dams, clean ditches, or repair fields, let alone expand into new and distant habitats (see Abruzzi 1981:169–177; Tanner and Richards 1977:41–51).

The conjoint enterprises established by the lower valley settlements were not ecologically viable, despite their manifest ethnoecological basis, because they were not compatible with regional environmental conditions. Nor was their viability enhanced by the fact that they were based on the cooperative Mormon values that underlay their communal United Order organization (see Peterson 1973:91–122). The small populations of these communities suffered an intense drain on their meager resources due to the variability of surface water flow in the Little Colorado River. At the same time, chronic labor shortages in the face of frequent dam failures and high dependency ratios limited the ability of lower valley settlements to invest sufficient resources to effectively exploit distant habitats. Thus, despite its cooperative orientation, communal organization, and explicit ethnoecological basis, the system of conjoint enterprises failed as a mechanism of environmental regulation.

By contrast, tithing redistribution succeeded as a mechanism of environmental regulation, despite the fact that its critical supporting institutions were established for nonecological purposes. Although tithing redistribution itself was employed in part to offset the impact of local environmental variation, the Board of Trade and the ACMI were established primarily in response to competing non-Mormon business interests, while the quarterly stake conferences functioned ostensibly to promote religious unity and social separation. However, despite their manifest nonecological origin, the latter institutions provided the foundation for an ecologically viable multihabitat resource-flow system for the very reasons the conjoint enterprises did not. By broadening the organizational and environmental scope of the exchange network and by incorporating within this network a sufficiently large aggregate population permanently occupied within numerous, widely dispersed habitats, the system of tithing redistribution was suitably structured to circumvent local environmental variation within the basin.

By including every Little Colorado Mormon settlement and thus integrating resource flows from every exploited habitat, this later regionally coherent exchange system was able to provide substantial resources (labor, food, and supplies) at those specific times and places where resources were critically needed to offset the destabilizing impact of local environmental variation. In addition, tithing redistribution integrated the productivity and labor of more than 2,000 persons in two dozen independent settlements scattered among widely separated habitats. As a system of environmental regulation, tithing redistribution stood in sharp contrast to the conjoint enterprises that integrated the material resources of only a few hundred persons inhabiting three or four neighboring settlements located in similar highly unstable primary habitats.

The effectiveness of tithing redistribution was also enhanced by the integration of local settlements into a regional, centrally administered religious organization and by the affiliation of local institutions with external parent organizations. While the former increased the responsiveness and reliability of local tithing redistribution, the latter provided access to resources whose availability was independent of regional environmental conditions. Enveloping Church institutions frequently provided critical subsidies to stricken communities which augmented the regional system's ability to respond to local needs. The hierarchical structure of 19th-century Mormon settlements and institutions therefore provided an adaptive organizational framework from which a suitably complex regional resource-flow system could emerge. Furthermore, despite its manifest cooperative orientation, tithing redistribution actually functioned through supporting institutions that made participation in the system individually profitable. As already indicated, by fixing prices on commodities the Board of Trade also enabled individuals to exchange their surpluses more profitably with the local Church marketing apparatus, either as tith-

ing or as credit in the local Church-operated cooperative stores. In addition, during its earliest years, the ACMI paid investors dividends exceeding 25% (see Abruzzi 1981:20), and as late as 1890 the ACMI still declared a dividend of 20% (LeVine 1977:38).

The creation and central redistribution of local surpluses, combined with the availability of additional subsidies from external Mormon sources, contributed substantially to the success of Mormon settlement in this basin. These were the same institutional arrangements that underlay successful Mormon colonization elsewhere (see Arrington 1958), and it is for this reason that successful colonization of the Little Colorado River Basin and much of the American West was largely a Mormon achievement.

Significantly, the differential success of Mormon attempts at multihabitat exploitation in the Little Colorado River Basin conforms to expectations derived from general ecological principles and suggests broader theoretical implications for explaining the success of Mormon colonization. Ecological redundancy was clearly absent in the system of conjoint enterprises established by the early United Order settlements in the lower valley of the Little Colorado River. Although these enterprises exploited resources away from the lower valley, the labor needed to operate them was directly linked to conditions affecting agriculture along the Little Colorado. Consequently, the negative impact of environmental instability upon irrigated farming in the lower valley ramified to the conjoint enterprises. Rather than offsetting environmental instability, as anticipated by ecological theory, the multihabitat exploitative system of the early lower valley settlements succumbed to it.

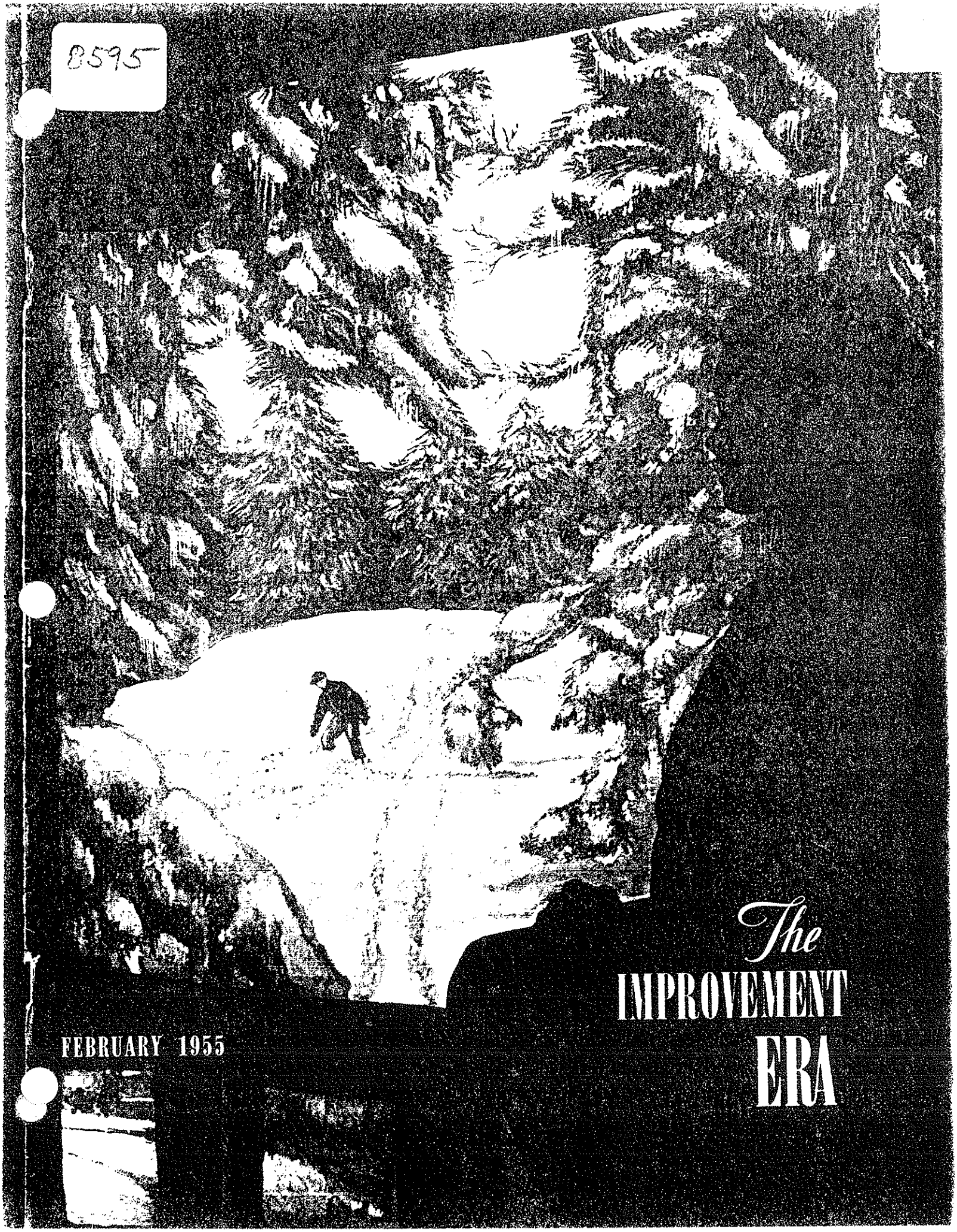
In contrast, the later system of tithing redistribution integrated settlements throughout the entire basin by uniting the productivity and labor of separate populations concentrated in the intensive and independent exploitation of diverse local habitats. Productive shortfalls at one location were compensated for by surplus productivity elsewhere. Thus, separate and independent resource flows in numerous, distinct habitats provided sufficient redundancy to circumvent local habitat variability. Linking local tithing redistribution to encompassing Church institutions merely enhanced the redundancy that already existed. Consequently, again as anticipated by ecological theory, tithing redistribution operated as an effective mechanism of environmental regulation and contributed substantially to successful Mormon colonization of the region.

In summation, then, this article has shown (1) that successful Mormon colonization of the Little Colorado River Basin resulted largely from the development of a system of resource redistribution that offset the destabilizing impact of local environmental variation, (2) that general ecological theory explains both the role of resource redistribution in successful Mormon colonization and the differential success of Mormon efforts to develop a multihabitat resource-flow system, and (3) that ecological theory combined with a consideration of local material conditions provides a more precise understanding of this colonization effort than do references to cooperative Mormon values. It is, therefore, suggested that general ecology offers a potentially important theoretical framework for explaining both the general success of Mormon colonization and the evolution of complex human communities (see Abruzzi 1989).

Notes

Acknowledgments. The research upon which this article is based was supported by the National Science Foundation under Grant No. BNS 78 21488. The author wishes to express his appreciation to NSF for its support. Appreciation is also expressed to Brian Foster, Mike Little, Hal Koster, John Frazier, Mark Leone, and Charles Peterson for their valuable assistance during the research, to Mary Reith for the illustration that accompanies the text, and to the anonymous reviewers who made valuable suggestions for the revision of the original manuscript.

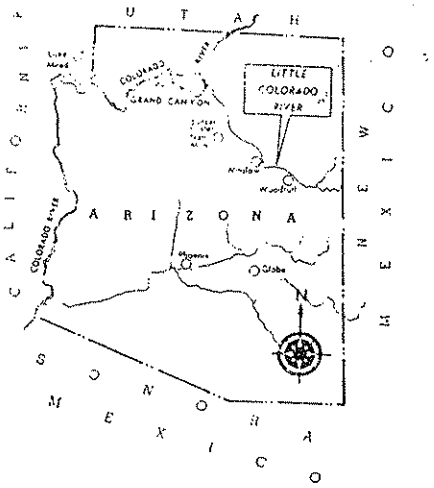
[1]Mormon settlement along the Little Colorado River began under an organizational arrangement known as the United Order (see Arrington 1958:323–349; Peterson 1973:91–122; Tanner and Richards 1977:51–63 for discussions of the United Order and of the United Order Movement in Mormon history). Within United Order settlements, both property and labor were pooled (see St.



The IMPROVEMENT ERA

FEBRUARY 1955

The washout of flume number three during 1918.



Map of Arizona, showing the location of Woodruff.

Damming the Little Colorado

by Ruth Savage Hilton

EVER SINCE the late Ammon Tenney discovered the picturesque little valley of Woodruff on the banks of the Little Colorado in Arizona in 1876, that particular place has been in a constant stage of pioneering. Will it always be so?—is the common question.

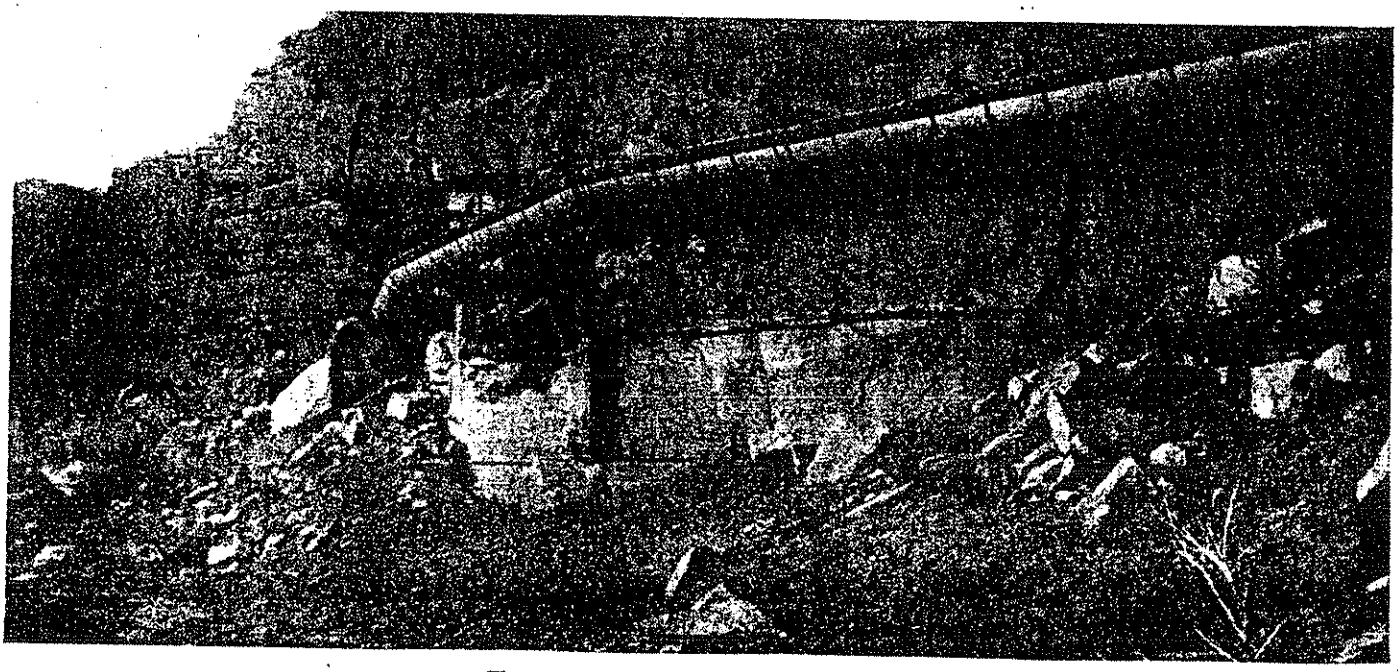
The ordinary observer would undoubtedly answer yes. However, if the reply came from one whose childhood had been spent in the valley, we might hear a smothered sigh, but the reply would be a clear and sure—no, for in very deed our childhood was obsessed with the one determination of reclaiming that special piece of the great southwest, "that it might blossom as the rose."

It was in the early spring of that eventful year when Ammon Tenney, an LDS scout of pioneer days in Arizona, came riding into Sunset* to tell with enthusiasm of the wonderful location for a settlement which he had just found while on a reconnoitering trip up the river.

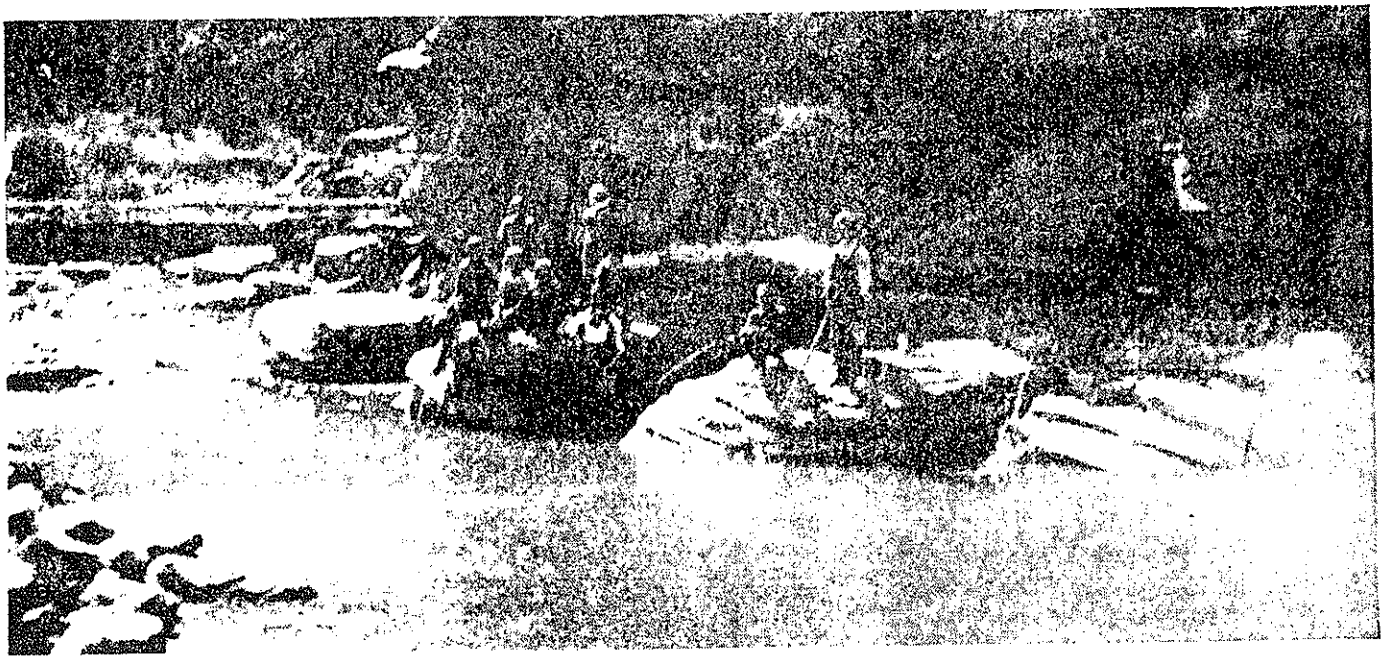
"We have discovered a site with most marvelous possibilities," Brother Tenney declared, "a real little Eden."

The townsite thus referred to is a small valley which nestles at the base of a huge volcanic neck known as the "Butte." This mass of black rock makes a conical-shaped mountain rising about four hundred feet from the valley floor. Two smaller buttes, forming the basin for a clear, small lake, bound its eastern side while the Little Colorado River skirts the entire western line. At the point where this river makes a swirling

*Sunset was located very near to the present site of Winslow. Lot Smith was captain of the group of colonizers who made the camp. They immediately organized themselves into what was known as the "United Order," according to Brigham Young's instructions. This order lasted for seven years, with Levi M. Savage as bishop. Lot Smith was sustained as president of the Little Colorado Stake of Zion. The stake was composed of some four new settlements including Sunset.



Flume number one as it appeared in 1917.



Many a pleasant day was spent fishing below the old dam.

crook and passes from rocky canyon walls to high, concave banks of red clay was the most wonderful dam site that anyone could possibly ask for, according to the pioneer, Brother Tenney.

The old scout declared with animation, "Why—just a bit of brush and a few scrapers of dirt placed at that sharp bend in the river—about one mile south of the Butte—and the thing is done."

The inhabitants of Sunset were among those called by President Brigham Young to what was known as the Arizona Mission. Their specific assignment was to colonize the Little Colorado district. To the end that this task might be accomplished became the life of these pioneers. It represented their hope, their faith, the future of their children. Hence it required very little persuasion to induce about a dozen families to move up the river to Ammon Tenney's new project. Cedars were cut from the surrounding hills and dragged to the river, dirt pulled in by the scraper method, and by late June water was on the fertile soil.

This dam proved to be only the beginning. These thrifty, God-fearing pioneers were entirely unacquainted with the treacherous, turbulent, stream which they presumed to harness. The rains came in early August changing their clear, small stream into a raging torrent of reddish billows. The Zuni Wash joined both Showlow and Silver creeks, and all combined to swell the waters of the ferocious river. This flood carried that first dam away as if it were a single log.

This catastrophe changed the river bed, leaving the dam site widened and enlarged many times. Then began that long struggle with rain, wind, and rock which makes the history of Woodruff. I was about twelve years old when they told me that the mass of rock, timber, and earth which served as our dam was the thirteenth one put at or near that particular site by a mere handful of people who must wrest their living from the soil as they struggled with irrigation's problems. At no time did our population exceed twenty families, and there was no federal aid for reclamation projects in those days. This thirteenth dam had withstood so many floods and had cost so much more than any previous one, that I recall having a feeling of its stability which sensation no doubt was reflected from the adult folk of our town.

However, the crash had only been postponed. That very fall a rider, breathless and dusty, came hurriedly into town. We listened as he warned our parents of imminent danger. The Lyman Reservoir—located above us on the same river—swollen for days beyond capacity, had broken. Shrilly he cried, frightening us most to death, "It isn't a flood that's a comin'—it's an ocean."

That night with its blackness and drenching rain will never be forgotten. It is easy still to vision the grim determination written on every face as all eatables and grain were stored in the second story of granaries. Our rugs, furniture, and the like were raised onto boxes. Then at last the youngsters, bedding, and provisions were loaded into the old farm wagon, and away to the hills. Still it rained more and more.

Morning showed a rather dampened community camping on the heights. The sun came out gloriously. We children laughed. The men and women looked grave. Water was running down the narrow, beaten streets. Cellars were full of the reddish flood. Then came the reeking, swaying crash; the dam gave way. Everyone, young and old, stood on the river bank watching slide after slide *our dam* washed downstream by angry waters. Great rock boulders lunged, rolled, and sank. The mass of logs fastened together which we called the "apron" was tossed aside as a plaything. The waters receded from town to the now deepened river bed. That night we slept in the good old rock house—at home.

Undaunted, the assembled community vowed to rebuild quickly and stronger than ever before. "We are going to build of solid rock and concrete," I heard my father say; however, no rock bottom could be found to tie to, hence a huge rock pier was built on each side of the stream proper. The men blasted out the ledge to make a rock floor for them to stand

(*Concluded on page* 98)

DAMMING THE LITTLE COLORADO

(*Concluded from page 95*)

on. The dam itself was dovetailed into these piers.

That entire winter saw every man and boy of our little town on the job. We youngsters rathered enjoyed it. When school was out, we would run to the dam. Sunday afternoons we would walk to the dam. Moonlight nights we held parties on its rock quarries, and had "Hard Time Dances." Thus we grew to know much of the handling and working of rock derricks, cables, and pulleys, giant powder and blasting, as well as the use of Portland cement.

Spring came; the dam was not completed, but far enough along that everyone felt reasonably safe. In an ordinary river it might have been, but not in the Little Colorado. The melting snows of early May came down the mountainsides in splashing, gnashing glee. They dug under our dam and tumbled it away. It was Sunday morning. The entire community stood on the bank gazing at the great new gap in the river. Both rock piers stood alone, erect, and unimpaired, as if to remind us of what had been. There was little said, no call for noise; silent tears slid down more than one swarthy face.

The townspeople were now thoroughly discouraged, but any thought of giving up the project was never voiced. The fact is, many grimly set their lips and said, "I reckon it'll prove a blessin'."

When and how to rebuild became the ever constant question. Many men went off for work to obtain the ordinary necessities. So time dragged on, and it was some fifteen months before any new plans were matured. These plans called for a solid rock and concrete dam four miles above the old one. Even here, rock bottom was out of the question, but the Little Colorado could be left out; in fact the only way to succeed was to let it go its unconquered way, carrying away the heartaches and backbreaking tasks of many years. Yes, we would dam the river by damming its tributary, the Silver Creek, whose junction was more than four miles above the old dam.

To get water from Silver Creek would necessitate the construction of a Big Ditch the entire four miles, most of the way through solid rock. It was possible, but to a mere handful of people already reduced to bare living it seemed a gigantic task; however, work began, and Community Day was celebrated at the *new dam site*. We children played hide-and-seek among the rocks. Men looked grave and tired. Some of the women sang while others wept. Then the entire group joined in united hymns and prayers—and the work started off with the first blast as giant sticks of powder were exploded at the rock quarry.

The men chiseled the great ditch through solid rock after the dam was completed. Then when they met the canyon walls, two siphons were laid beneath the river, while in other places great flumes were strapped to canyon walls that the precious stream might be guarded and guided on its precarious way from dam to town.

Some days nine able-bodied men, assisted by a few boys, would comprise the working force. Another day there might be fourteen or even fifteen; and on still another day, no one would be there, for the settler must find the wherewithal to feed and clothe the family from somewhere while his valley home waited for *water* to make it "blossom as the rose."

Often the weary worker lingered to fish that he might literally take home his supper. And if the day chanced to afford a long summer twilight, he might meet his wife and the children, his friends with their wives and children, at the old "Fishin' Hole" where picnic supper would be served and his faith would be renewed, his laughter become sweeter, and his friendships stronger.

It required six years to complete this last project. The first year we hauled water in barrels to our trees, then one by one this was given up. First the shade trees (poplars), then vineyards and shrubs, lastly the fruit trees became dry. Finally there remained but one green spot in the entire valley, a small portion of our own front lawn. Nothing could induce my mother to give up this loved spot. She would line us—the little children—up in a sort of bucket parade from barrel to lawn. Here daily we passed the priceless liquid from hand to hand that this precious bit of verdure might not choke to death.

Mother's effort seems almost heroic now as I recall that the grim reaper called her home, in June 1916, and soon that bit of lawn had perished.

At last—the great day in 1918—water was in town again! The long years were over. We had grown from boys and girls to men and women. Our schooling had suffered, more or less, but our faith in life, in persistent endeavor, in the virtue of hope, in the glory of the future was immeasurably heightened. We were married; many of us had moved to distant parts; but all heard the news and joined in the glad "Hurrah!"—or was it a shout of "Hosanna"?

"A stable water supply was available for Woodruff."

"Does it pay, such persistence?" I hear you ask. My answer is to point to the beautiful, contented old age which came to my father, Levi M. Savage. He lived to enjoy his eighty-fifth year, still straight and swift of movement, exemplifying that type of man that has ever pioneered our great West. For almost thirty years he was bishop of Woodruff. His release came shortly after the Big Ditch was completed.

He makes one of the most glorious pictures of my memory as I recall the last year of his life—full of hope, joyous as youth knows how to be, and ever whistling as he milked his cows or went his nightly round, lantern in hand, to make sure that all was well on the premises.

Ask him that question, "Does it pay?" and he would surely answer, "Pshaw, folks, it doesn't matter so much what you do or where you live, it's how you do it."

Turning Tides

(*Continued from page 91*)

A second partnership, entered into after two years' struggle to accumulate another stake, was more disastrous than his first ill-starred venture. His intemperate new partner frittered away the profits in a short time, plunging them both into a deep pool of indebtedness.

Seeking to keep afloat, the partners, in desperation agreed to sell out, and accepted terms from a purchaser, whose unscrupulous dealings entirely finished them.

The purchaser failed to make his payment at the year's end, sold the entire stock of goods, took the receipts,

(*Concluded on page 100*)

DAVID KING UDALL

ARIZONA PIONEER MORMON

David King Udall
his story and his family

1851-1938

written in collaboration
with his daughter
PEARL UDALL NELSON

ARIZONA SILHOUETTES
TUCSON, ARIZONA
1959

FIRST PRINTING
1959

Published by
ARIZONA SILHOUETTES
TUCSON, ARIZONA

PRINTED IN THE UNITED STATES OF AMERICA

My life is but a weaving between my Lord and me,
I cannot choose the colors He worketh steadily.
Ofttimes He weaveth sorrow, and I, in foolish pride,
Forget He sees the upper and I the under side.
Not till the loom is silent and the shuttles cease to fly
Shall God unroll the canvas and explain the reason why
The dark threads are as needful in the Weaver's skillful hand
As the threads of gold and silver in the patterns He has planned.
He knows, He loves, He cares! Nothing this truth can dim.
He gives His very best to those who leave the choice with Him.

—Hughes Fawcett

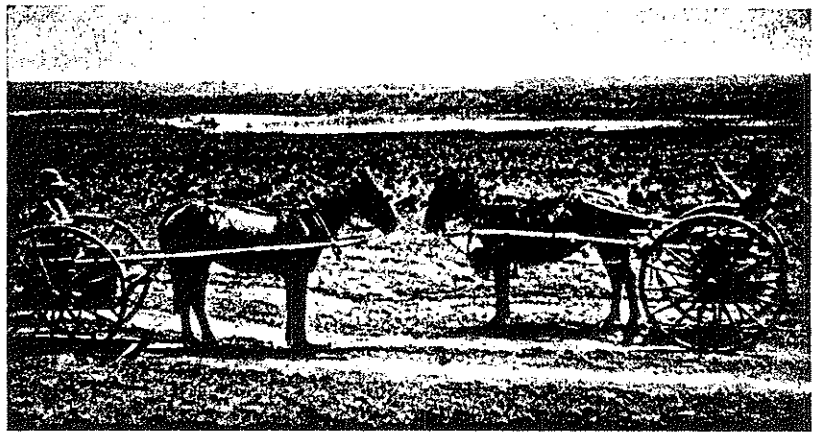
CHAPTER VIII

Home Life and Business Affairs

In our first home in Arizona we hung a beautiful motto in our living room. On its black background, entwined with sprays of wheat and flowers in color, are four gilt words: "The Lord Will Provide." (I purchased this motto in St. Louis about 1883 when I went there to buy goods for our Co-op Store.) When mother and I look at that motto now—for it still hangs on our wall—we gratefully acknowledge that He has provided, not only the wheat, but the flowers. In spite of the struggle that we have sometimes had to make, we have always had the necessities of life, and a spiritual abundance beyond what can be expressed in written words. It is true that we toiled early and late to gain a livelihood, and that our children worked hard along with us. I have been especially grateful to the Lord for the good wives He gave me. We were always blessed with the friendship of our good neighbors, and we were uplifted frequently by the visits to our home of the Church authorities who came to attend Stake Conferences. We felt the benefit of contacts with these cul-

tured people, and in the sum total, lived along as happily as most any family in the land. We had many financial reverses in our family life but we also had many blessings to offset them.

Summarizing our activities briefly, we had mail contacts from 1881 to 1918; we bought sheep from Barth Brothers in 1886-1887. When prices on wool and mutton went so low during President Cleveland's administration, we turned the sheep in on the purchase of the "Milligan Farm" from Henry Huning of Show Low. This farm, a



MEETING OF THE MAIL CARRIERS

section of land with the best water rights on the river, was located two miles southwest of Springerville in Round Valley and fifteen miles from the headwaters of the Little Colorado. Joseph and I at this time went into partnership and were known in business as "Udall Brothers."

We both liked farming, which in St. Johns had proved to be a failure due to heavy mineral water.

The Milligan Farm had good soil and pure mountain water. There were three Mexican houses and a burr grist mill run by water on the property. The farm and improvements were valued at $20,000.

About 1888, we moved our families to the "Mill Farm," as we came to call it. It was a great joy to me to have Ella and Ida and our children living near each other for the first time in our checkered experience. The Mex-

UDALL BROTHERS' GRIST MILL

ican houses with their thick adobe walls and many fireplaces were really comfortable except when the dirt roofs leaked, which was not very often. Thus began a long period of strenuous work.

For three or four years our crops were large. One year we threshed six thousand bushels of grain, and in addition had good crops of hay. Then came ten successive years of drought. Every year our crops, whether good

or poor, were freighted to Henry Huning's ranch in Show Low or to Fort Apache. In this way we made generous payments on the principal of our debt for the first few years, and then as one crop after another failed it was all we could do to live and keep up the interest on the notes. In the early days when farming was successful we installed a new roller mill to take the place of the old burr mill, and had the valley grown its average crops of wheat our mill would have proved a profitable business.

However, the drought continued. In 1898, Joseph withdrew from our partnership and bought a home and some farmland in Eagar. Then in 1899, Mr. Huning took advantage of the situation and foreclosed the mortgage he held on the property. This mortgage covered the farm with its thousands of dollars of added improvements and better water rights we had secured by building new reservoirs and ditches; with new fences, barns and roads, together with a modern mill. The law gave Huning all of this, and what was worse for me and mine, it gave him a deficiency judgment against us for over $11,000. I asked Huning in the name of justice to allow me more time. He had made a small fortune from the sheep we had turned to him, had prospered in his other business negotiations, and was in a position to have shown some consideration to us had he been so inclined, but he was relentless in his decision. This meant financial ruin, not only for the time being but for many years to come; however, eventually we took care of every just indebtedness. Ella, Ida and the children meant much to me during this trying period. With their love, loyalty and help I endured this blow to my pride and in time we re-established ourselves financially.

The foreclosure sale took place at the courthouse in St. Johns and the place was sold at auction to Huning for $8500, he being the only bidder. Huning and his coachman and lawyer left immediately after the sale and I knew intuitively that they were intending to reach the mill before I did and take possession—an illegal thing to do because the law gave me possession during the six months in which I could redeem the property.

But at any rate, Huning was trying to beat me to the mill. He went by Springerville and I, coming away behind him, cut across the mesa and reached the mill first. Will Slade was running the mill. I told him Huning would be there and for him to go on with the work and know nothing.

Huning came, his lawyer and the deputy sheriff with him. Johnson, the lawyer, came to the door and called, "Mr. Udall, are you there?" They all came in or stood in the doorway. I said, "Gentlemen, will you please step out? I am going to lock up the mill." I repeated this three times. Huning left and Johnson said to the deputy, "You are the sheriff, and you have a right to stay." Then he and Huning drove away.

The deputy and I both stayed in the mill all night; he having brought his roll of bedding slept on the floor, and I ran the mill. Mother sent me some supper and, needless to say, the folks were too anxious to sleep much that night. Next morning I wanted to get out and water my horse which was tied up near the mill. I told the deputy to step out or I would lock him in while I went out. He stayed in and I locked the door and when I came back he had taken the lock partly off. Then he went out after some wood, and I attempted to close

the door. He saw me and ran up the steps and struck the big heavy door with the ax, with a look of murder in his eye. He backed me clear across the mill with the ax. I called, "You would not do that." It was a harrowing experience and I knew there would be bloodshed if I stayed on. His gun lay on his bed all the time.

About this time Ella and her dear friend Mary Cheney came over and insisted that I go away and they would hold possession of the property. Feeling sure they would not be molested, I left them there and sent a boy to Bishop Crosby to find some relief for us. Mother said that the deputy told her to go home where she belonged. She replied, "My place is here." The bishop went to Mr. Gustav Becker, who came up at once and said to the deputy, "Why man, you have no legal right in here even though you are an officer. What in the name of Heaven are you here for? You had better clear out." And he did.

But Huning was thwarted in one purpose—that of possessing the Mill Farm. My friends, John P. Rothlisberger, C. P. Anderson, John W. Brown and John T. Lesueur bought the property for the price of the judgment. They gave me the privilege of rebuying from them. I thought it unwise to undertake this obligation, for my prospects for paying for it were far from promising. But we decided to lease the property from them for a year, which gave us time to close up our affairs and to move away deliberately. John P. Rothlisberger bought the farm from the others. We were glad to move away.

This is the dark side of those years from 1888 to 1900, but that period too had a bright side. In the driest years there was enough water to raise good gardens, wheat for our bread, and to provide pasturage for our cows

and horses. We also managed to keep on with our mail-driving and while we were burdened with debt and my good wives worked far too hard in cooking for hired men and rearing our family, yet we were together and we enjoyed many blessings, chief of which came to us in our children.

When Joseph and I took over the Mill Farm, he had Emma and little daughter, Nellie, and one son, Joseph. We had Pearl, Erma, Pauline and Luella. Then our boys began to arrive. First, Emma's Harry, then Ida's Grover and Ella's David—a trio. Then Ida's John Hunt, Emma's Earl, and Ella's Levi—another trio. Then Emma's Gaius, Ida's Jesse, Ella's little Paul (whom we lost); Ida's Gilbert and Don, and Emma's little Oscar who died in infancy, and Joyce. Then Ella's beautiful little Rebecca who lived less than a year. Emma had another son, Pratt, and her girls, Alta and Lula, after they moved to Eagar.

While living on the Mill Farm, Joseph's family and ours were like one big family. What a happy, happy group of children that old farm sustained! In many ways our farm was an ideal place for girls and boys. They had plenty of playmates, good Arizona sunshine, wholesome food and pure water. The children loved the calves, the chickens, geese and ducks, and most of all the riding ponies we provided for them. The boys monopolized the swimming holes, but the girls had swings, playhouses and many houseparties for their friends. Always there were interesting things to do in the big out-of-doors—the old mill, the flume and penstock, the pastures, the river—all had their attractions. Our farm was in a beautiful country very different from the salt grass fields around St. Johns.

As soon as the children were old enough they learned

to work. There were many chores to do, weeds to pull, and finally for the boys there were horses to drive in the field work. The children walked to school in Eagar. Our rule was that during the school season, school must come first. Sometimes it was difficult to get so many off on time, and one of my most amusing memories is that of seeing Luella, tiny golden-haired girl that she was, taking Grover and David, her two younger but larger brothers by the hands, and resolutely pulling them along through the big field, about one mile between our home and the schoolhouse, so that they would not be late.

The mothers managed things very well. They kept our homes attractive. They provided good books for the children and read to them. There was music and song in our home and this added joy and color to our lives, and to the community in which we lived, which reminds me of an amusing incident: Fred W. Schell, the principal who worked from daylight until dark to put our Eagar school on the map, was dangerously ill with rheumatic fever—so ill that for weeks the slightest movement of his muscles was excruciating. One night our youngsters, thinking they would cheer their teacher up, went to his bedroom window to serenade him. Nellie played the guitar and the chorus of small Udalls sang their favorite song, "The Dear Old Slave Has Gone to Rest." Poor Mr. Schell racked his poor body with alternate laughter and screams of pain!

Our Church went along as usual. I had many public duties in connection with my office as stake president. Often my work took me away from home, but we enjoyed our labors, and rendering service was our privilege and blessing.

and to Pearl's patience in treating her for many months, she made a very good recovery and has had the use of her hand for these many years.

BUSINESS ACTIVITIES

Reservoir Building:

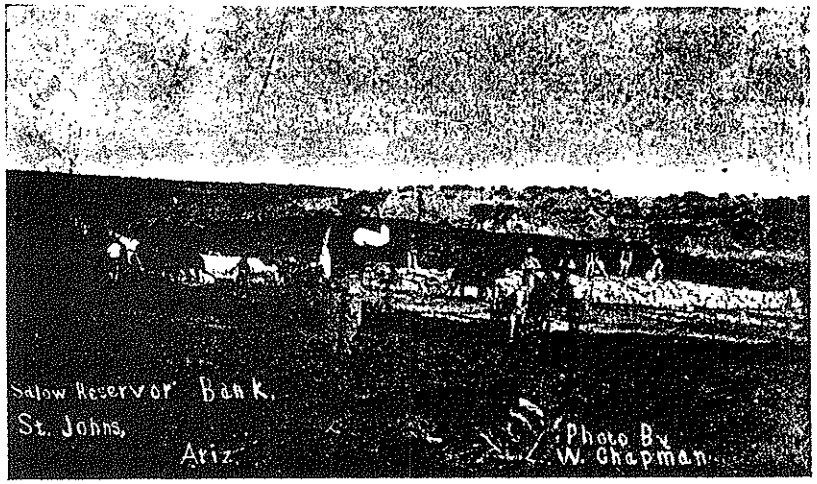
Reservoirs had to be built to maintain the Mormon people in Arizona and farming was primarily my vocation in life. In those early days in the northern part of the state, with no engineers and in our own way—for we did most of the work by ourselves—we stopped the water from going to the sea. We had no government help and but little Church help. The government did not want to put its money into a proposition as uncertain as impounding water in a country subject to such extremes of droughts and floods. The building of the reservoirs in Apache County, by which means the reclamation of land was made possible, forms one of the most interesting chapters in my practical life. In St. Johns, first came the Little Reservoir, and the Padre Reservoir, as we first called it, built in the early and middle 1880's. Then the "Big Reservoir" at Salado Springs, completed about 1900, was washed away in 1905. Then the rebuilding of that and selling, or merging into the Lyman Reservoir in 1909-1910. Then the loss of that dam in 1915, and the rebuilding of it again.

At one time, the Church made a gift to the saints of St. Johns of $2500, with which we bought wheel scrapers. Later, when the Lyman Irrigation Company was organized, we received credit from it for the moneys thus expended.

During the years we lived in Round Valley a portion of each year was spent with men and teams working on

irrigation projects on the upper reaches of the Little Colorado River. Near Greer will be found the cluster of small lakes known locally as the "Bunch Reservoir," the "Tunnel Reservoir" and the "River Reservoir" (or Number Three), which we aided in constructing or rebuilding under the able direction of Bishop George H. Crosby.

Our Gentile friends from Denver came to the country in 1909 intending to turn Hunt Valley into a reservoir. They approached me on the subject of selling our prop-



RESERVOIR BUILDING OPERATIONS

erty in Hunt for that project. I told them of the reservoir possibilities above St. Johns in connection with the St. Johns Reservoir. After an investigation they decided to spend their efforts and money on the St. Johns proposition and organized the "Lyman Land Company" and the "Lyman Irrigation Company," giving our original company stock for our holdings in the latter company, and our

people contributed labor. The Denver capitalists owned three-fifths of the stock and the local people two-fifths. It first cost $250,000. It was rebuilt after the dam washed out in the flood of 1915, by loans aggregating $750,000 from the State of Arizona. Half of the indebtedness to the state was ultimately cancelled by legislative action upon the theory that the state, having taken over the management of reconstruction was responsible for the excess cost. (*Udall v. State Loan Board,* 35 Ariz. 1.)

After moving to Hunt at the turn of the century, we, in company with our associates, materially aided in building and rebuilding the "Udall Reservoir" (commonly called Zion's Lake) on the Little Colorado River, some ten miles above Hunt. The breaking of the reservoir above St. Johns in the wet years of 1905 and 1915 washed out this dam, leaving our farming lands high and dry.

Ventures in Sheep Business:

In 1886, a few weeks after my return from Detroit Prison, Sol Barth greeted me one morning with this question, "Bishop, how would you like to go into the sheep business?" I replied, "Sol, you know I am broke and could not consider such a thing because I have no money." He said, "It won't take any money. You can get them on time—8,000 head at $1.75 per head for old sheep and $1 per head for the young ones, with interest at six or eight per cent."

I made the bargain with him and was reminded of President John Taylor's promise to me in a letter received in prison saying that because of my imprisonment I would not lose the confidence of people. I wrote John and Tommy Stewart (Ella's brothers) about the deal. They came from

Kanab to investigate the matter and we formed a partnership and took the sheep. A little later, not liking the country, they took two-thirds of the herd to the Buckskin Mountains. Then my brother, Joseph, came into the business with me.

Soon after that, our prospects were ruined when President Cleveland's low tariff lowered the value of wool and sheep.* We had one extremely annoying experience after Barth Brothers sold our notes to Lowenthal and Myer in Albuquerque. Through unscrupulous sharp practice the latter brought us into litigation which hung fire for years. It was very expensive for us, but was finally settled by the court in our favor.

In 1888 we turned over our interest in the sheep to Henry Huning as first payment on the old Mill Farm near Springerville. Eight or ten years later I tried the sheep business again in partnership with John P. Wimmer. The seasons and other things were against us, and again the sheep business proved unprofitable to me.

Carrying the United States Mail:

July 1, 1881, Miles P. Romney and I took a U. S. mail sub-contract from Sol Barth, to carry the mail from Ft. Wingate, New Mexico to Ft. Apache, Arizona, a distance of two hundred miles, two trips per week at $5,000 per year. During that year we had the heaviest rains and the deepest snows ever known in our country. Mother reminds me that it rained forty days in succession in the autumn. The route was from Ft. Wingate by the Zuñi Village to St. Johns, then by the Romney Ranch, the

* Incidentally, this financial reverse may have been instrumental in making staunch Republicans out of the "Udall Brothers."

fornia, brought into good use and with no extra expense to us our buckboard or auto service to and from the railroad. It was some compensation to us for the sacrifices we had made in keeping the mail-line going.

Much may be read between these lines. An analysis of our mail-contracting business would reveal the inner feelings, the ideals and motives of our hearts. At some future time someone else may add to this little chapter. I have sketched only a background for much that might be written.

Nebo Electric Light and Power Company:

I enjoyed establishing it in the years of 1911-12. We—John P. Rothlisberger and my sons and I—purchased an old building put up years before and known as the "Excelsis Roller Mill" site. It is on the bank of the Little Colorado in the northeast corner of town. We put in some good machinery which was run by water power conveyed from the Little Reservoir through the St. Johns Irrigation Company's canal. To make the water power greater we raised the dam of the Little Reservoir, improved and straightened the canal and put a concrete dam in the river at a point above town. This was to our advantage and it also improved the irrigation system and has been of lasting benefit to the community.

We wired a good many of the homes and delivered electricity to them at certain hours in the evening. All lights went off at 11:30 p.m. It was a difficult piece of pioneering, not very popular at first. In 1915 the Lyman Dam broke and interrupted operation, and broke many of the people in town. Then came the war with its problems and economies. Again one of my projects failed,

and in 1922 I sold out to Brother Rothlisberger for $3,000, taking a loss of an equal amount.

[*Pearl's comment:* On one of my summer visits to the folks, father proudly took me over to "Nebo" (how he loved that name), to show me the electric plant. For a year or two most of the time he attended to the running of it and stayed there nights to save walking home about midnight in the dark after the lights were turned off. His couch-bed was made up and the Church works and some magazines were on a stand beside it. I remarked on the tidiness of the place and he said, yes, he had always liked things tidy and had tried to teach his boys that way in their camps and bunks on the road or reservoir, but he thought he had not done too good a job. To this day father is very proud of the arc light he placed near the old home which he liked to call the "Elms." I said, "Father, dear, you are true to yourself—always endeavoring to give your people light." He smiled.]

Take Up Your Mission

Mormon Colonizing Along the Little Colorado River 1870-1900

Charles S. Peterson

The University of Arizona Press
Tucson, Arizona

About the Author . . .

CHARLES S. PETERSON, a native of the Little Colorado country, whose forbears participated in the Mormon migration to Arizona, has been privileged as few others in the field to carry out his research directly from tremendously rich primary sources. Among his published works, his biographical sketch "A Mighty Man Was Brother Lot" won the Oscar O. Winther Award for the best article appearing in the *Western Historical Quarterly* for 1970. Associate Professor of History at Utah State University, and Associate Editor of the *Western Historical Quarterly*, he previously served as Dean of Instruction at the College of Eastern Utah, as Professor of History at the University of Utah, and as Assistant Secretary-Treasurer of the Organization of American Historians. Additionally, he served as Director of the Utah Historical Society and as Editor of the *Utah Historical Quarterly* for three years.

THE UNIVERSITY OF ARIZONA PRESS

I. S. B. N.-0-8165-0397-4
L. C. No. 72-89621

and the use of the term mission to designate a place and a process passed, shading off imperceptibly at first and more rapidly later. Although no official statement was issued ending the mission, it was largely a thing of the past by 1885.

Extraordinary needs arose occasionally that extended the usefulness of the mission, and the fact that numerous crises marked the course of Mormon affairs in Arizona tended to prolong its use. On the other hand, the fact that the region was settled late in the history of the frontier curtailed its longer use. Indian trouble no longer necessitated extraordinary mobilization, and railroads and contact with the Gentile economy likewise lessened the need for the mission's task-force organization. A combination of such factors resulted in an extensive use of the mission during the first decade of settlement and its passing as a useful instrument thereafter.

By the mission, the Little Colorado's earliest administrative organization came to be. By its use, society was mobilized to carry out what to most was an unattractive task. Even the limited success of this colonization could not have been achieved without the mission.

4. TREK OVER THE MORMON WAGON ROAD

> The fond old route known as Lee's Ferry by way of upper Kanab.
>
> L. H. HATCH

> To describe this country and its sterility for one hundred miles, its gloomy barrenness, would subject the reader's credulity to too high a strain. Not even the caw of a crow, or the bark of a wolf, was there to break the awful monotony . . . here there was nothing but a continual stench of miasma, and hot streaks of poisonous air to breathe. Was this Hades . . . or the place for the condign punishment of the wicked? Or was it the grand sewer for the waste and filth of vast animation? . . . It was a horrible place.
>
> GEORGE W. BRIMHALL

Preparations

IN JANUARY OF 1876 James S. Brown returned to Salt Lake City from his exploratory mission and reported his favorable impression of the Little Colorado region. Fearing that the open conditions necessary to preemptive expansion were passing, the church moved immediately to establish colonies there. Acting with such haste as to suggest that the plan of colonization had been previously laid and was waiting only on Brown's final report for implementation, Brigham Young prodded the first of recurrent groups onto the southward roads within four weeks. During the ensuing months, trails penetrated earlier by only the hardiest scouts became beaten ways known firsthand to hundreds of Mormon emigrants and to thousands more through personal letters and the pages of the *Deseret News.*

A call for two hundred men and families was hastily circulated. Following its directive, most of the missionaries met in Salt Lake City late in January, where they were organized into companies of fifty according to the locality from which they came.[1] They were also briefed as to what they might expect in the Little Colorado country and given some idea of how to prepare for the trip. Haste, they were told, was an imperative.

As they rushed to put their affairs in order, these first missionaries were confronted with problems that characterized the entire Mormon migration to Arizona. Since most mission calls were for permanent colonization, it was necessary to make extensive and careful preparations. Although there was a sameness about the process, the time allowed varied greatly, according to the needs out of which the different calls grew and the circumstances and energy of the individuals called. The missionaries who left during those short winter days of 1876 took no more than a month to get under way. Inevitably some were unable to settle their affairs and had to return to Utah to finish their preparations. Later, as the nature of the urgency shifted and the costs of the return trip in terms of time and truancy became apparent, it was more customary to give six months or even longer for the missionary to make ready.

One of the first steps in preparing was the disposition of Utah property. Although such was not always the case, prospective emigrants were usually counseled to dispose of their holdings and sever all economic bonds. Therefore the move south generally required that property not only be sold but that it be moved quickly. Characteristic of the first year's experience was that of a central Utah missionary who received his call on January 23. On January 31 he sold his homestead and at the end of another week left for the Little Colorado River.[2] A favored few were helped in the process when the call by which they were directed to Arizona charged other men to purchase their property. Such was the case at Mt. Pleasant in Sanpete County where "persons were designated to buy out the brethren called at fair, just and equitable prices."[3]

Forced as a rule to seek their own markets, missionaries found it extremely difficult to get "equitable prices." Indeed, mission calls appear to have created a buyer's market with land and improvements almost always going for prices far below the value placed upon them by the missionaries. There is no evidence that the tight land situation that is generally said to have prevailed in territorial Utah was sufficiently acute to result in ready sales for those called to Arizona. Although they sometimes resented the dilemma and commented on its irony, most regarded the losses they sustained as part of the sacrifice incident to settling a new country.

Some tried to minimize losses by leaving their property in the hands of friends or family to sell, or they returned themselves and sought to move it at their leisure during subsequent winters. Even when this course was followed, ready markets and satisfactory prices were rare. An instructive case was that of Miles P. Romney, who after a year or two in Arizona returned to St. George to sell his holdings. After reducing the price to one quarter of its "ordinary value" without finding a buyer, he finally boarded up his buildings and held on.[4] Others depending upon the returns from property to outfit themselves for the trip found it necessary to sell at whatever price. Most transactions took place with little or no cash changing hands, the emigrant bartering land and improvements for cattle, horses, or equipment.

In planning for the trip and the new life that lay at its end, missionaries drew from various sources. Although at the time of their call many were not frontiersmen in the ordinary sense, the Mormon experience had been one of pioneering, and in a general way they had a good grasp of what would be expected of them. Many had crossed the continent by wagon or handcart; all knew people who had. The processes of the church, including its expansions, had resulted in a mobile frontier so that the pioneers of the Little Colorado were not novices in the lore of the trail. In addition to this environmental or cultural preparation, many of the early missionaries met for briefing sessions where they were instructed as to the route and needs of the trip. Furthermore, during times of heavy migration, successive rendezvous were established where experienced frontiersmen gave additional instruction and aid to travelers.[5] As the years passed, leaders and personal friends in Arizona wrote detailed letters specifying needs that had become apparent during the process of colonization. These letters, some of which were addressed to the *Deseret*

[1] See Frihoff G. Nielson, "The History of the Little Colorado Mission," a fragmentary document included in "Joseph City Ward History."

[2] "John Bushman Diaries, 1871-1923," handwritten original in possession of Martin D. Bushman, Snowflake, Arizona; typescript prepared by George S. Tanner in possession of author.

[3] *Deseret News*, February 9, 1876.

[4] *Ibid.*, November 23, 1881.

[5] In the migration of 1873, for example, Pipe Springs and Moenkopi were designated as such rendezvous. At these two sites, incoming travelers were met by Joseph W. Young and Horton D. Haight. See letter of Brigham Young to Joseph W. Young, March 10, 1873, Brigham Young Letters, HDC, and letter of Henry Holmes to F. D. Richards, June 27, 1873, *Millennial Star* 25 (1863): 552-54.

News, received broad circulation, probably coming to the attention of all prospective emigrants.

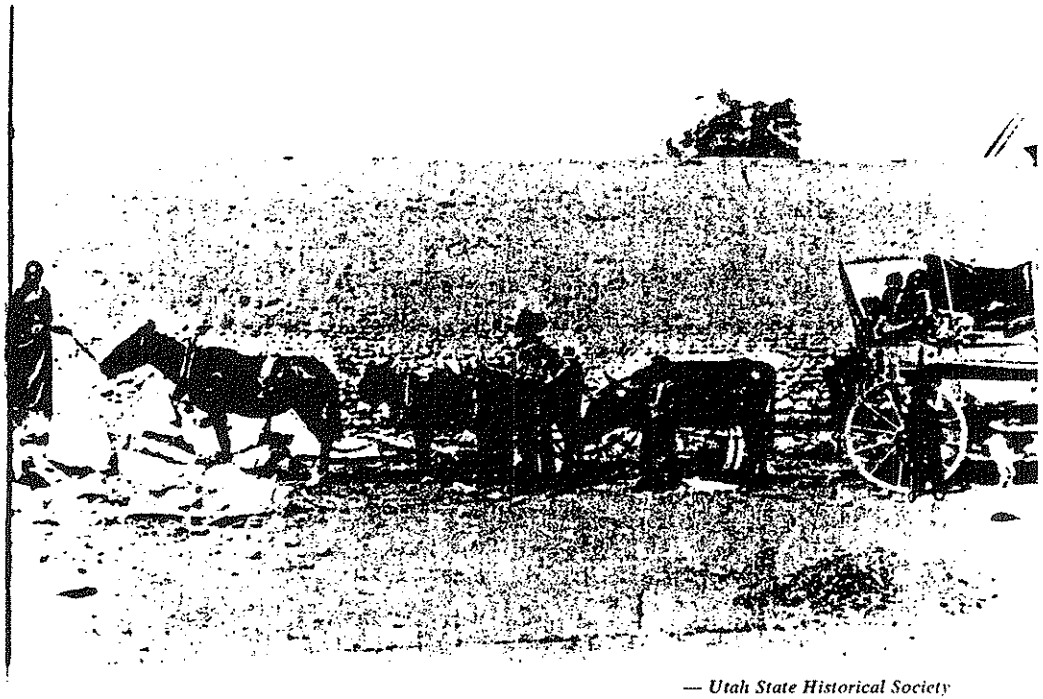
Special attention was given to draft stock and wagons. Although what a man had on hand was often the determining factor, considerable pains were taken to secure the best. Teams were trained and animals traded. It was thought by some that brood mares would be of the greatest value. Yet individual preference often dictated in favor of oxen or mules. In any event it was a diverse array that took to the trail at the front of the wagons of the Little Colorado settlers, with teams of horses, oxen, and mules to be seen in virtually every group of emigrants.

Wagons were repaired and when possible new ones purchased. From the very first it was found possible to refit along the way, and references to both buying and selling wagons en route are not infrequent. Within a short time it was apparent that well-made, medium-sized wagons were best. But as in the case of teams, variety was the norm. Many proceeded with only one wagon and a two-horse team, while others equipped themselves more elaborately, taking as many as five or six wagons and draft animals in commensurate numbers. Frequently wagons in tandem drawn by long strings of oxen or mules were used. The characteristic wagon was covered with a tarp which kept the worst of the elements out, though inevitably water and dust reached the precious goods within.

Loads were made with an eye to the long haul south and to the needs of the new life at the end of the trail, with each pioneer seeking some kind of a practical adjustment of the problems raised by the two sets of needs. A rule of thumb sometimes followed was to limit the weight to 2,000 pounds per wagon. A more valuable guide came from a missionary who wrote from Arizona to suggest medium-sized work horses and good wagons not loaded "to exceed six (6) or seven (7) hundred pounds to each animal."[6]

Cargoes were characteristically utilitarian in nature. Grain for draft stock and seed purposes was an ordinary item as were implements for use once the new land had been gained. One bachelor missionary from northern Utah's Hyde Park who accompanied Lot Smith in 1876 stressed the essentials, taking:

> $50.00 in cash, 4 oxen, one wagon, one plane, hoe, pitchfork, crow bar, one rifle, two barrels of nails, one bucket, milk pan, and strainer, lantern, bake and camp kettle, a fry pan, two tin plates and cups, knives, forks and spoons, four blankets and a bed, two pair of shoes, and three pair of boots, 4 bu. wheat, 1½ bu. of potatoes, 500 lbs of flour, 40 gal of molasses, 20 lbs of apples, one ham and six lbs of butter, 4 lbs of candles, 9 lbs of soap, 16 boxes of matches and some garden seed.[7]



— *Utah State Historical Society*

Ready for the road: a Mormon pioneer outfit.

All did not limit themselves to such spartan necessities, and luxuries were taken to brighten new homes, including an occasional piano or organ. Men either found it easier to restrict themselves in what they loaded or were persuaded that the items they selected were necessaries. Women, on the other hand, were often accused of taking things that could be done without. Regardless of where the blame lay, these pioneers like others who had gone before often loaded too heavily and found it necessary to jettison a variety of items en route, including family heirlooms and such necessities of the frontier as flat irons, wood ranges, and sewing machines.

Leaders and experienced travelers worked constantly to limit loads. An interesting story related by Daniel W. Jones, who in 1877 led a party south by way of St. George and Pearce's Crossing below the Grand Can-

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[6] *Deseret News,* March 24, 1880.

[7] See "Diary of Peter Nielson," translated from Danish by J. F. Nielson, compiled by Frihoff G. Nielson, in possession of Mrs. LaVinta Shiner, Price, Utah.

yon, reveals Brigham Young's ability to deal with this sort of trouble where the best efforts of lesser leaders failed. Jones, who had cut his own load to the bare essentials, had given up in his efforts to get others to do likewise and meeting Young in St. George told him so. To his remark, the president replied:

> Get your company in the best shape you can and as soon as possible move out. There is a nice little settlement, Santa Clara, on your road. There is a beautiful piece of sandy road from here to there, just as will help you get the brethren to see the importance of lightening up. When you get there you can set up an auction store. The people are pretty well off and will be able to buy what you have to sell.[8]

Jones complied, and it proved to be substantially as Young had foreseen, with the exception that the emigrants traded with such skill that their new loads of grain and dried fruit were nearly as heavy as the irons and sewing machines swapped off. But as the expedition's wagon master laconically commented, it was better to "roll at a wheel to help get a sack of corn over a hard place" than it was to "strain his back to move an old stove along that was not worth hauling."[9]

In addition to the ordinary physical preparations for the trip and pioneer life, many of those called took advantage of the newly opened temple at St. George or the Endowment House in Salt Lake City to solemnize holy ordinances that could not be performed in the deserts of Arizona. Some were married for the first, second, or third times, and others did temple work for their dead. Church and civic positions were resigned, and the inevitable round of farewell parties and meetings wound up the process of preparation. Send-offs were sometimes elaborate. A crowd of four hundred gathered in one town to see their representatives depart. At Lehi the town square was thronged and the 1876 leave-taking charged with such excitement and sentiment that a least one man, born four years later, caught its spirit and though not there in person seemed to recall the square, crowded and festive for the occasion.[10]

The Trail

Preparations completed, the missionaries took to the trail. The routes south through Utah were well worked out and followed the existing line of settlements. Always important in the West, roads were rarely more

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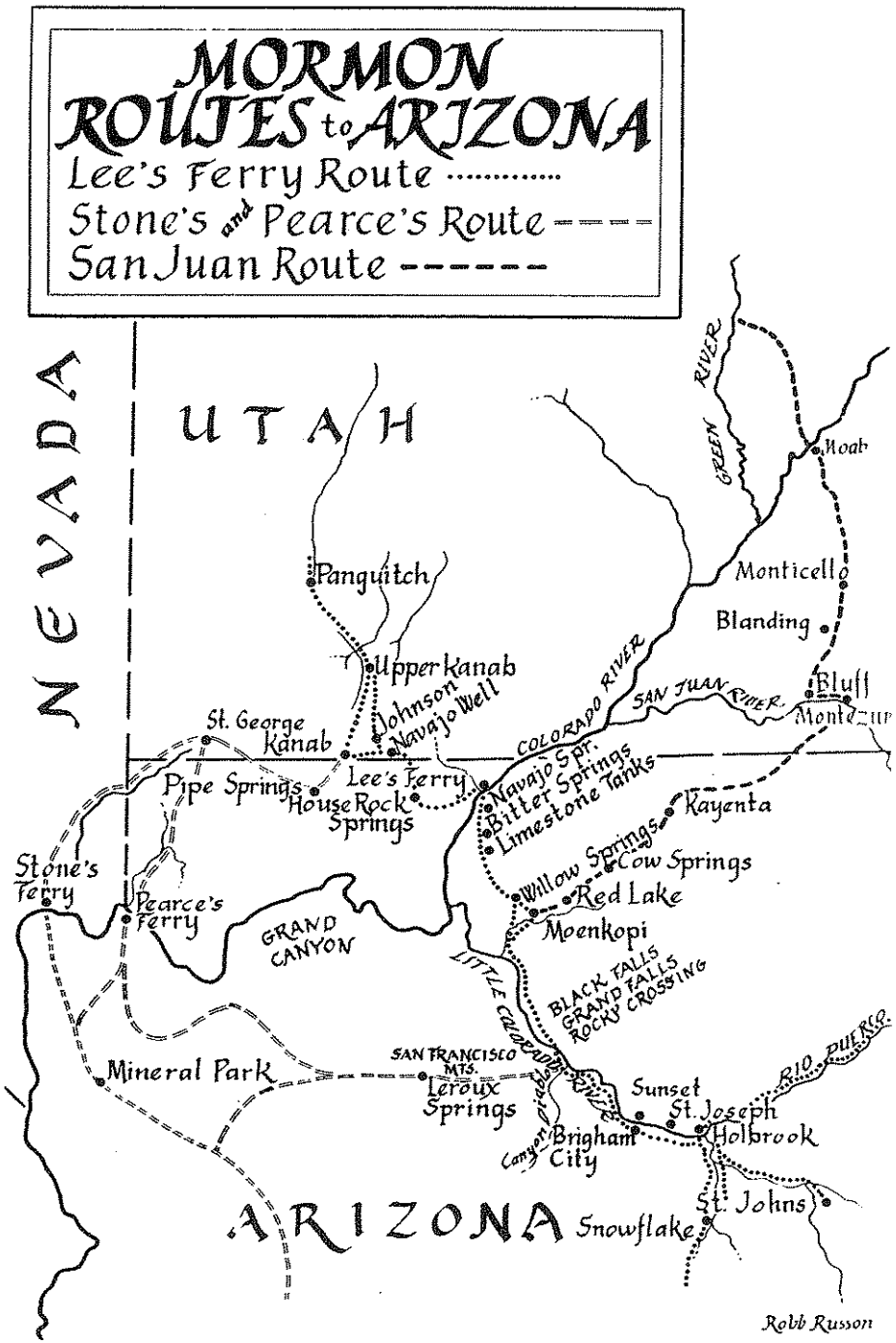
[8] Jones, *Among the Indians*, p. 290.
[9] *Ibid.*, p. 291.
[10] Interview with David A. Peterson of Lehi, Utah, July 1963.



significant, as the closeness of the religious bond between mother and daughter communities gave a two-way movement that was as necessary to the essential character of the Little Colorado colony as it was constant and continuing. Unlike the great national trails, the Mormon routes bore north and south. Threading through mountain defiles and along desert water courses, they were the product of pioneer use rather than of government or army transportation. Beginning as Indian trails, they became first the path of exploration and later the highroad of Mormon expansion.

By 1880 three routes to the Little Colorado were known. Two little-used passages flanked the canyon lands that lay athwart the borders of Utah and Arizona. The western road, which had been pioneered by Jacob Hamblin, ran south from St. George to cross the Colorado at Pearce's Ferry at the mouth of Grand Wash. An extension crossed the river a few miles downstream near the confluence of the Virgin and the Colorado at Stone's Ferry, or Bonelli's Ferry, as the Mormons knew it. Once over the river, traffic from Stone's Ferry bore a little east of south to about the present site of Kingman, from which it cut east between the headwaters of Bill Williams Fork and the Verde River and then on to the Salt River. Leaving the Colorado River by way of Grapevine Wash, Pearce's Ferry traffic either veered southwest to join the Stone's Ferry road or held nearly due south through Wallapai Valley before turning east by southeast along the Sitgreaves trail which joined the Prescott to Fort Wingate mail road just south of Bill Williams Mountain and thence east to strike the Little Colorado at Canyon Diablo. Little Colorado emigrants who chose the Stone's Ferry route followed it to a few miles south of Mineral Park where they turned sharply east to pick up the Prescott to Fort Wingate road.[11] In addition to these trails there was also some effort to open a more direct route east from Wallapai Valley to strike the Little Colorado north of the San Francisco Mountains.[12] In spite of high hopes among their advocates, these roads did not solve the problems of feed and water and circled far to the west; as a consequence, they did not bear any great portion of the Little Colorado traffic but were important in the movement to southern Arizona.

Another little-used route to northern Arizona went by way of Utah's San Juan country. Taken aback at the rigors of the trip over the Lee's Ferry road, Arizona's first pioneers and church leaders looked to Utah's

[11] For a detailed account of a trip by way of Pearce's Ferry, see "Journal of John W. Tate," entries for November and December. Also see Melvin T. Smith, "The Colorado River: Its History in the Lower Canyons Area" (unpublished Ph.D. Dissertation, Brigham Young University, 1972), pp. 374-439.

[12] See letter of Jacob Hamblin to *Deseret News*, February 28, 1877.

southeast for an easier path. Revealing this interest, Brigham Young advised Lot Smith late in the summer of 1876 to counsel missionaries to stay with the known route while the San Juan was further studied. But after William C. Allen, one of the original leaders of fifty, struggled back to Utah through the San Juan during August and September, the route was abandoned temporarily. However, as the movement of the church to the southeast accelerated in the last years of the 1870s, Apostle Erastus Snow continued to feel that this would become a strategic and convenient route. Indeed, the San Juan Mission was to some degree founded to serve in the communications system envisaged.[13] Even after the Hole-in-the-Rock expedition had taken the measure of the area's tangled canyons, Snow persisted in his hope that a Mormon road could be developed, and in the fall of 1880 wrote urging church authorities to settle at Green River Crossing thus securing the route "which is destined to be our nearest and best . . . to . . . Eastern Arizona."[14]

The Main-Traveled Way

The main-traveled way was the most direct, passing between Utah's mountain ranges to cross the Colorado River at Lee's Ferry. It was over this road that the missions of 1873 and 1876 picked their way, and despite persistent effort to flank its canyons it continued to be the most heavily traveled road between Utah and the new colony during the nineteenth century.

The Lee's Ferry road was impressive, among other reasons, for its distances. From northern Utah, it stretched out for seven hundred miles or more. From the southern part of the territory, it was substantially shorter, perhaps a little more than three hundred miles, depending on the points of origin and destination; but these last were the hardest miles and still constituted a long and exhausting trip.

South to the Sevier Valley the route was heavily traveled and ran through a relatively level country. Consequently, pioneers made good time, pausing only to recruit their stock and visit friends in the communities that lay along the way. But as the road wound up the meadowed valley of the Sevier River, conditions worsened, and the cold of the winter

[13] Reflecting this hope, Erastus Snow wrote to John Taylor on November 6, 1879: "Silas S. Smith has started for San Juan with forty to fifty men and some boys and quite a few families, with Boats &c intending to hew their way threw the Canyon and open a straight or more direct route to San Juan and as he thinks also to the head of Little Colorado." Erastus Snow Letters, HDC.

[14] See letter of Erastus Snow to John Taylor, September 29, 1880, *ibid.* For the Hole-in-the-Rock company's incredible undertaking, see Miller, *Hole-in-the-Rock*.

travel that characterized most of the Arizona migration was made more extreme by mounting elevations. Forced to cross and recross the stream, winter migrants experienced great difficulty getting in and out of the river by way of partially frozen dugouts. Crossings were further complicated by the necessity of entering freezing water to chop ice not yet thick enough to hold loaded wagons.

Possibly no large group had a better opportunity to test these frosty miles than did the missionaries of 1876. Toiling through snow that lay up to eighteen inches on the level, and in temperatures that froze the feet of both livestock and humans, they were well initiated to the rigors of winter travel by the time they reached Panguitch in the south end of the Sevier Valley. But, as many of them feared, the hardest part of the journey lay in the thirty-five-mile mountain stretch from Panguitch to Orderville. After crossing south of Panguitch, they followed the old road up the west branch of the Sevier, a long day's drive to Hatch Ranch. Here they girded themselves for the push on to the timbered rim of the Great Basin, which they reached near present-day Long Valley Junction. Although there were many outfits on the road, the trace through the snow drifted in almost as it was broken, and each new party was forced to break its own way through drifts three or four feet deep.[15] By pushing far into the night, some who were fortunate in the condition of their animals made it up the divide from Hatch to the rim of the basin in one long day. It took others four days, and one unfortunate party floundered in the snows eighteen days in making the sixty miles from Panguitch to Kanab.

From the summit they continued along the course now followed by Highway 89. Flanked by canyons, whose delicately shaded rock more than hinted at the proximity of the latter-day tourist meccas of Bryce and Zion canyons, the downhill road proved to be nearly as trying as had the drag up. The primary problem of the descent was ice. One man finding that the steepest roads in northern Utah would not compare related that "sometimes three animals were down out of four, and every minute we expected to see an axletree broken."[16]

Although the entire emigration of that winter moved through Long Valley and Kanab (approximately Highway 89's present course), later

[15] The following characterizes the accounts of the journey over the rim of the Great Basin: "They were four days on the divide, where the snow was three feet deep, making ten miles a day, working till midnight one night to make that distance. The road had been broken previously, but had filled up again, and was the worst road they had ever seen." *Deseret News*, September 27, 1876.

[16] *Ibid.*, April 5, 1876. The snows of that year were unusually heavy; for one period of over a week it snowed without letup. James T. Woods and three other families who were caught on the divide abandoned all but one wagon in which they escaped, pushing on with their livestock. *Ibid.*, September 27, 1876.

traffic often ran from the rim of the Great Basin east to Upper Kanab, or present-day Alton, and then down a narrow passageway through Johnson Creek past vast cedar forests to the village of Johnson twelve miles east of Kanab. Cutting several miles from the trip, this road avoided a hard pull over the sand hills between Carmel Junction and Kanab. From Johnson migrants passed on east about eight miles to Navajo Wells before leaving Utah and mounting the Kaibab Plateau. The road across the sprawling east bastion of the Kaibab was perhaps the most variable of the journey, changing sharply according to the season. During the winter, it was a frozen waste of juniper and pinon where snows piled axletree deep. In the spring it became a slimy sea of mud and in the summer a searing dust-choked and wagon-wrenching stairway.[17]

From the east foot of the Kaibab, the road dropped through House Rock Valley, which opens out toward the river like a giant cornucopia, to pick up the Vermillion Cliffs which it followed as they looped east and north to Lee's Ferry. Four waterholes — House Rock Springs, Jacob's Pools, Soap Creek, and Badger Creek — provided a scanty and, in the case of the latter two places, a foul-tasting supply of water. Of the four, House Rock Springs, which lay about three-quarters of a mile east of the road at the foot of steep sandstone cliffs, provided not only the best water but good grazing and firewood as well. Consequently, it was a major resting place, and the cliffs and rocks around it became the most complete register of the Arizona migration, as hundreds of travelers took time to chisel their names and the dates of their visits. Some idea of the potable qualities of Soap Creek may be gained from one early diarist's account that it had been named when Jacob Hamblin and other Indian scouts used its water to boil pork and beans and found that the entire concoction turned to soap.[18]

Presaging the future of travel across this section, John D. Lee's experience in opening the road between Johnson and the Colorado River at the mouth of the Paria in 1871 had been almost unbelievably difficult. Like most Mormon colonizing endeavors, the establishment of the ferry

[17] "Lorenzo Hill Hatch Journal," p. 87. In May of 1876, James T. Woods, who a few weeks before had suffered from frostbite and fled the drifting snows near the rim of the basin, found the Kaibab stretch to be transformed by unseasonable heat and had his "entire satisfaction of summer." See *Deseret News*, September 23, 1876. Anthony W. Ivins noted that the mountains received their name "Kaibab," or "lying," in Indian from their sprawling nature. "Anthony Woodward Ivins Journal," p. 27.

[18] "Horatio Morrill's Book," typescript USHS, October 8, 1869. I have chosen to refer to most of the springs and wells along the road to Arizona in the plural, because pioneer diaries use the plural. In so doing I have ignored the established nomenclature of modern maps where most are referred to in the singular.

was a cooperative action, and scouts who knew the Kaibab–House Rock Valley trail were directed to guide and help Lee in opening the new road. As it turned out, the entire undertaking was a medley of error, miscalculation, and struggle. Men failed, equipment broke, and cattle and Lee himself went astray. Consequently, it was only after weeks of appalling exertion that Lee succeeded in moving his livestock to the site and working the first wagon trace south to the ferry.[19]

Persistent rumors of hostility on the part of the miners, coupled with the fact that a considerable number of them were crossing the country en route to the San Juan mining field in Colorado, raised fears among the apprehensive Mormons. Their suspicion mounting when certain miners announced their intent to claim key waterholes, Hamblin and Lee moved to acquire clear control of the springs on the House Rock section of the road. Hamblin established a small livestock operation in the House Rock Valley, which according to his son the Indians had ceded to him. Developing the springs somewhat, he built a small cabin at the site.[20] A few miles to the southeast Lee claimed the water at Jacob's Pools and after building a rock hut there ran stock in the area for several years before trading his claim to Hamblin. Lee, whose name was closely linked with the Mountain Meadows Massacre and who was finally tried and executed for his implication in the event, felt his vulnerability. He was therefore anxious to exclude Gentile neighbors. Pushing to secure the water in the interest of the church, he found the "want of a little snap" on the part of his associates to be most galling.[21]

However, the flurry of prospecting interest soon passed and with it the threat of Gentile control. With the exception of Lee's holdings and occasional use by Orderville herds, the ranching operations appear to have lapsed for a time. Nevertheless, the movement of miners over the

[19] Cleland and Brooks, *Mormon Chronicle*, vol. 2, pp. 185-86.

[20] *Ibid.* Also see Pearson H. Corbett, *Jacob Hamblin, Peacemaker* (Salt Lake City: Deseret Book Co., 1952), pp. 328, 330, 518.

[21] In company with John Mangram and a Brother Heath, Lee arrived at Jacob's Pools on April 16, 1872, where the following exchange took place which is instructive as to both the plan to control the route by possession of its water and Lee's feelings about it: "Here [Jacob's Pools] Jno. Mangram proposed to return home & at some future time come & secure this & the Ranch at Soapcreek. I felt so indignant at the Idear of Coming some 80 Miles & going back without doeing anything and risking the chance to fall into the hands of our Enemies for the want of a little snap, that [I] spoke a little cross & sharp & said that I had to much reguard for the confidence that leaders reposed in me & too Much interest for this Kingdom than to flat out like that; that he was a conselor & Should be the last man to flat out."
Lee evidently won some concessions from Mangram as they stayed. On the seventh, they staked off the springs and built a "3 feet wall of a House by noon" when a company of miners came along and announced that they had intended to secure "those Springs." But as Lee exultantly notes, "we were ahead of them." See Cleland and Brooks, *Mormon Chronicle*, vol. 2, pp. 185-86.

route in 1872 and the Mormon effort to retain control did much to establish the road. Government surveyors, especially those connected with the Powell Survey, also found frequent cause to use the route during this period; by the time of the Little Colorado migration, its course was well fixed. But for many years the approaches to the ferry remained a challenge and a threat to all who passed that way.

Lee's Ferry

A vital link in the chain of communications was Lee's Ferry. This crossing had been discovered prior to 1860 by Jacob Hamblin, who along with other scouts used it occasionally. As we have observed, John D. Lee was dispatched to the spot late in 1871, establishing a ferry which he operated until he was taken by the federal authorities in Panguitch in 1874.[22] At the time of Lee's arrest, his wife Emma assumed responsibility and with the help of Warren Johnson operated the ferry for the next five years. Before his death in 1877, Brigham Young authorized Ephraim K. Hanks to purchase the ferry in the interest of the church, but the transaction fell through on the passing of the president. Thereafter, Warren M. Johnson made similar overtures, but the ferry remained in Mrs. Lee's hands until the spring of 1879. It being rumored that outsiders were negotiating with Mrs. Lee, President of the Church John Taylor directed John W. Young, who was at Moenkopi during that spring, to buy the place. This Young was able to do for a consideration of $3,000 paid mostly in livestock. The ferry became the property of the church and of the Little Colorado settlements which advanced some of the cattle used in the purchase.[23]

Important Mormon use of the ferry, however, had begun in 1873. The outward-bound missionaries of that year found Lee living in primitive

[22] By 1870 Lee was a source of some embarrassment to the church. Some hint of Brigham's thoughts as to the future was apparent in a conversation between Lee and Young recorded by the former when the president visited Paria in 1870: "Pres. Young . . . Said to Me that he would like to have Me Gather My wives, sons & Daughters around me & setle in any of the Places we should Select & Start the Family order, stating that I had passed through a great deal of Hardship in my life & Now he would like to See me Enjoy peace the balance of my days. I replied that My Mind led further to a country that I had Seen in visions & dreams. He continued, You will see that country; it [is] over the Colorado in the San Francisco Mountain. I intend Bro. L. Stewart to go there & you May go too when the Time comes &c." See Juanita Brooks, "Lee's Ferry at Lonely Dell," *Utah Historical Quarterly* 25, (1957): 284-95.

[23] For reference to the role of Hanks and Johnson, see McClintock, *Mormon Settlement in Arizona*, p. 93. Young's purchase of the ferry is recorded in the "Diary of L. John Nuttall, 1834-1905," original in possession of Mrs. Clara Nuttal Glass, Provo, Utah; typescript BYU, p. 285. For the important role of Warren Johnson at Lee's Ferry, see P. T. Reilly, "Warren Marshall Johnson Forgotten Saint," *Utah Historical Quarterly* 39 (1971): 3-22.

conditions, but their wagons were moved across the river without untoward incident and without delay. Most of them were pleased with the operation and commended Lee for his service. With inimitable spelling, Andrew Amundsen recorded his favorable impressions: ". . . we corsed . . . all over sef and sound. . . . Dea Lee was a verry jocky, an jovele, full of fun."[24] As the spring wore on, some missionaries even found time for pleasure and, much to Lee's satisfaction, joined his family in moonlight boat rides "over the Still waters of the Colorado" complete with "Music by the constantina."[25]

The river's passage was always accompanied by a certain amount of tension and fear. In part, this was a matter of expediting traffic and keeping this potential bottleneck clear. The nature of the desert over which the migration moved required that emigrants be spread out, and delay at the river complicated the trip. An additional factor was the limited feed at Lonely Dell, as Emma Lee had named their home. Large numbers of stock simply could not be fed; consequently, traffic had to be kept moving. This was not easy. The ferry was small and open, and excited cattle crowded onto its unfamiliar deck often quit it singly or en masse and headed back for the north shore. Pioneer accounts indicate that much stock was forced to swim, an expedient that appears to have been more successful with horses than cattle. After 1879, as large herds were driven to Arizona, cattle sometimes milled on the north bank or, if crossed early, strayed unattended from the river while herdsmen struggled at the ferry as long as ten days to get herds across.[26]

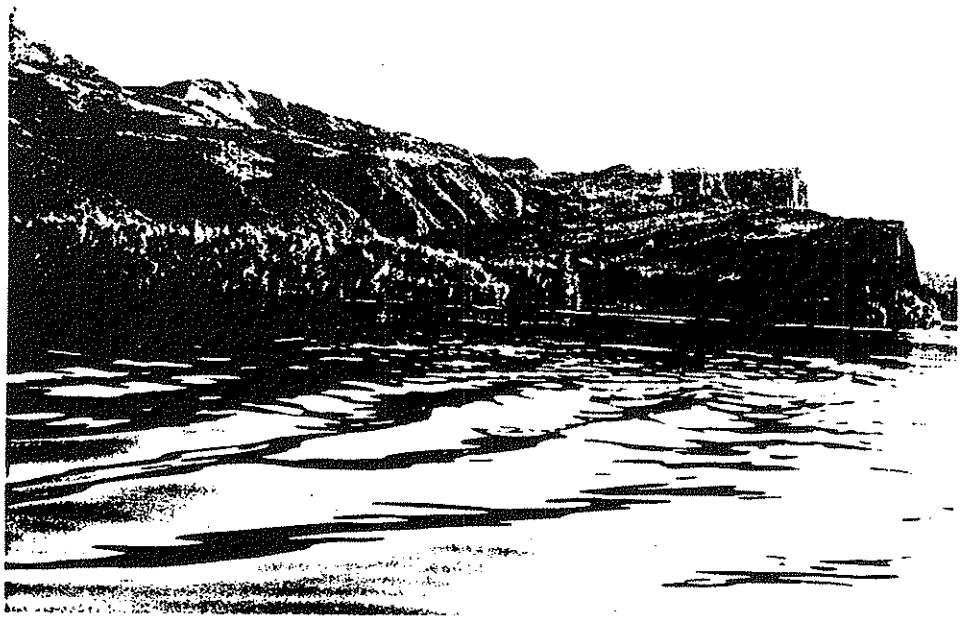
At other times, crossing was accomplished much more quickly. On at least one occasion, early in the winter of 1878, the river froze, enabling pioneers to cross on the ice without waiting for the ferry. Children and household belongings were loaded upon upended tables and sledded across while wagons were pushed and cattle were either thrown and dragged or driven after the ice had been sanded. It was an easy crossing but still a slow process and not without its anxieties as the burdened ice groaned and snapped and even parted at one point so that the water could be seen below. Anthony W. Ivins, who crossed the ice thirty-two times in the course of moving one party over, revealed characteristic relief when he wrote that all were "feeling very thankful that we had successfully crossed that horrid river without loss of life or property."[27] Others took

[24] See Amundsen, "Journal."

[25] Cleland and Brooks, *Mormon Chronicle*, vol. 2, p. 238.

[26] See Evans Coleman, "Biographical Sketch of William B. Maxwell," Coleman Papers, AHS.

[27] "Anthony Woodward Ivins Journal," p. 98.



— *C. Gregory Crampton*

Lee's Backbone, first known as Lee's Hill, a tilted apron of rock on the south side of the Colorado River at Lee's Ferry, as viewed from the north bank.

the ice span which appeared only in the comparatively calm water of the crossing to be a manifestation of the hand of the Lord in answer to their importunings that He "Cast up an highway in the midst of the deep."[28]

Fear grew, of course, from concern for human life. Dry marches, Indians, and bad roads notwithstanding, the river with rapids running only a few hundred yards below the crossing was undoubtedly regarded as the journey's greatest danger. Anxiety was often expressed at the condition of the ferry and other equipment which was of insufficient size and often in a state of disrepair. The ferry operators, on the other hand, inspired confidence and a feeling of well-being. The reaction of travelers to Lee's competence has already been noted. Emma Lee and Warren Johnson were also known as capable and careful operators.[29] But occasionally

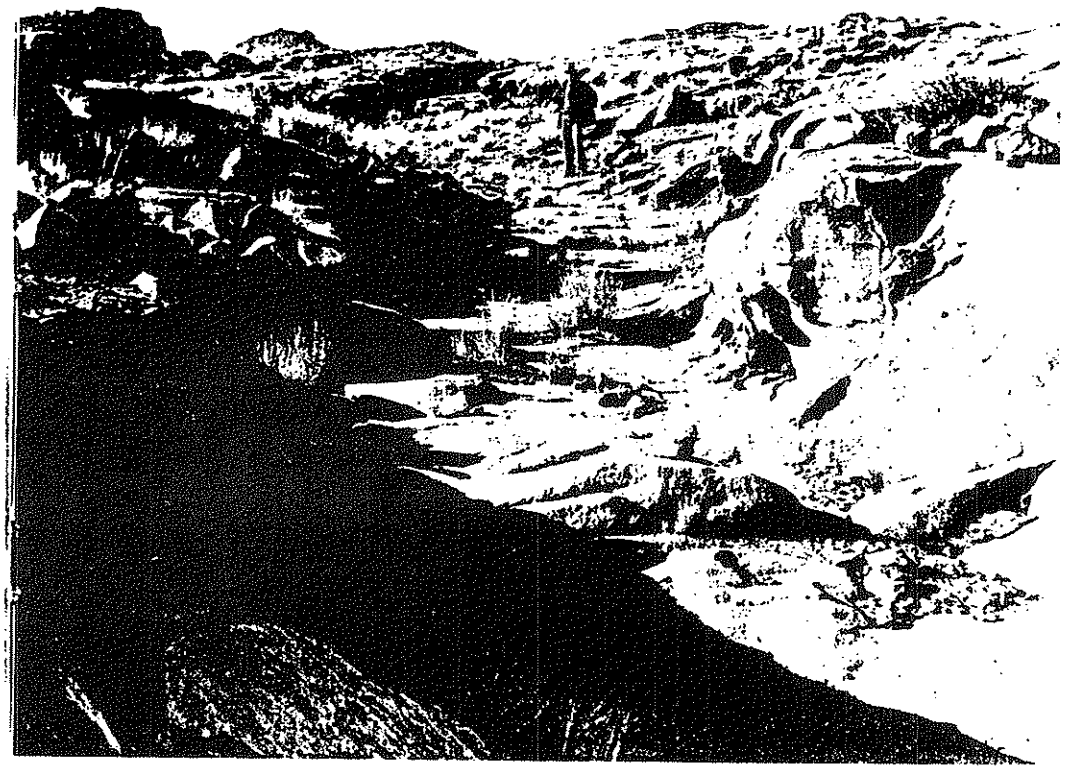
[28] Logan Brimhall, "Table Sleighs," taken from "Diamond Jubilee Gems, Snowflake Stake of Zion, 1887-1962," compiled by Alice S. Hanson et al., multilithed copy in possession of author.

[29] "Autobiography of Joseph Fish," p. 155. Also see Brooks, "Lee's Ferry," *Utah Historical Quarterly* 25 (1957): 284-90.

mishaps occurred, and in the course of the ferry's history several people drowned. Perhaps the best known of these was explorer Lorenzo Roundy, who lost his life in the spring of 1876 while making a crossing with Daniel H. Wells of the First Presidency, and an official party bound for the new settlements on the Little Colorado.[30]

There was some variation in the fees charged for ferriage. According to Lee's own account, the Haight expedition of 1873 paid $3.00 per wagon and $1.00 extra for horses. By 1876 missionary fees (half-fare) were worked out at $1.00 per wagon and $0.25 for each extra animal. These charges were maintained for several years, but by 1879 there was either considerable inconsistency in their application or the general rate had been altered upward. At that time Silas S. Smith, who was exploring the southern route to the San Juan country, chose to swim his horses rather than pay what he considered the excessive rate of $1.00 per head. However, most missionaries seemed grateful at the nominal prices charged.[31] Some felt that because of the church's obvious interest in the ferry, which included ownership of the ferryboat, missionaries ought to be entitled to free passes, but church leaders instructed Lee to charge "a suitable price" for his labor and stated their own intent to pay on such occasions as they used the ferry.[32]

Before leaving the subject of the crossing, a word should be written about the road out of the river to the south. Hurriedly opened as the migration of 1873 approached, it led up a tilted and precipitate apron of rock since known as Lee's Backbone but called merely "the mountain" or "the Lee Hill" during years prior to 1880.[33] Complicated by the crazy pitch of the backbone and its scarred and broken rock surface, the climb was perhaps the worst that the pioneers encountered on the Lee's Ferry route. Teams were doubled and wagons taken singly to the top of the two-mile pull. Slowed by such procedures, parties of any size usually took a half-day or more on the up-grade and a like period dropping off the other side where a steep and contorted terrain required that hind wheels be locked and spring seats and other loose equipment tied to the wagons. When extra teams were not available for doubling, it was necessary, as one pioneer laconically noted, to "unload . . . and pack it up on our backs."[34]



— *C. Gregory Crampton*

After crossing the river at Lee's Ferry, the pioneers faced the difficult climb over Lee's Hill. This original precarious road was constructed from the river, over the hill, toward the south.

[30] McClintock, *Mormon Settlement in Arizona*, p. 87, gives an account of Roundy's death. For a brief report by an eyewitness, see "Lorenzo Hill Hatch Journal," p. 83. P. T. Reilly considers the entire question of drownings on the Colorado River in "How Deadly is Big Red?," *Utah Historical Quarterly* 37 (Spring 1969): 244-60.

[31] For reactions typical to these two points of view see "Journal of Joseph Fish," original, HDC, December 19, 1878, p. 176. Also see the letter from George Dabling, *Deseret News*, September 20, 1876. For Silas Smith, see Miller, *Hole-in-the-Rock*, pp. 19-149, including "Nielson B. Dalley's Diary," Appendix I.

[32] Letter of Brigham Young to John D. Lee, January 28, 1874, St. George, Brigham Young Letters, HDC. Also see Cleland and Brooks, *Mormon Chronicle*, vol. 2, pp. 327-28.

[33] Joseph Fish notes specifically that it was called "the Lee hill" in 1878, which name he again applied to it in the following year. See "Autobiography of Joseph Fish," p. 156. Jesse N. Smith uses the same name in 1878 and calls it "the Hill" in 1880. See Smith, *Journal of Jesse N. Smith*, pp. 231, 241. Two diaries that refer to it in the 1876 migration both call it simply "the mountain." See "Lorenzo Hill Hatch Journal," p. 87, and "Journal of Daniel H. McAllister, Northern Arizona, 1876-77," typescript BYU; copy in possession of author, p. 4.

[34] "Autobiography of Joseph Fish," p. 163.

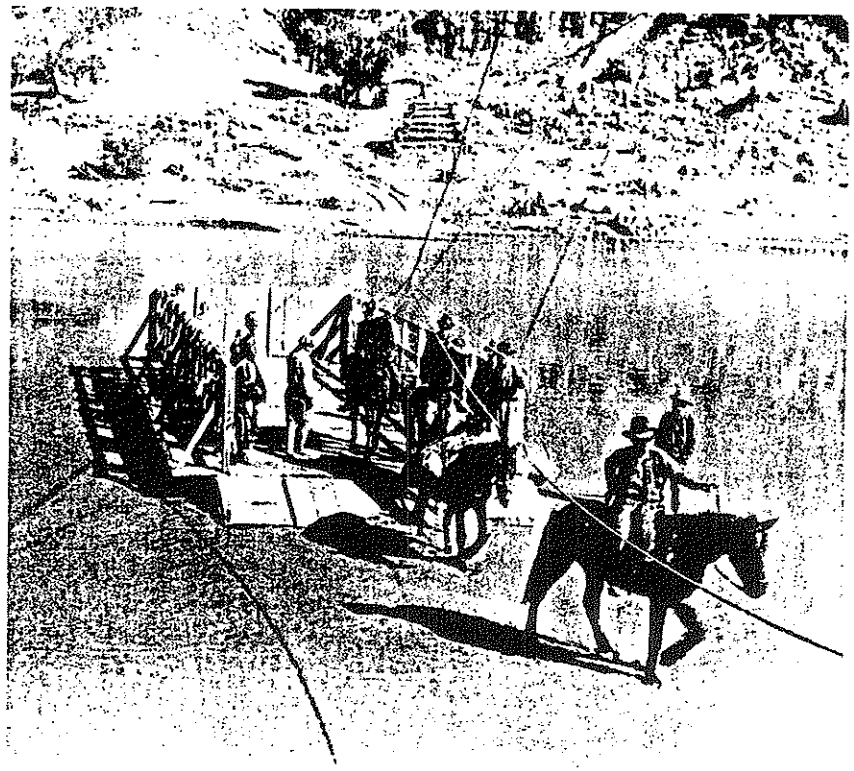
The climb over the Lee Hill was regarded with scarcely more enthusiasm than the river crossing itself, and alternate routes were ultimately developed. Even before the work of construction was undertaken, the question of where a road could best be located led to a sharp conflict of opinion between Lee and Jacob Hamblin. Lee had established the ferry at an upper crossing which gained in safety what it sacrificed in ease of leaving the canyon. Hamblin favored a more dangerous crossing somewhat downstream leading to a much easier ascent from the river. After a good deal of consideration, it was concluded that the safety of Lee's upper route merited the added expense of construction and difficulty of travel, and a rudimentary trail was cleared during the late winter of 1873. Thereafter, occasional crews made small improvements, but the road remained substantially as it was left by the original construction mission until 1887 when a way was cleared, circling somewhat to the left of the rock apron but still making the climb over the hill.

Although Lee's judgment had prevailed and the main crossing led out over the backbone, the ferry did use a lower crossing when conditions permitted, thus enabling travelers to avoid the hard climb out of the canyon. Finally, in 1898 a long dugout was constructed from the upper ferry around the edge of the cliff to the lower road which was used until 1928 when Navajo Bridge was completed a few miles downstream, consigning both the ferry and its routes out of the canyon to disuse.[35]

Arizona's Mormon Wagon Road

After crossing the river and struggling up Lee's Backbone, emigrants moved south and east, following the Echo Cliffs on the left and on the right a country of rolling hills fractured by deeply etched washes that fell sharply toward the Grand Canyon. Opened first to wagons by the mission of 1873, this trail became known in Arizona as the Mormon Wagon Road. Proceeding south their course approximated the route along which Highway 89 eventually would be constructed, leading into the Little

[35] For a thorough study of Lee's Ferry, including data on the road, see C. Gregory Crampton and W. L. Rusho, "A Report on the History of Lee's Ferry, Arizona," prepared for the National Park Service, mimeographed, 1965. P. T. Reilly of North Hollywood, California, has also provided much information on the ferry from his personal collection. For much of my information about the ferry and the road on both sides I am indebted to Gregory Crampton of the University of Utah. As he has kindly pointed out to me, the wagons of the 1873 mission were the first wheeled vehicles to penetrate this remote quarter of Arizona. For additional information see Dr. Crampton's work written for the National Park Service, "Mormon Colonization in Southern Utah and in Adjacent Parts of Arizona and Nevada, 1851-1900," mimeographed, Salt Lake City, 1965.



— *Lynn Lyman*

Crossing at Lee's Ferry, about 1925.

Colorado River a bit above the present-day bridge at Cameron some eighty-five miles south of the Colorado River.

Passing Navajo Springs eight miles from the ferry, the road ran up what is variously called Tanner Wash and Roundy Creek twelve miles through intermittent rocks and sand patches to Bitter Springs. Nine miles beyond Bitter Springs over a similar road were the Limestone Tanks where rain collected in pockets to afford a scanty supply of water. From the tanks the road continued up a gentle but sandy slope into the cedars of the divide between Roundy Creek and Hamblin Wash, which is part of the Little Colorado drainage. About fifteen miles beyond the divide, the road ran through a litter of weather-sculpted stone monoliths to Willow Springs, which flowed out under the cliffs, providing the best water on the direct route to the Little Colorado. A much-used stopping place, the rocks around it became covered with the graffiti of migration, travelers

chiseling and daubing axle grease to record their passing. Leaving the main road south of Willow Springs, an alternate route ran several miles out of the way to the east, passing through Moenave to Moenkopi. Traveling this way for the first time, one prominent churchman described the area as:

> A strange country of a barren desert of rocks, sand hills, mounds, gravel beds, and many curious rocks. . . . The hills are of thin slate in a decayed state, rocks are in every shape of men, women, children, and palaces. The country is without grass, or soil.[36]

Leaving Moenkopi the road turned west to pick up the main trail again in Moenkopi Wash. Through-traffic ran from Willow Springs down Moenkopi Wash twenty-five miles to the Little Colorado across what was often termed the "bad land."

No other part of the road was more barren or dry than this section between rivers. There was live water at only three places, and at two of these – Navajo Springs and Bitter Springs – it was often limited in amount and, as the name implies, was bitter tasting at the latter spot. By timing their migration to coincide with the cooler and wetter seasons and carrying water for the dry marches, humans and draft stock usually made the trek without undue suffering; but efforts to trail large herds of livestock brought heavy losses, and bleaching bones soon laid a melancholy mark on the road.[37]

From where the road struck the Little Colorado River, it was approximately a hundred miles to the first Mormon settlement. Although the Mormon Wagon Road along this section was regularly traveled until the turn of the century, it has since fallen into complete disuse and no modern traffic follows the river's course except for the last twenty-five miles into Winslow, which stands near the sites of the defunct villages of Sunset and Brigham City. Many of the landmarks and names that designated the route have likewise fallen into disuse. Since this is true, and since the writer has visited only the more accessible spots along the river, it is difficult to reconstruct the course of the road with any precision, and yet some tentative remarks should be made.

After reaching the river, the road evidently followed its sandy bottoms for about four miles to old Camp Utah, as the site of Haight's 1873

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[36] Cowley, *Wilford Woodruff*, p. 513.

[37] Several herds of over a thousand head of stock were brought over the trail before 1880. Most of these lost heavily, some well over one-third of the total. According to one pioneer who later became an Arizona cowboy, the loss was in large part the result of ignorance as "none of them had the remotest idea of handling cattle or horses on the trail." See Coleman, "Biographical Sketch of William B. Maxwell," Coleman Papers, AHS.

— C. Gregory Crampton

Grand Falls of the Little Colorado River in high water.

encampment was known, which because of sheltering cottonwood trees became a primary resting place. About twenty-five miles beyond, through drifts of sand that had been regarded as impassable by the mission of 1873, was the first major landmark, Black Falls, where the river spread over a lava outcropping to form a waterfall of about 125 feet in width and with a fall of twelve or thirteen feet. Unlike most of the country along the lower river course, the rolling hills around Black Falls provided fairly good grazing. From the first, herdsmen, who marveled at the Indian ruins that have since been dignified as the Wupatki National Monument, held stock there that were too weak to make it on to the settlements. About a half-day's trip up the river lay Powder Hill, which became a nooning place between Black Falls and Grand Falls. In the neighborhood of Grand Falls, which took its name from a spectacular drop in the river of about a hundred feet, grazing grounds were also found, and around it were established a number of temporary camps for herders and travelers.

Some six miles beyond was Rocky Ford, where most of the traffic crossed from the north to the south side of the river. Beyond, the road went past Roundy's Point to Canyon Diablo, or San Francisco Wash, as the earliest pioneers knew it, where it joined the Prescott mail road. From there it continued to the Mormon settlements, following the bend of the river up a broad valley, which because of its heavy cottonwood growth was reminiscent of the Platte Valley to a few widely traveled immigrants. Thence it proceeded through a monotonous landscape up the south side of the river to Horsehead Crossing, or Holbrook, where it split into three divisions.

The old mail road followed up the Rio Puerco east by northeast into New Mexico, while another trail crossing to the north side of the river worked its way along cedar ridges to St. Johns and on into beautiful senecas and timber near the New Mexico border. The third branch was itself two separate roads – one crossing the Rio Puerco a mile or so east of Holbrook before turning south through Woodruff to Snowflake along the east side of Silver Creek, while the other, bearing abruptly south at Holbrook went over the cedar hills on the west side of Silver Creek's canyon to Snowflake where the two joined to run on to Fort Apache.

The lower portion of this road was by all odds the more difficult, and unlike the part that lay above Sunset it remained a trail through an uninhabited desert. Although heavy sands and lack of feed complicated its use, water was the major problem. Bad-tasting and dirty at best, it could be so filthy that when left overnight to settle only an inch or two was clear and that had a white or milky appearance. As we have seen elsewhere, the river also was frequently dry. In such event travelers were

forced to dig for water or seek it in foul pools and tanks along the way. While water found by digging was of better quality than that of the river, it was both laboriously acquired and not without its hazards, as in the process of digging the unstable sands of the river bed were stirred, and thirsty stock rushing to drink often mired in quicksands.

Summer travel across this desert stretch could be a chancy thing indeed, and, while there is no record of loss of life due to water's lack, seasoned travelers undertook it with some apprehension, and well they might, as is apparent in the following account of a July trip in 1879:

> We found but little Grass and no water to speak of, occasionally there was a little in holes along the bed of the river but it was so salty that it could not be used. We dug near the mouth of some of the large washes that came in where we found some water that was a little better. . . . At the crossing of the river we found a little in a hole but it was very salty. On the 30th we found enough at Grand Falls to fill a ten gallon Keg. At Black Falls we found a little but it was not fit to use as the fish had died in it and it smelt very bad, like carrion.[38]

Touring the area in 1900, forester Gifford Pinchot found things substantially unchanged. Running out of water his party could locate only

> a stagnant pool of terrible green water. Sticking out of it were the horns of rotting carcasses of cattle that had waded in and drunk till they bogged down and died. . . . We had to drink it or go dry . . . although the water was so rank that in camp at nightfall its taste completely hid the taste of strong tea. Why it wasn't poison I don't know. In the desert such corruption seems to be harmless.[39]

It is not difficult to understand why oldtimers have later said that "you had to bite it off."

Travel over the Mormon Wagon Road was nevertheless comparatively heavy. It was not only the avenue by which most Little Colorado colonists came to Arizona, but the lifeline by which they maintained themselves. During the early years, supply wagons lumbered the three hundred miles from southern Utah to supplement the meager production of Little Colorado farms. Over it came the livestock which served as a medium of exchange in the Mormon land purchases and as foundation herds. Over it, too, moved churchmen, polygamists, wedding entourages, and jaded missionaries returning to Zion. Many settlers made the trip numerous times. Not unusual was William J. Flake, who between 1878 and 1895 came and went between Utah and northern Arizona thirteen times.

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[38] "Autobiography of Joseph Fish," p. 161.

[39] Gifford Pinchot, *Breaking New Ground* (New York: Harcourt, Brace and Company, 1947), p. 178.

His wife Lucy made the trip nine times.[40] Although traffic diminished somewhat after convenient and reasonable rail connections with Salt Lake City were opened, the peculiarities of Mormon society led to its continued use well into the twentieth century.

Patterns and Experiences of the Trip

Having focused primarily upon the route to this point, we shall now shift our attention to the journey itself and certain patterns and experiences that characterized it. As we have observed, the migration to northern Arizona was rarely made in large companies. The first parties that left Salt Lake City in February of 1876 departed in small groups as they got ready and with whatever company was convenient. Chance meetings sometimes resulted in the joining of as many as twenty-five outfits which split and regrouped as the fortunes of the road dictated. Little concern was manifest for maintaining any group identity other than that growing out of bonds of family and friendship. Lot Smith, who was with the vanguard of the 1876 migration, left word as he rolled out of Kanab that groups of ten wagons should travel on to Lee's Ferry and to the Little Colorado together.[41] Some effort may have been made to follow this directive, but the accounts of the southward trek that year and later leave the impression that people moved along the road pretty much at random. The usual traveling group was probably something less than the recommended ten wagons, and in many cases single teams or lone horsemen made the entire trek by themselves.

Although the trip to the Little Colorado was always long, time spent on the road varied greatly according to the nature of the outfit making the trip and the season of the year. Official church parties with good animals sometimes made summer trips from the southern Utah communities in two weeks or less. However, emigrants burdened with belongings and extra livestock took far longer, particularly those who made the passage during the winter. The first groups of missionaries in both 1873 and 1876 were two or three months on the road. Thereafter, single-wagon outfits made it from Kanab or Johnson or even Panguitch in four or five weeks. Even in the case of those who made good time, the course was marked by innumerable reverses and delays as outfits broke down, animals gave out or slipped away during the night, or delays were necessitated at the ferry or at slow-filling waterholes. Parties that started together often

[40] "Diary of Lucy Hannah Flake," June 16, 1895.
[41] *Deseret News,* March 29, 1876.

split, those able going on and those more plagued with hard luck falling back to be picked up by new groups or to labor on by themselves.

Indicative of the frustrations and delays of the trail is the following list of difficulties gathered from the diary of a missionary who with the help of his family took three wagons and a small herd ot stock from Kanab to the first Little Colorado settlements during the summer of 1876: between August 8 and 17, they looked for cows, were limited to a six-mile day by rain, waited six hours for water, held up an additional hour tor balking horses, looked for horses, attended a council meeting, lost entire string of horses one day out from the river, relayed wagons while other members looked for horses, broke a wagon in a night drive, spent a half-day in travel for tools and repair of wagon and finally spent two entire days finding remaining animals. To moderns used to convenient, undelayed progress, such interruptions would seem interminable, but the party made the drive in quick time, spending only three weeks on the road.[42]

The trek was usually marked by a good deal of individualism. At no point was this more apparent than in the mess practices. There is no evidence of a commissary or chuckwagon which cooked for entire companies. The ordinary procedure was for each family to carry and cook its own food. During the winter months, women with long flowing skirts and poorly made shoes kicked the snow back and, as half-frozen children warmed themselves and played underfoot, pulled heavy grub boxes out and cooked on open fires. Served up on tin plates, the food soon cooled in the near zero weather in which many of them traveled. It must have been a harrowing process – one that could have been materially eased by adopting the characteristic chuckwagon of the cow camp to their own trail or even the "long table" that some of them had seen in Orderville as they came south. Laundry and other chores were also done within each family, with women standing at the scrubbing board for hours in the cold and snow as they tried to maintain some semblance of cleanliness.[43]

Some pioneers sought to prepare to meet the cold of their winter trip. A few fixed special facilities for their women and children. Evans Coleman wrote of the arrangements enjoyed by himself and his mother:

> My mother and I together with numerous house-hold goods occupied the trail wagon. It was quite comfortable. The bows were set out from the sides of the wagon bed proper; a heavy carpet was stretched over them and tacked down, then a wagon cover was stretched over the carpet, making a water and wind

[42] See "Lorenzo Hill Hatch Journal," August 8 to 28, 1876, pp. 86-87.
[43] "Diary of Lucy Hannah Flake," vol. 1.

proof room, small wood burning stove and a large lantern, looking glass, comb, towels, wash basin, etc., completed the inside makeup.[44]

There were not many of these. Far from entertaining themselves in the comforts of specially constructed vans, most women and children rolled about on top of household goods or walked to ease the burden upon overloaded animals or to warm themselves. Women as well as older boys and girls teamstered, herded stock, and otherwise made themselves useful.

Sickness and physical hardship often attended the journey. Childbirth was not uncommon. Throwing ideas about protracted nineteenth century confinement into question and reflecting a hardiness foreign to modern women, the courage of expectant mothers who set out for the south knowing they would face delivery by themselves under winter conditions is almost unbelievable. Characteristically such events did not wait for convenient moments. One child's untimely arrival halted a party struggling through the snow in a crossing of the rim of the Great Basin.[45] Another was delivered on the Kaibab but lingered only nine days before finding a lonely grave at House Rock Springs and becoming the only casualty of the 1873 mission.[46] Another was born in November of 1880 in the remote and rugged approach to Pearce's Ferry. Noting the new arrival, one missionary wrote: "A pretty rough country for such an event, and then to travel over a rough road the next day." But indicating that it was to be taken in stride, he continued: "Yet I came into this world under similar circumstances."[47]

During the migration of 1877 an epidemic of diptheria flared late in December as the emigrants who all used the same waterholes approached Lee's Ferry. William J. Flake, whose own daughters "took diptheria" and "had it dredfull bad," came upon a standing wagon at the east foot of the Kaibab Plateau and, as his son Osmer recounts, found a woman

> . . . sitting on the seat with a dead babe on her knee. It had died as she drove the team down the mountain. Mother prepared the body for burial. Father got a few short boards from the wagons and made a box, the teamsters dug a hole, and we buried her darling in a lonely grave. It looked as though her life too, would go. Their outfit had gone on for water. We took their wagon with ours and went down the road.[48]

Although there were no doctors, midwives and other lay practitioners did provide minimal medical service. For example a blind mid-

[44] "Autobiographical Sketch," Coleman Papers, AHS.

[45] May N. Christensen, "History of Bendt Nielsen Jr., 1855-1944," mimeographed copy in possession of author.

[46] "Journals of John Henry Standifird," July 13, 1873.

[47] "Journal of John W. Tate," p. 15.

[48] Flake, *William J. Flake*, p. 60.

wife named Abbie Thayne rendered yeoman service during the diptheria outbreak mentioned above and was remembered afterward by grateful pioneers as Dr. Thayne, "a very fine physician."[49] The versatile John W. Young's gifts also extended to healing, as Apostle Wilford Woodruff, whom he nursed through a severe illness at Moenkopi in the spring of 1879, had good cause to appreciate. In December of the same year, Young happened into the Little Colorado communities in time to ply his medicinal skills upon an aging immigrant. After diagnosing his eighty-two-year-old patient's ailment as "Lung Fever," Young "drew his water off with a Cattelan [?] which was a great help to him."[50] The oldtimer was evidently far gone and his relief was temporary, for three days later it was necessary to treat him again.

Interesting and sometimes even bizarre home remedies were practiced among the migrants. Two examples will suffice. One traveler whose son was afflicted with shingles cut the tip from a black cat's tail and rubbed the blood over the shingles. Without attributing the cure specifically to the medication, he noted that the shingles "soon began to disappear." Wilford Woodruff also tried his hand at home remedies, prescribing sagebrush and charcoal poultices for infection. It was, as he said, a "safe medicine and can do no hurt." For cases that did not respond to this treatment, he recommended that the afflicted part of the body be held over a "smoke of woolen rags on wood." Presumably this too did "no hurt."[51]

When such skills as Woodruff and "Dr. Thayne" could boast were either unavailing or unavailable, the stricken traveler had recourse as elsewhere on the Mormon frontier to administration with blessed oil and prayer and often felt himself improved by the power of faith and the priesthood. Nevertheless, a goodly number gave their lives as the price of the exposure and the exertion of the long trek.[52]

This was in substance the experience of the trek to the Little Colorado River. Marked by its length, its isolation, and its barren and drouth-stricken stretches, it constituted a trying trip indeed. It was also one with

[49] *Ibid.*

[50] "Wilford Woodruff's Journal," April 25-May 1879. For the lung fever episode, see December 20-23, 1879.

[51] William Henry Solomon, "Diary of the Arizona Mission," p. 31, and letter from Wilford Woodruff to Lot Smith, January 31, 1882, Lot Smith Papers, UA.

[52] Characteristic gratitude for divine protection is obvious in the following words from Lucy Hannah Flake's brief account of the Flake family's winter journey: "We traveled very slow we had a very hard trip our two oldest daughters took the diptheria when we had been on the road about two weeks they had it dredfull bad and we never had seen a case of it before we did the best we could and the Lord hered our prairs and spared their lives." See "Diary of Lucy Hannah Flake," vol. 1.

which many Little Coloradans became well acquainted. Some even developed a certain nostalgia as they contemplated its role in their lives. One remembered it as the "honeymoon trail." Another as "the fond old route known as the Lee's Ferry by way of upper Kanab."[53] And in the waning years of the nineteenth century as the colony was stabilized, the entire community came to commemorate the trek, reliving it one day each year as they celebrated Old Folks Day in connection with July 24. Conscious of their past and of their bond with the mother community in Utah, Little Colorado Saints did not forget its miles.

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[53] See "Joseph City Ward History," p. 27, and "Lorenzo Hill Hatch Journal," p. 181.

5. THE UNITED ORDER

> . . . and I must say that I felt in spirit that these settlements . . . were living in the United Order as near as any people could, in mortality, until a better way shall be revealed.
>
> WILFORD WOODRUFF

> . . . We consider it the will of the Lord to live in this manner — otherwise many would prefer living in the old style, for there is a great many trials connected with this style of living not known to the other. . . .
>
> LEVI M. SAVAGE

Bond of Peculiarity, Agency of Expansion

MORE IMPORTANT EVEN than the Mormon Wagon Road in forging the bond that held Little Colorado Mormons to the mother institution were the cultural and spiritual values common to both. None of these — save possibly polygamy — was more unique or more consciously cultivated than the United Order, a communal arrangement under which the first villages on the Little Colorado were settled. As planned and in effect, the United Order was a badge of peculiarity. In its Arizona phase it was also a vehicle for the outward thrust of the Mormon Kingdom.

When the Mormons began their colonization of Arizona, the United Order movement had been underway in Utah for three years. Reduced to its simplest terms it was an effort to seek out grass-root social arrangements that would enable the Latter-day Saint society to advance more quickly in Christ-like attributes, maintain the church's separation from the world, and solve a variety of economic problems. It implied a unity

8. THE COSTS OF WATER

> With a cloudburst of rain, it becomes a raging torrent, rampaging along, sweeping everything in its path. It is dirty, muddy, gurgling, seething, belching, vicious, demon-like, bringing havoc, destruction and death. . . . Yet with all its dangers it was a lifesaver. In the early days, man and beast survived only because of its life-saving power. It was the only water for miles around so it was "that or nothing" and without it that part of Arizona could not have been settled.
>
> ELLEN GREER REES

THE WATERS OF THE LITTLE COLORADO were judged by some early Mormons to be so limited, hard to control, or "mineral" as to render the country unfit for human habitation. Others more optimistic visualized the day when the stream would support a community numbering into the tens of thousands. All, however, acknowledged that water was the key to successful colonization. On its development hinged the prospects of the future. In seeking to escape the strictures laid upon them by the limited water and the capricious nature of the country's streams, colonists struggled for decades to establish effective control, but in the long run found that the costs of all but the most primary developments were beyond their abilities.

Their experience, except perhaps in its extremes, was not unique. As a matter of fact, it was a replica with variation of a drama that unfolded over the entire Colorado Plateau. Settlers in southwestern Utah's Virgin River Basin, in eastern Utah's Castle Valley, and farther east into Colorado and New Mexico encountered similar problems. The name of the river varied and the detail was not identical, but water development

on the Price, the San Juan, or the Mancos had much in common with water development on the Little Colorado. The process of taming these desert streams dominated the lives of those who stayed as it dictated the departure of many who left. Certainly, the Little Colorado River left an indelible mark upon the colony that depended upon it.

Although its watershed, which spreads over 25,900 square miles, must be reckoned among the larger areas drained by Colorado Plateau rivers, the Little Colorado is relatively unimportant in terms of the water it carries. Measured by the U.S. Geological Survey at Holbrook, below which the river is fed only by intermittent flooding, its average annual discharge during the early years of this century was less than 200,000 acre-feet – statistics which may be taken as somewhat characteristic of the period of colonization. Comparatively, a section of the Virgin River, which empties only a little more than a thousand square miles, boasted a flow similar in volume during the same years. The San Juan River, whose flow approached ten times that of the Arizona stream, runs from a region somewhat smaller in size. According to estimates made in 1905, the Little Colorado's maximum annual runoff likely never exceeded 300,000 acre-feet. Not only was its discharge small, but its water volumes varied widely during the year, running as high as 69,000 acre-feet in flood months and dropping to little more than a trickle in the dry months of June and July when its flow was only 244 acre-feet.[1]

Rising in the White Mountains near New Mexico's border, the Little Colorado flows northwest, flanked variously by mountain meadows, rolling hills, wide sandy bottoms, and by rugged but comparatively modest canyons. Farther back from the river the country also varies greatly. In the main, however, it can only be termed a desert possessing the thin soils, sands, clays, rocks, and minerals that generally characterize such regions. Whatever prospect such a country held for agriculture obviously lay in the utilization of the river. A moody and fitful stream virtually lost in its vast arid drainage, it was nevertheless the country's primary asset.

Water Development

Early-day water development was of three sorts: diversion, impounding, and conveyance. The first and basic measure was diverting the water from stream beds. In a few cases this was relatively simple. Rock walls

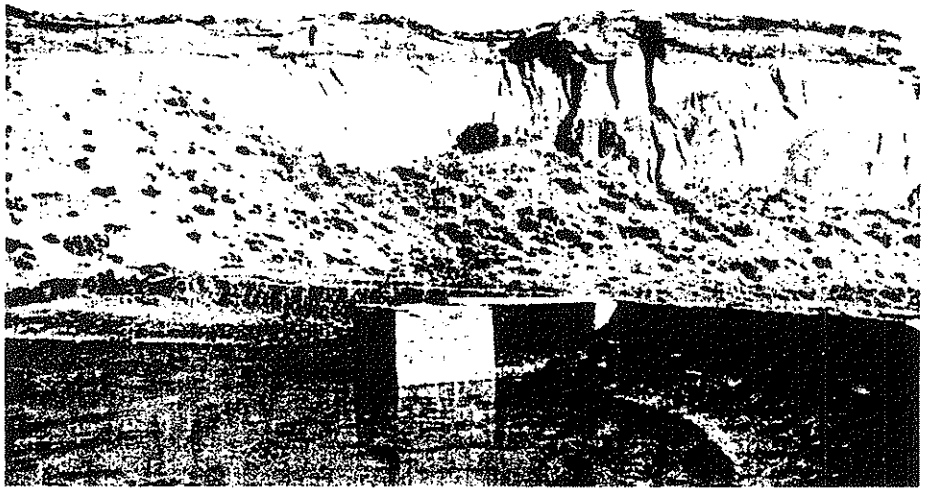
[1] The variations would have been even more pronounced had measurement been taken below Sunset where the stream drew additional flood waters from numerous washes in wet periods and dried up completely in the early summer months of dry years. The data presented above was taken from E. C. LeRue, *Colorado River and Its Utilization,* United States Geological Survey Water Supply Paper 395 (Washington, D.C.: Government Printing Office, 1910), pp. 109-120.

into which headgates were built were located at strategic spots, usually at a bend or "at the top of the water" where the flow could easily be drawn off into some earlier course which was near stream level. More often it was a matter of lifting the water and "taking it out" by means of diversion dams. Like the rock walls, these were located according to footing conditions and convenience of diversion. The first dams were not large works, rising no more than twelve feet. As a lift of more than a few feet was usually avoided, it was hoped that such modest barriers would be adequate. Hard experience soon proved that the happy combination of conditions under which the small dam sufficed was limited indeed. Larger works or continuing reconstruction were consequently required.

All of the earliest dams were constructed of dirt-fill, bound and stabilized by rock, cedar brush, and logs. In time settlers learned to lay them with the side fronting the water rising at a gentle pitch so that floods swept up and over, leaving the dam intact. Before the turn of the century, more impressive works had been made on the Little Colorado, but Silver Creek was still controlled by a series of these earthen and rubble diversion dams. For decades it proved necessary to replace them with

— Albert J. Levine, Snowflake, A Pictorial Review, 1878-1964

Silver Creek diversion dam near Snowflake.



Mormon reservoir near Tuba City.

heartbreaking regularity. Later a degree of permanence was achieved by pouring concrete shells over the dams and laying aprons downstream onto which flooding waters fell as they came over the dam.

After the earliest years, efforts were made to impound unused water in reservoirs to supplement the natural flow of the streams during periods of heavy irrigation.[2] Between Snowflake and Taylor, for example, three such reservoirs had been constructed by the early 1890s. Dams or levees ten or twelve feet in height and perhaps two hundred yards in length were built, generally at sites removed from the direct path of the river. One of these was said to have "about 4,550 yards of earth work in the bank besides rock and brush." Its capacity was estimated at "enough water to irrigate 1,000 acres over once."[3]

Perhaps the largest and most effective reservoirs were built at St. Johns. Beginning with two in the immediate vicinity of town in the early 1880s, development progressed until before 1915 the Lyman Dam backed up a substantial amount of water. While the utility of St. Johns' dams was great, they frequently broke, precipitating a chain reaction that swept dams away at Woodruff and St. Joseph that might otherwise have held.

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[2] See "Minutes of the Woodruff Irrigation Company, 1895-1906," pp. 154, 161, 166. The original minutes are in possession of Earl Crofford at Woodruff, Arizona. He has been kind enough to furnish the writer with a copy.

[3] Fish, "History of the Eastern Arizona Stake," p. 22.

The third aspect of water development was ditching. Because of the modest size of Little Colorado irrigation projects, ditches were not of great capacity, rarely being more than six feet wide or of greater depth than two or three feet. On the other hand, they often ran long distances and involved great expense and continuing labor. In the fall of 1876, touring territorial officials noted that the colonists on the lower river had already dug "many miles of large irrigating ditches . . . often for long distances through solid rock."[4] The experience of that first summer was duplicated with variations almost annually throughout the colony during the next decade and a half and occasionally thereafter. With notable exceptions, the terrain through which Little Colorado ditches ran was not unduly rough, but the lower country was covered with sandstone upcroppings and the higher elevations with volcanic malapai formations that complicated ditching. On the lower river, the soil was "sugary" in character and frequently cut out or merely absorbed the entire stream. At the higher elevations, porous volcanic deposits also drained water out of ditches, constituting a technical difficulty that was never solved.

Ditch networks, of course, were subject to constant revision as reservoirs, new lands, and natural factors altered the water situation. Even after primary construction was completed costs remained high. Windstorms and gully-washing rains filled and refilled ditches with sand and debris. Dependent on Silver Creek and the river itself, ditches never escaped the fury of floods and even when left intact regularly filled with sediment. Consequently, ditch-cleaning was a job that settlers knew well, returning to it in a dogged annual rhythm punctuated by periodic repairs necessitated by floods and washouts. Water assessments and work schedules announced from church pulpits were frequent ceremonials as the cycle of maintenance went on. While they bore the expense, colonists often felt oppressed by it. Characteristic of their feelings was the following expression:

> Labor on ditches in this stake has been enormous, at Snowflake this year [1889] the tax was a trifle over $3.00 per acre. Paying out this amount every year per acre . . . tells upon the people and they begin to think it is too much of a burden to carry. Other places have paid about as much as this.[5]

Nevertheless, ditch work was a norm of agriculture on the Little Colorado.

[4] See Territorial Governor A. P. K. Safford's report of the visit in the *Deseret News*, December 20, 1876.

[5] "Minutes of the Woodruff Irrigation Company," p. 92.

Organization and Leadership

Organization to meet the continuing problems of irrigation was inevitable. Its first manifestations came with an immediacy that indicated that the lessons of Utah's experience had not been lost upon the earliest colonists. The day after the vanguard of settlement arrived on the lower river in 1876, the Allen's Company contingent met to consider "the best way to secure" their "water right by cooperating together." The following day after limited discussion, they accepted an "agreement for an irrigation company" and "commenced work on the Ditch."[6]

Though one of their purposes was to form an association under territorial law, it is unlikely that either this company or others were incorporated in the early years. As a matter of fact, in the years before the mid-1890s some of them appear to have lost their identity as independent agencies entirely. For example, the March association of the Allen's Company water users was soon supplanted as the effective administrative unit by the St. Joseph United Order. As long as the Order remained intact, St. Joseph residents apparently handled all irrigation matters within its jurisdiction.[7] Elsewhere, arrangements corresponding more or less to the church organizations assumed the primary obligations of water development.

Informal associations persisted as the primary form of irrigation organization until the 1890s when they were supplanted by irrigation companies incorporated under Arizona law. Among the early incorporated companies was the one at Woodruff. Although stock in the Woodruff water system had long been divided according to the amount of land held, there is no reference to any formal organization prior to 1895. During later years, Woodruff users reasserted rights to waters that had fallen into disuse, and in the process ascertained that their water right, which was not filed officially until 1898, is anterior to any other on Silver Creek. In view of this fact, it would not seem that Woodruff turned to incorporation primarily because of economic factors or matters of internal regulation. These had been effectively provided by the earlier church-oriented association and were still being adequately dealt with at the time of incorporation. It consequently appears that when incorporation came, it came in large measure as a necessary prelude to the securing of legal title to the water.[8]

[6] See "Joseph City Ward History," pp. 10-11.

[7] See George S. Tanner, "Henry Martin Tanner, Joseph City Arizona Pioneer" (multilithed, 1964), p. 59.

[8] "Minutes of the Woodruff Irrigation Company," pp. 24-25.

The shadow of the church loomed large in both the associations of the early years and the chartered companies of the later era. Stake presidencies and bishops played vital roles. They became involved in water development when they entered the country and remained at its forefront until they were removed from office or died. In many cases their successors inherited this obligation, carrying the tradition into the twentieth century.

L. H. Hatch, who served in the stake presidency from its inception in 1878 until 1901, spent the entire period in a struggle to solve Woodruff's water problems. Tending to pessimism and self-recrimination, he was nevertheless the figure around which Woodruff's shifting population formed as he helped build twelve dams and weathered the destruction of eleven of them. His voice on the stake presidency and access to the General Authorities, most of whom he knew well, won concessions far beyond what the size and prospects of the community might otherwise have merited. Driven by despair as dams continued to fail, he carried his requests for aid beyond the confines of the Mormon community, securing funds from public sources as early as 1890. He sulked, preached, threatened, and prophesied to focus the elements of continued effort on the "famous Woodruff dam."[9]

According to a son living in 1966, the old gentleman's determination was in part the result of a personal pact with Brigham Young to locate the "worst place on the Little Colorado" and develop its water as evidence of success to other less determined missionaries.[10] Whatever the facts, L. H. Hatch's leadership was an important, if not the paramount, factor in the course taken by Woodruff's long fight to tame the Little Colorado River.

Less a joust with fate and more a matter of positive leadership was the role of D. K. Udall, who first as bishop of St. Johns and later as president of a stake by the same name also spent the better part of a lifetime in water development. Between 1880 and 1915 he was intimately associated with the promotion and construction of seven reservoirs some of which were immense projects requiring effective cooperation between Mormons and outside financiers and engineers. At Round Valley where he lived for a time, he put "a portion of each year" into "building and rebuilding" a "cluster of small lakes." At Hunt, about halfway between St. Johns and Holbrook, he also participated in successive construction of the "Udall Reservoir" or, as it was called locally, "Zion's Lake."[11]

In company with visiting General Authorities, Jesse N. Smith, president of the Eastern Arizona and Snowflake stakes, provided much of the

[9] "Lorenzo Hill Hatch Journal," p. 157.

[10] From a personal interview with Wilford L. Hatch of Franklin, Idaho, August 20, 1966.

[11] Udall and Nelson, *David King Udall*, pp. 184-85.

initiative for water development. His counsel was often sought though less frequently taken, and upon him rested responsibility for a surprising amount of technical decision for which only good judgment and practical experience had prepared him. Local leaders often required him to take a position on controversial issues in order to buttress their own positions or to unify public opinion. As water matters came to take a large part of his time, stake gatherings increasingly assumed the character of staff meetings from which water policy and administration issued. One Danish settler uttered a truism when he remarked from the pulpit that all that was talked about in worship meeting was "Vater Ditch! Vater Ditch! Vater Ditch!"[12] Indicative of Smith's participation in water affairs and their invasion of church meetings is this curt notation from his own journal:

> Attended meeting at Woodruff. I spoke of the break in the dam; did not see but what the men who put in the portion that remained could put in more of the same kind. Counseled the brethren not to be discouraged, neither by the reports of what the railroad company was going to do about the land, nor about the damage the water had done to the dam. Know of no better place to make a living by farming in Arizona, any place occupied by Latter-day Saints, than here in Woodruff.[13]

Continuing to give close attention to water development, he broadened his horizons in the last years of the century to become an important figure in the national irrigation congresses of the time.

As noted before, bishops too were in the forefront of water affairs. At St. Joseph, John Bushman manifested a contagious optimism that accounts in some degree for that town's resilience. This spirit was much in evidence when following the loss of a dam in 1890 Bushman wrote: "Our people are not discouraged." Twelve months later when another dam, the product of much toil, went down the river, he noted with equal complacency: "No one seems discouraged. Probably because it is so common."[14] Personal attributes and perhaps other economic opportunity rather than familiarity with disaster appear to have been the basis of St. Joseph's optimism since repetition did nothing to assuage the bitterness of disappointment at the loss of dams in Woodruff. There washouts plunged the populace into such gloom that even ardent supporters rallied their spirits only by leaving town for awhile. Seeing divine rebuke in its repeated reverses, Woodruff tended to self-remorse. More pliant, St. Joseph

[12] From a personal letter to the writer from Lenora Hansen of Snowflake, Arizona, February 15, 1966.

[13] Smith, *Journal of Jesse N. Smith*, pp. 274-75.

[14] "The Life and Labors of John Bushman," February 20, 1890, and February 20, 1891.

— *Jesse N. Smith Family Association*

Jesse N. Smith, president of Eastern Arizona and Snowflake Stakes.

with Bushman and others like him at its head also saw God's hand in the course of events but was less frustrated and guilt ridden by it.

With an eye to temporal means, leadership, and tenacity, the church successively called three bishops to Woodruff. The primary obligation of each was to hold the community together in its effort to build the dam. During the forty years before this objective was successfully accomplished, each of the three succumbed to social discord, depression, or sheer weariness, leaving the village with bitterness and relief. But before each took his leave he had turned again and again to lead a fight in which there was a minimum of personal economic interest and a maximum of commitment to the basic objective.

The Famous Woodruff Dam

Other general aspects of water development may be viewed through the experience at Woodruff. Founded in 1877, the community fought a stubborn battle with the river; the battle, though it may have ended in nominal victory in 1919 when a staying dam was finally erected, was in reality something of a study in postponed defeat, as no really satisfactory solution was ever achieved. Located four miles below the junction of the Little Colorado and Silver Creek, Woodruff lies east of the river where it flows through a rock cut some thirty-five feet in depth. Varying around thirty families, the town's population formed and reformed following each washout. In all they built thirteen dams, eleven of which were lost to the flooding river, one cut voluntarily, and one which was still surviving in the early 1970s.

The pattern began in 1878 when, after months of labor, high water cut around both ends of the first dam. A flurry of construction during the early 1880s was hammered by incessant reverse as dams number two, three, four, five, six, seven, and likely eight were swept away. Brief respite was experienced between 1886 and 1890 as meteorological changes led people to hope they had conquered the river. In the latter year, however, floods of unprecedented proportions again did their "awful work." The construction of dam number ten was immediately launched, bringing the water out again before the summer's end; however, in a wet November that hampered life throughout the colony, it too was lost. Finished again the next year as engineering skills increased and the weather moderated, the eleventh dam, now flagged by stone slabs, held until 1904 when Zion's Dam at Hunt gave way before large storms, releasing a torrent that again left Woodruff's settlers high and dry. Built with much assistance from the church and the Little Colorado stakes, the twelfth and last dam on the river — a masonry structure, remnants of which still were standing in the early 1970s as stark sentinels of the Little Colorado's prowess — was lost

Remnant of the "famous Woodruff Dam."

as the Lyman Dam above St. Johns collapsed in 1915, adding the waters it had impounded to an already swollen stream.

Weary, but this time with substantial state and church aid, Woodruff turned to dam number thirteen. Engineers now determined that ditches could be chiseled along the canyon side making feasible the construction of a dam on Silver Creek just above its confluence with the river. Escaping the silts and minerals of the Little Colorado as well as its fierce floods, a permanent diversion dam was completed in 1919. Mormons in quest of a happy ending for Woodruff's long struggle have tended to regard this as a successful conclusion, ignoring the fact that the technical difficulties of ditching along the canyon walls proved to be virtually beyond the exhausted town's ability to overcome.[15]

Certain characteristics of the entire colony are seen in sharp relief on this troubled background. Keeping in mind that Woodruff's struggle

[15] Recent decades have witnessed an almost complete abandonment of irrigated farming under the dam. A move to restore the ditch and once again "bring the water out" is presently afoot. The pace of changing times is apparent in the ironic fact that impetus this time comes not from the church nor even the village natives but to all appearances from an "outsider" who purchased the old home of a long-time bishop and in the process of its restoration has been caught up in the broader course of Woodruff's ongoing struggle for existence.

and its precarious hold on life were in a sense symbolic of the Little Colorado's general experience, we may now turn to a consideration of the village's marginal existence, certain communal elements in its history, its dependence, and the failure of Mormon means to solve any but the most superficial water problems.

Apparent in the foregoing narrative is the fineness of the balance in which Woodruff's existence hung. Closely circumscribed by natural conditions, it barely escaped joining the Little Colorado's roster of ghost towns. From the first, settlers appear to have vacillated about the desirability of staying. After the loss of dam number one in 1878, only three families remained – those of L. H. Hatch, James Dean, and Hans Guldbransen. Interestingly, these, along with the families of James C. Owens, who came in 1879, L. M. Savage, and one or two other latecomers, became the stable element in the town's population. It became the role of these people to recruit others. Time and again the initial phase of construction was building population. Church counsel was used unstintingly in the process, as was any promotional talk the people could muster.[16]

With the town built to a peak population of about thirty families during periods of construction and successful diversion, failure of a dam usually resulted in a general exodus. Most merely left. Occasionally there were those who justified or attempted to justify their departure. At least one, a Brother Dexter, reported that "the spirit had directed him to move his family to Utah."[17] In 1891 even L. H. Hatch became discouraged. Being "very much exercised" about the village's destitute condition, he stated in strong terms, "if we were going to defer longer the building of a dam, I would move and advise the people of Woodruff to scatter out where they could make a living."[18]

In 1905 after receiving a lamenting report of the loss of dam number eleven, Salt Lake authorities, whose willingness to subsidize Woodruff had been unflagging, proposed that the community be abandoned. In reply to a request for help from Jesse N. Smith, they suggested that the village could be moved as a unit to southern Nevada's Muddy River. Smith quickly backed off, responding that he considered it "better for Woodruff and cheaper to the church" to build another dam. Ignoring the facts of the

[16] Typical of their overtures were those made to Allen Frost in April of 1889. After conferring with Jesse N. Smith at Snowflake, Frost visited Woodruff in company with its bishop. On April 15 he wrote: "Looked around Woodruff, and visited a little. Received a pressing invitation to locate here." With the laconic but accurate notation of "Poor Water," he declined the invitation and established his home in Snowflake. See "Diary of Allen Frost," p. 550.

[17] "Lorenzo Hill Hatch Journal," p. 170.

[18] *Ibid.*, p. 157.

town's long history of subsidy and help, he rested the crux of his argument on the embarrassment Woodruff's citizens would feel "if they had to take charity." Given such an alternative, he thought "the value of the poor homes they had left would be enhanced a thousand fold in their eyes, and they would long for Woodruff if they went to paradise." Concluding that the distance to the Muddy by rail was six hundred miles and the "wagon road the worst in the country," he turned again to plans of construction and soon won cash grants totaling at least $1,500 from the church as well as the right to apply local tithing receipts to the project.[19]

That Woodruff escaped the tragedy of extinction was due in part to the fact that its citizens were not unduly sensitive about accepting aid. Indeed, their tolerance to "charity" was pronounced, and after the very earliest attempts Woodruff was given help on most if not all its dams. Aid came from various sources. Individuals who saw fit to make the town their permanent home were often helped by family members in Utah. While their strong sense of mission relieved this practice of some of its onus, settlers appear to have chafed under the relationships so imposed. The church, which apparently recognized a broader significance in the town's success than the handful of homes thus provided, advanced aid in various guises. Outright cash grants were infrequent but with the passing of time became increasingly important. According to one account, the church "contributed twenty-two thousand five hundred" of the total cost of $85,000 that the last dam cost.[20] More common were tithe reliefs which were generally gathered in labor and kind from about the Little Colorado community. Also important were opportunities to work out debts contracted to the church for water development, land purchase, and other undertakings.

In addition to grants requiring action of the General Authorities, labor was donated by the surrounding towns on at least three occasions – once in 1884, once in 1890-91, and again in 1905. With tongue in cheek but nevertheless with real insight, Evans Coleman wrote the following relative to this practice:

> The Church authorities were practical and philosophical. For example: The people on the Little Colorado were having a hard time, especially at Woodruff and Joseph City. They just couldn't keep those dams in, and a couple of the Apostles came down to look things over and give encouragement and aid to those people.

[19] See letters of Jesse N. Smith to Joseph F. Smith under dates of June 6 and December 5, 1905, Jesse N. Smith Personal File, HDC.

[20] See "Our Town and People, A Brief History of Woodruff," (multilithed), compiled by Sara E. Brinkerhoff and Nina B. Brewer, p. 7.

> Those Apostles came on up into the more prosperous communities and at meetings asked us to donate. Quote: "Brothers and Sisters: You know the extreme difficulties our people are having along the Little Colorado. We must not let those settlements be broken up. You more prosperous people must help them. Donate of your cattle, horses, grain, wagons – anything you can spare that they can use. . . . Listen, (and the speaker lowered his voice) If we can just keep those old people there till they die off and the young ones grow up, it will be home to those young people. They will know no other home nor want any other home. And when the dam goes out they will be just like a bunch of beavers. They won't know anything else but to go and put it in again. They will be permanently located – rooted into the soil." unquote. Good philosophy, no? Who else would have thought of that but a Mormon colonization promotor? And, the people of the more prosperous communities contributed liberally.[21]

Though inconvenient and at times even oppressive, local contributions generally seem to have been regarded as part of the community responsibility of colonists whose lot was somewhat less austere.

Woodruff's residents were not without their own sense of communal obligation. Indeed, on one or two occasions their willingness to jeopardize their own welfare for the broader weal was heroic. In May of 1880 as their second dam impounded the entire flow of the Little Colorado, it had adverse effects on the lower river villages. Woodruff's response to the dilemma is perhaps best expressed in the words of L. H. Hatch:

> Next day I received a letter from St. Joseph about the water affairs. We were damming the water at Woodruff so that it did not flow on to St. Joseph. Our dam had been closed up for eight days and the people at St. Joseph were all out of sorts waiting for the water to flow over our headgates. It would have to fill up two and a half more feet before it would pass over and that was too long to wait. We cut our dam and let the water through. It was a sorry time for those who had worked so hard to put in this immense dam.[22]

The following year, St. Joseph representatives again appeared in May to request that Woodruff turn water down to relieve their critical need. Although "some murmurred," the headgates were opened leaving crops dependent upon natural moisture which soon came in good amounts despite the fact that the rainy season generally did not start until much later.[23]

[21] Coleman, "Historical Sketch of Dr. W. E. Platt," p. 12.

[22] "Lorenzo Hill Hatch Journal," May 16, 1880, p. 115. Of the same event, Joseph Fish wrote: "A few days after this Major Ladd came up on behalf of the people of St. Joseph and claimed that there was a great scarcity of water with them, and if the water was not turned down they would lose their crops. A meeting was called and it was decided to cut a hole in the dam and turn the water down. This was a damage to the dam of about $500.00 and blasted their hopes of a crop for that season." See "History of the Eastern Arizona Stake," p. 35.

[23] "Lorenzo Hill Hatch Journal," p. 121.

Not surprisingly, Woodruff citizens gained much support from non-Mormon sources. From the beginning, outside work was characteristic of life. With the railroad near at hand, freighting became a major source of income. Sons were hired out to cow outfits. Men scattered as far afield as the mines in central and southern Arizona. Entirely typical was the condition in 1905 when a count made pursuant to commencing a new dam revealed that the community consisted of thirty-three families, ten of which were headed by widows or aged men. The men of twenty families were working at various jobs away from home and could return to the dam only if support could be found for them. Of the total, only three could sustain themselves on their Woodruff holdings for any length of time.[24]

Pressed repeatedly by such need but determined to maintain the principle if not the essence of nonfraternization, Woodruff men and boys, and (over the loud protest of church authorities) occasionally its women, became something of a service community. Honest and steady, they left home for long periods of time to carry on the necessary functions of many businesses without actually becoming part of them. Reflecting a characteristic aloofness, one settler wrote in 1883: "I spent nearly two months among the Gentiles laboring for wages, at Flagstaff. . . . Their company is not pleasant for me."[25] Reserved and closemouthed, particularly after the polygamy raids gathered impetus in the middle 1880s, Woodruff settlers found it to their interest to perform their duties with little protest or agitation. Combined with their impecunious financial conditions, their separatism placed sharp limits upon the nature of their business participation. Few of them acquired stock in or joined the management of outside companies.

Woodruff also sought outright relief from Gentile sources. In 1890 petitions were addressed to the Atlantic and Pacific Railroad requesting that land debts be written off or at least temporarily waived. During the same crisis, the territorial legislature appropriated $1,500 for their relief. In 1915 Arizona, by now a state, advanced $10,000 to rebuild the dam. Before the complex system of flumes and siphons by which the ditch was worked down the canyon from the new dam was completed, the community had also received $26,000 under the Federal Emergency Relief Act of the 1930s.[26]

Conditioned by the climate of crisis in which they lived, Woodruff citizens and to a lesser degree Little Coloradans generally were thus anything but independent. The effects of this conditioning were diverse. On the one hand bonds between colony and mother institution were enhanced. On the other was a strong centrifugal force that led colonists into reciprocal relations with the secular world.

Other Little Colorado reclamation projects that sought to control floods or to develop any but the most accessible waters met with a fate not unlike Woodruff's. At St. Joseph where quicksand and shifting riverbeds combined with floods, the problems of building a dam that could both survive the river's moods and divert irrigation streams at low water was not permanently solved until 1923.[27] As we have seen, relatively large projects at Hunt and St. Johns either failed totally or succeeded only upon repeated efforts and after large-scale outside help was secured.

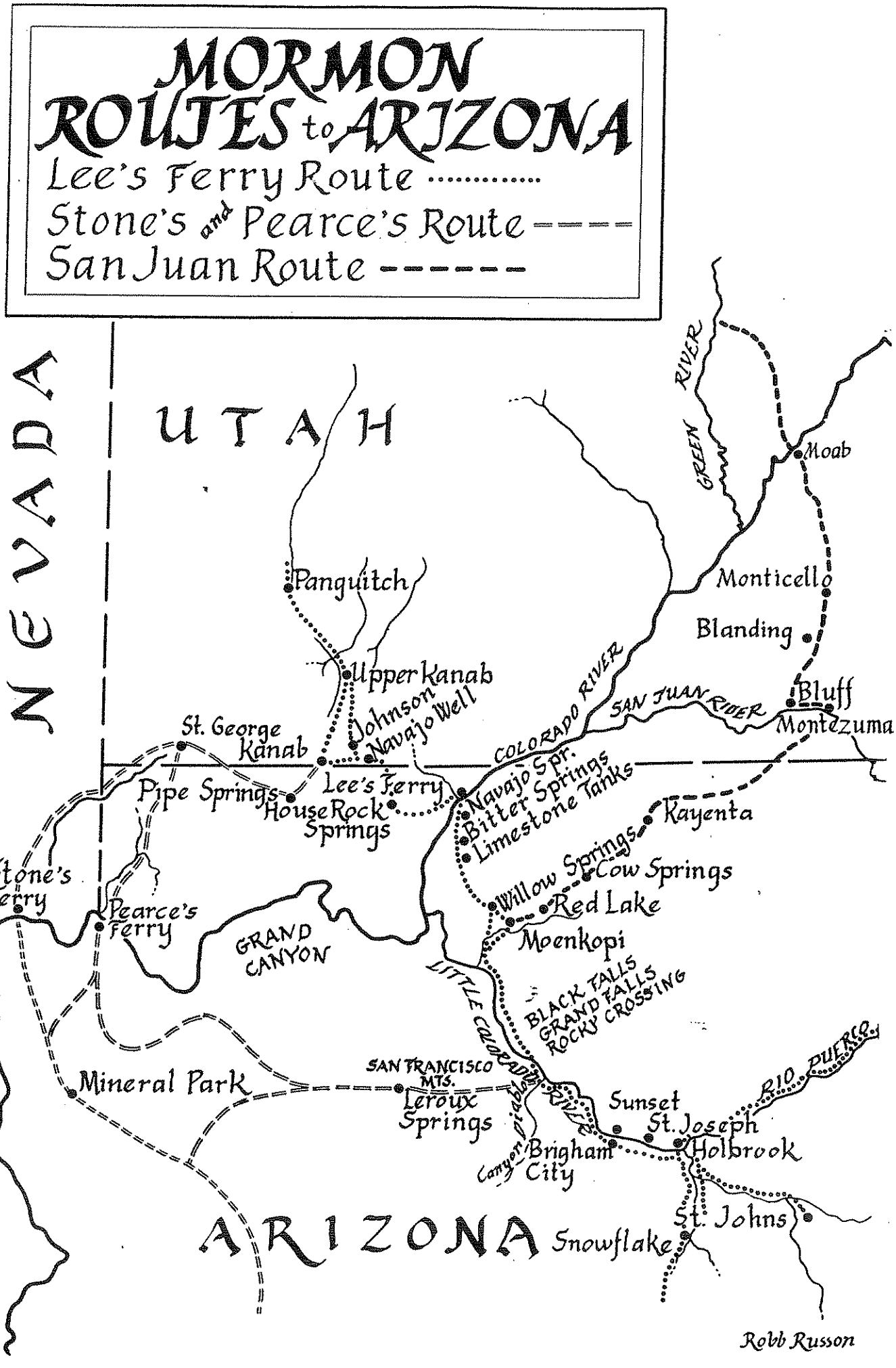
Guided by their ecclesiastical leaders and functioning from the basis of informal water boards, Little Colorado pioneers undertook to subdue their stream. This they were able to do only in the most limited sense and then only by dint of lasting sacrifice and effort. The repeated crisis of water development strengthened both the communal bonds within the church and cooperative relationships with the Gentile community with Mormons appearing as trusted employees and as recipients of territorial aids. Closely related was the fact that crisis produced a highly dependent society. Consequently a major factor in molding the size and character of the Little Colorado community was its inability to exploit fully even the modest drainage of the river's vast watershed.

[24] See letter to the First Presidency, May 13, 1905, Jesse N. Smith Name File Box, HDC.

[25] "Journal of Levi Mathers Savage," p. 37.

[26] "Our Town and People," p. 6.

[27] See "The Life and Labors of John Bushman," p. 86. For a good short treatment of St. Joseph's experience see Tanner, "Henry Martin Tanner," pp. 57-64.


MORMON ROUTES to ARIZONA
Lee's Ferry Route .....
Stone's and Pearce's Route - - - -
San Juan Route - - - - - -
NEVADA
UTAH
ARIZONA
GREEN RIVER
Moab
Monticello
Blanding
Bluff
Montezuma
SAN JUAN RIVER
COLORADO RIVER
Panguitch
Upper Kanab
Johnson
Navajo Well
St. George
Kanab
Pipe Springs
Lee's Ferry
House Rock Springs
Navajo Spr.
Bitter Springs
Limestone Tanks
Kayenta
Willow Springs
Cow Springs
Red Lake
Moenkopi
Stone's Ferry
Pearce's Ferry
GRAND CANYON
LITTLE COLORADO RIVER
BLACK FALLS
GRAND FALLS
ROCKY CROSSING
SAN FRANCISCO MTS.
Mineral Park
Leroux Springs
Canyon Diablo
Sunset
St. Joseph
Holbrook
RIO PUERCO
Brigham City
St. Johns
Snowflake
Robb Russon


The
MORMON SOUTHWEST
Settlements of the Little Colorado
And Adjacent Areas
MILES
0 10 20 30 40 50
NEVADA
UTAH
ARIZONA
CALIFORNIA
Parowan
Panguitch
Escalante
Boulder
Hite
Monticello
Blanding
Bluff
Clover Creek
Meadow Valley
Mountain Meadows
Harmony
Kanarraville
Sevier River
Upper Kanab
Tropic
Paria River
Hole in the Rock
San Juan River
Crossing of the Fathers
Toquerville
Carmel Junction
Santa Clara
St. George
Rockville
Kanab
Johnson
Littlefield
Virgin River
Pipe Springs
Fredonia
House Rock Springs
Lee's Ferry
Navajo Springs
Jacobs Pool
Tanner Wash
Echo Cliffs
St. Joseph
St. Thomas
Rio ville
Pearce's Ferry
Callville
Stone's Ferry
Colorado River
Grand Canyon
Moenave
Tuba City
Moenkopi
Little Colorado River
Cameron
Oraibi
Ft. Defiance
Black Falls
Grand Falls
San Francisco Mts.
Fort Moroni
(Leroux Springs)
Flagstaff
Gallup
Ft. Wing
Leroux Wash
Rio Puerco
Sunset
Sunset Crossing
Brigham City
(Ballingers Camp)
Mormon Lake
St. Joseph (Allen's Camp)
Holbrook (Horsehead Crossin
Lower Little Colorado Settlements
Woodruff
Snowflake
Taylor
Show Low
Hunt
St. Johns
Concho
(Erastus)
Springerville
Eager (Amit
Upper Little
Prescott
Bill Williams Fk.
Atlantic and Pacific RR
Bria River
Verde River

"EL VADO," THE CROSSING OF THE FATHERS
Gateway of the Pioneers Into Arizona

MORMON SETTLEMENT in Arizona

James H. McClintock

Foreword by Charles S. Peterson

The University of Arizona Press
TUCSON

About the Author

JAMES H. MCCLINTOCK (1864–1933), a California native, came to Arizona Territory in 1879 as a cub reporter, working for newspapers in Prescott, Globe, Tempe, and Phoenix, as well as serving as the Arizona correspondent for the *Los Angeles Times*. After military service with Theodore Roosevelt's Rough Riders, during which McClintock was wounded at the Battle of San Juan Hill, he returned to Arizona and devoted himself to public service. McClintock was named State Historian in 1919, partly in recognition of the research that led to his *Arizona: The Youngest State* (1916), and he continued in that office until 1928, when he became the Phoenix postmaster.

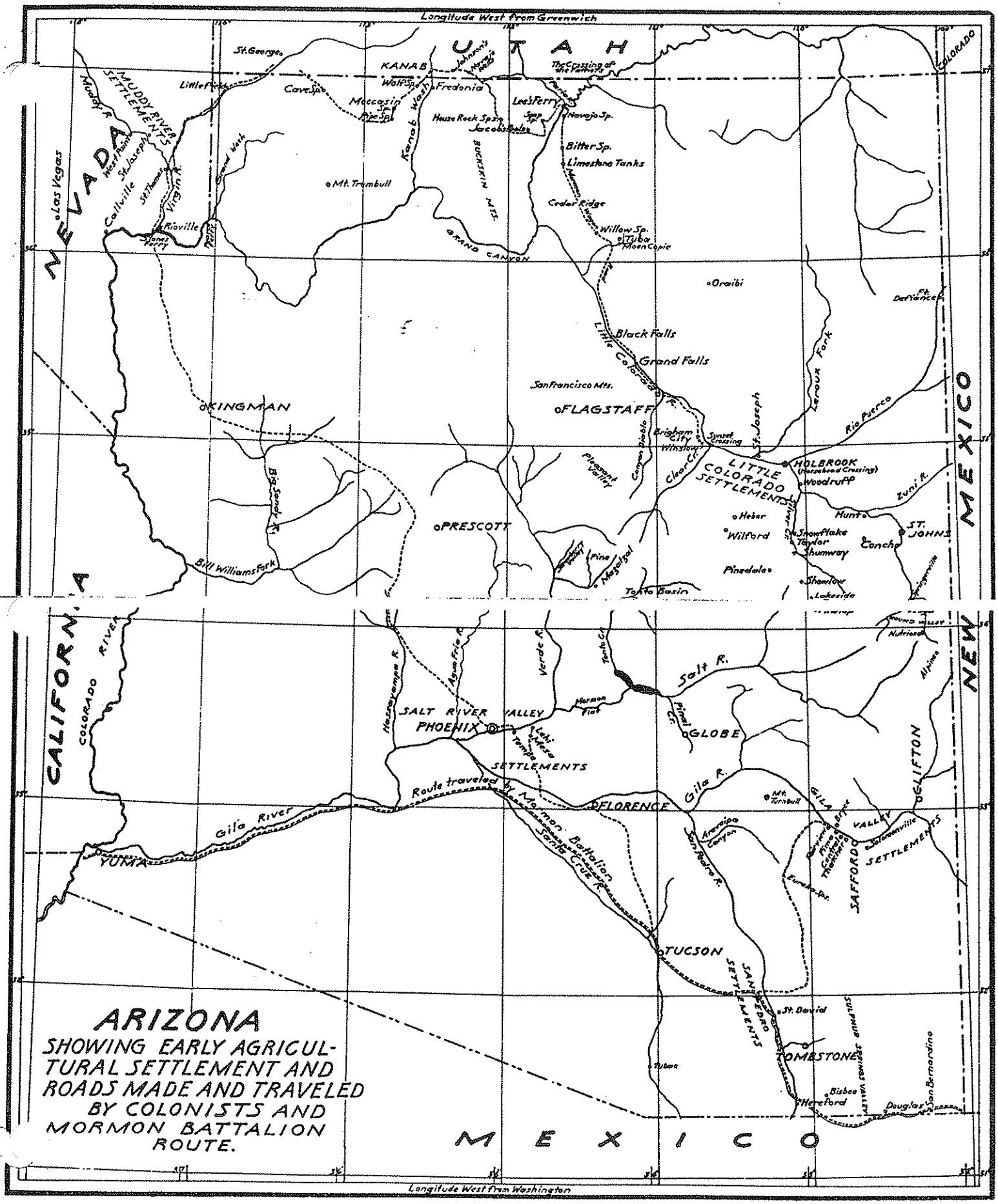
THE UNIVERSITY OF ARIZONA PRESS

Manufactured in the U.S.A.

Library of Congress Cataloging in Publication Data

McClintock, James H., 1864–1934.
Mormon settlement in Arizona.

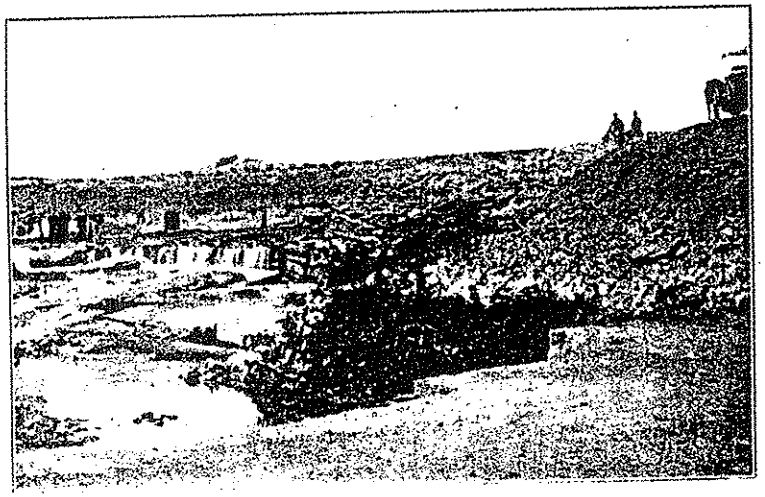
Bibliography: p.
Includes index.
1. Mormons—Arizona—History.
2. Arizona—History—To 1950.
I. Title
F820.M8M35 1985 979.1'00882830 85-8458
ISBN 0-8165-0953-0 (pbk.)



ARIZONA

SHOWING EARLY AGRICULTURAL SETTLEMENT AND ROADS MADE AND TRAVELED BY COLONISTS AND MORMON BATTALION ROUTE.

WOODRUFF DAM, AFTER ONE OF THE FREQUENT WASHOUTS



THE FIRST PERMANENT DAM ON THE LITTLE COLORADO AT ST. JOSEPH

August 23, 1876, a postoffice was established, with John McLaws in charge. A weekly mail service operated between Santa Fe and Prescott.

The first child in the settlement was Hannah Maria Colson, July 17, 1876. The first death was exactly a year later, that of Clara Gray. The first school district was established and the first school was taught during the winter of 1877-78. Of all the lower Little Colorado settlements, this is the only one now existent.

The present St. Joseph lies only a hundred rods from the main line of the Santa Fe railroad system, 25 miles east of Winslow. The first Allen's Camp, in April, 1876, was three miles east of the present site. There was a change to the western location in June, at the suggestion of Daniel H. Wells, who had followed for an inspection of the new settlements. Later there was survey, nearby, of a townsite, the same that now is occupied. Among the few remaining settlers of the Little Colorado settlements, is Joseph Hill Richards, who writes that he was the first justice of the peace for Yavapai County in that region and the first captain there of territorial militia. He also was prominent in the Church organization.

Struggling with a Treacherous River

Every settlement along the Little Colorado River has known repeated troubles in maintaining its water supply. It would be vain recapitulation to tell just how many times each of the poor struggling communities had to rally back on the sands of the river bed to built up anew the structure of gravel and brush that must be depended upon, if bread were to be secured from the land. The Little Colorado is a treacherous stream at best, with a broad channel that wanders at will through the alluvial country that melts like sugar or salt at the touch of water.

There are instances that stand out in this struggle for water. The first joint dam of Allen's Camp and Obed cost the settlers $5000. It is told that 960 day's work was done

at old Holbrook. In January, 1882, this establishment was left high and dry by the moving of Holbrook station a mile and a half west to Berardo's, or Horsehead Crossing. There was difficulty in getting a location at the new site, so this store, in February, 1882, was moved to Woodruff.

In January, 1881, at Snowflake was started a "Co-op" that merged into the Arizona Cooperative Mercantile Institution. The following month, under David K. Udall, a similar institution was opened at St. Johns, where there was attached a flouring mill. Both at St. Johns and Snowflake were cooperative livestock herds.

One of the most extensive enterprises of this sort was started in Mesa in September, 1884, with Chas. I. Robson, George Passey and Oscar M. Stewart at its head. The first stock was valued at $45, yet in 1894, the Zenos Cooperative Mercantile & Manufacturing Institution had a paid-up capital stock of over $25,000 and a two-story building, and had paid dividends ranging from 10 to 50 per cent annually.

Almost every phase of communal effort now appears to have been abandoned in Arizona Mormon business life, probably because found unnecessary in the latter-day development in which the membership of the Church has had so large a share.

The Author feels there should be addition of a statement that the Church is far from acceptance of the European idea of communism, for one of its tenets is, "Thou shalt not be idle, for he that is idle shall not eat of the bread nor wear the garments of the laborer." Nothing of political socialism ever was known in the United Order.

Spreading Into Northern Arizona

Failure of the First Expeditions

The first attempt from the north of the Mormon Church to colonize within the present limits of Arizona failed. It was by means of an expedition placed in charge of Horton D. Haight. A number of the colonists met March 8, 1873, in the old tabernacle in Salt Lake City, and there were instructed by President Brigham Young. At Winsor Castle they were warned to be friendly to but not too trustful of the Indians and not to sell them ammunition, "for they are warring against our government." The route was by way of Lee's Ferry, the crossing completed May 11. On the 22d was reached the Little Colorado, the Rio de Lino (Flax River) of the Spaniards. From the ferry to the river had been broken a new road, over a tolerably good route. There was no green grass, and water was infrequent, even along the Little Colorado, it being found necessary to dig wells in the dry channel. Twenty-four miles below Black Falls there was encampment, the road blocked by sand drifts.

On June 1 there returned to the expedition in camp an exploring party, under Haight, that had been absent eight days and that had traveled 136 miles up the river. There was report of the trip that the country was barren, with narrow river bottoms, with alkaline soil, water bad and failing, with no spot found suitable in which to settle. There also appeared to be fear of the Apache. So the expedition painfully retraced its steps to Navajo Springs, sending ahead a dispatch to President Young, giving a full

1873

report of conditions and making suggestion that the settlement plan had better be abandoned. At Moen Copie on the return was met a party of 29 missionaries, under Henry Day.

An interesting journal of the trip was written by Henry Holmes of the vanguard. He was especially impressed with the aridity of the country. He thought it "barren and forbidding, although doubtless the Lord had a purpose in view when He made it so. Few of the creeks ran half a mile from their heads. The country is rent with deep chasms, made still deeper by vast torrents that pour down them during times of heavy rains." There were found petrified trees. One of them was 210 feet long and another was over five feet across the butt, this in a land where not a tree or bush was found growing. Holmes fervently observed, "However, I do not know whether it makes any difference whether the country is barren or fruitful, if the Lord has a work to do in it," in this especially referring to the Indians, among whom there could be missionary effort. Jacob Miller acted as secretary of the expedition.

On the back track, the company all had ferried to the north bank of the river by July 7, although there had to be improvised navigation of the Colorado, for the ferry-boat had disappeared in the spring flood and all that remained was a little skiff, behind which the wagon bodies were floated over. In all, were ferried 54 wagons, 112 animals, 109 men, 6 women and a child.

This first company had been called from different parts of Utah and was not at all homogeneous, yet traveled in peace and union. The members assembled morning and evening for prayers, at which the blessings of the Lord were asked upon themselves and their teams and upon the elements that surrounded them.

President Young directed the members of the 1873 party to remain in Arizona, but the message was not received till the river had been passed. The following year he ordered

another expedition southward. According to a journal of Wm H. Solomon, who was clerk of the party, departure from Kanab was on February 6, 1874. John L. Blythe (who had remained at Moen Copie after the 1873 trip) was in charge. With Blythe was his wife. Ira Hatch took his family. Fifteen other individuals were included. Progress southward was stopped at Moen Copie by reports of a Navajo uprising. Most of the party returned to Utah after a few weeks, leaving behind Hamblin, Hatch and Tenney.

Missionary Scouts in Northeastern Arizona

When the unsuccessful expedition turned back to Utah in the summer of 1873, there remained John L. Blythe of Salt Lake and a number of other missionaries. They located among the Indians on the Moen Copie, where they sowed the ground and planted trees and grapevines, also planting at Moabi, about seven miles to the southwest. Blythe remained at Moen Copie, alone with his family, until 1874, including the time of the Indian trouble more particularly referred to in this volume in connection with the work of Jacob Hamblin.

The failure of the Haight expedition in no wise daunted the Church authorities in their determination to extend southward. In general, reports that came concerning the Little Colorado Valley were favorable. Finally, starting from Salt Lake October 30, 1875, was sent a scouting expedition, headed by Jas. S. Brown, who had a dozen companions when he crossed into Arizona. This party made headquarters at Moen Copie, where a stone house was built for winter quarters. Brown and two others then traveled up the Little Colorado for a considerable distance, not well defined in his narrative, finding a fine, open country, with water plentiful and with grass abundant, with good farming land and timber available. The trio followed the Beale trail westward to a point southwest of the San Francisco Mountains, where there was crossing back to the Little

Colorado. Christmas Day, before Moen Copie was reached, the scouts were placed in serious danger by a terrific snowstorm. Brown returned to Salt Lake with his report, January 14, 1876, after traveling 1300 miles, mainly on horseback.

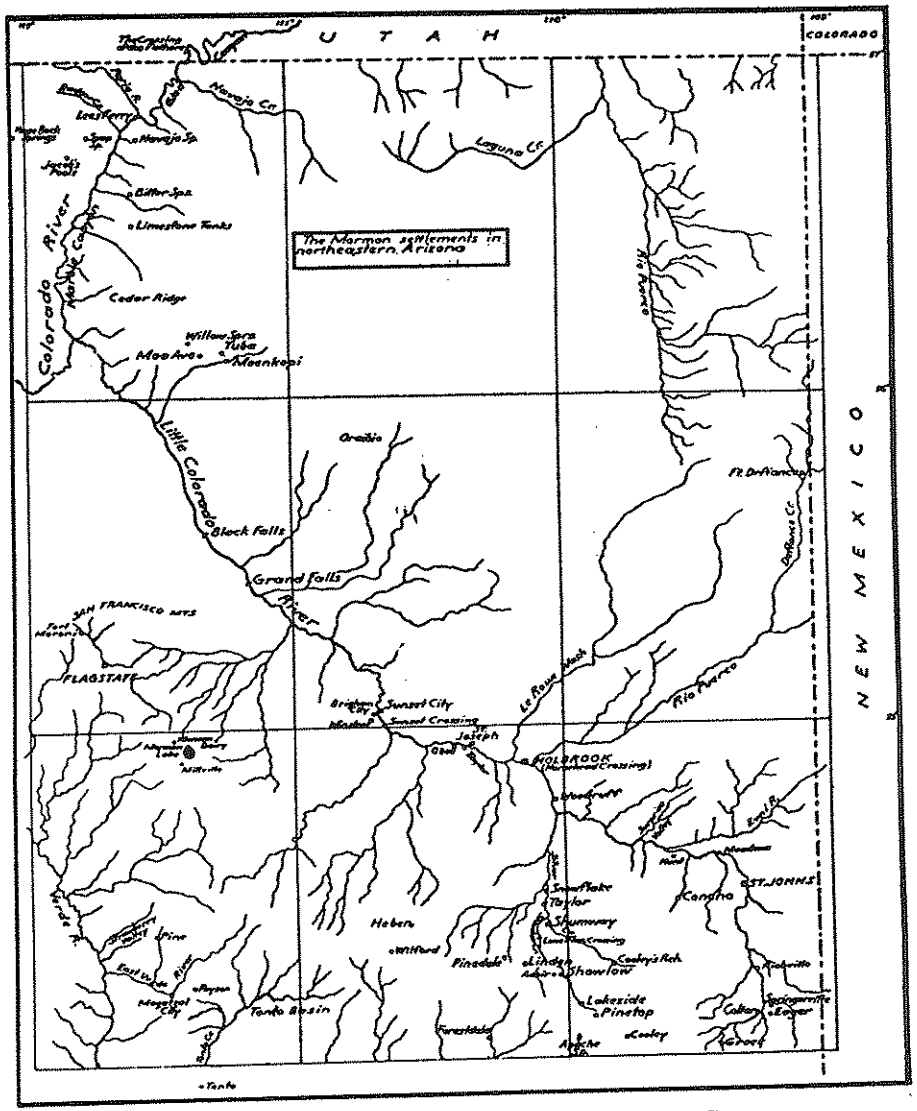
Here might be stated that Brown was none other than a Mormon Battalion member who had participated in the discovery of gold at Sutter's Fort in California. At some time prior to coming to Arizona he had lost a leg, shot off by hunters who had mistaken him for a bear. He should not be confounded with Capt. James Brown of the Battalion.

Foundation of Four Settlements

The first Presidency apparently had anticipated Brown's favorable report, for quick action was had immediately thereafter. Four companies, each of fifty men and their families, were organized, under Lot Smith, Jesse O. Ballenger, George Lake and Wm. C. Allen. The 200 missionaries were "called" from many parts of Utah, but mainly from the north and around Salt Lake. There was no formal gathering of the companies. Each member went southward as he could, to report to his leader on the Little Colorado. The assembling point was Kanab. Thence there was assemblage of groups of about ten families each, without reference to companies. An entertaining detail of this journey lately was given the Historian in Phoenix by David E. Adams, captain of one of the Tens.

The leading teams reached Sunset Crossing on the Little Colorado March 23, 1876, the migration continuing for many weeks thereafter. Allen, Smith and Lake continued up the river twenty miles, to a point about five miles east of the present site of St. Joseph.

From exact data furnished by R. E. Porter of St. Joseph is learned that Allen's company settled at the point where this march ended, establishing Allen's Camp. There was later change to a point one mile east of the present



NORTHEASTERN ARIZONA—The Little Colorado Country

location, a site maintained till 1877. The name was changed January 21, 1878, to St. Joseph, after Prophet Joseph Smith.

Lot Smith's company retraced, to establish Sunset, three miles north of Sunset Crossing, on the north side of the river.

Lake's company established itself across the river, three miles south and west of the present site of St. Joseph. The settlement was named Obed.

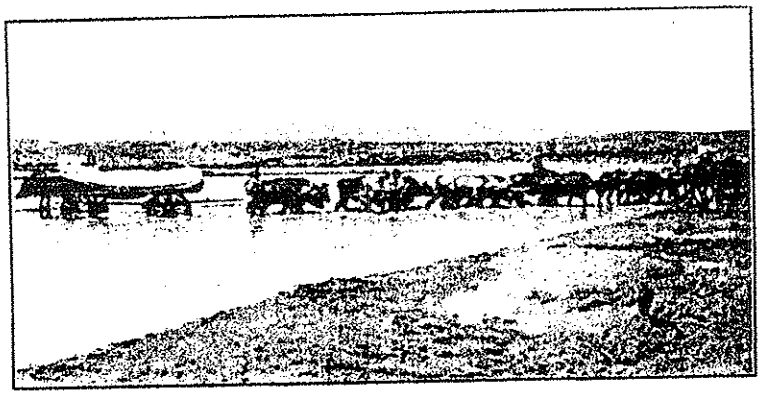
Ballenger's company located four miles southwest of Sunset Crossing, on the south side of the river, near the site of the present Winslow.

Genesis of St. Joseph

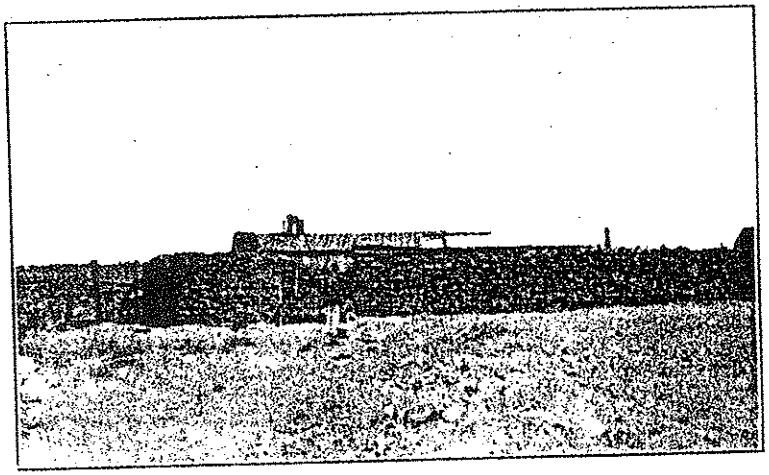
There was quick work in the way of settlement at Allen's Camp, where the first plowing was on March 25, 1876, by John Bushman and Nathan Cheney. Jacob Morris immediately commenced the construction of a house. Two days later an irrigation ditch was surveyed and on the following day John Bushman got out the first logs for a diversion dam. April 3, Bushman sowed the first wheat. A temporary structure was built for protection and for storage. May 26 the name of Allen City was given the settlement, in preference to a second suggestion, Ramah City. Early in August, 23 men, including Allen, started back to Utah, from which a few returned with their families.

On Allen's return southward with a number of families, the old Spanish Trail was used, in its eastern section, via the San Juan region, with some idea that it might be made the main thoroughfare, for thus would be obviated the ferrying of the Colorado River, either above or below the Canyon. But the way into Arizona through northwestern New Mexico was too long, and the experiment was not considered successful.

In the fall, the families moved into a stockade fort, planned to be 152 feet wide and 300 feet long. Only part of this was finished. Probably twenty or more houses were built within it.

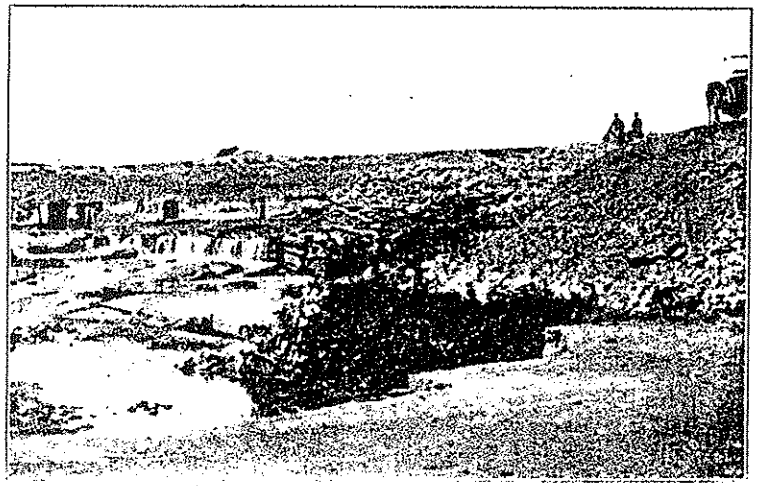


CROSSING THE LITTLE COLORADO



THE OLD FORT AT BRIGHAM CITY

WOODRUFF DAM, AFTER ONE OF THE FREQUENT WASHOUTS



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There are instances that stand out in this struggle for water. The first joint dam of Allen's Camp and Obed cost the settlers $5000. It is told that 960 day's work was done

on the dam and 500 days more work on the Allen ditch. This dam went down at the first flood, for it raised the water about twelve feet. Then, in the spring of 1877, another dam was built, a mile and a half upstream, and this again washed away. In 1879 the St. Joseph settlers sought the third damsite at LeRoux Wash, about two and a half miles west of the present Holbrook. In 1881 they spent much money and effort on a plan to make a high dam at the site of the first construction, but this again was taken downstream by the river. In 1882, a pile dam was built across the river, and it again was spoiled by the floods. This dam generally was in use until 1891, but had to be repaired almost every year. In the year named, work was started upon what was hoped to be a permanent dam, at an estimated cost of $60,000. In 1894, Andrew Jenson wrote that at least $50,000 had been lost by the community upon its dams. Noting the fact that only fifteen families constituted the population, he called St. Joseph "the leading community in pain, determination and unflinching courage in dealing with the elements around them."

St. Joseph, as early as 1894, had completed its eighth dam across the river. Jos. W. Smith wrote of the dedication of the dam, in March of that year. He remarked especially upon the showing of rosy-cheeked, well-clad children, of whom the greater part of the assemblage was composed, "showing that the people were by no means destitute, even if they had been laboring on ditches and dams so much for the last eighteen years."

The main prayer of the exercise was brief, but characteristic: "O Lord, we pray that this dam may stand, if it be Thy will—if not, let Thy will be done." The invocation was effective. The dam stood, as is illustrated within this book.

Decline and Fall of Sunset

Sunset, the lowest of the settlements, was near the present railroad crossing of the river, below the river

junction with Clear Creek. There had been a temporary location two miles upstream. The main structure was a stockade, twelve rods square, mainly of drift cottonwood logs. Within were rock-built houses, a community dining hall and a well. Combination was made with Ballenger, across the stream, in the building of a dam, two and a half miles above the settlement.

Apparently the sandy land and the difficulty of irrigating it drove the settlers away, until, finally, in 1885, Lot Smith's family was the only one left upon the ground, and it departed in 1888.

Years later, Andrew Jenson found the rock walls and chimneys still standing. "Everything is desert," he wrote, "the whole landscape looks dreary and forbidding and the lonely graveyard on the hillside only reminds one of the population which once was and that is no more." Only ruin marks the place where once was headquarters of the Little Colorado Stake of Zion. The settlement was badly placed, for floods came within a rod of the fort and covered the wheat fields.

Lot Smith wrote in poetic vein, "This is a strange country, belonging to a people whose lands the rivers have spoiled." Very practically, however, he wrote of good lands and slack water supply, "though the river shows it would be a mighty rushing torrent when the rains commence in summer, with the appearance of being 25 miles broad, and the Indians told us that if we are indeed to live where we are encamped, we had better fix some scaffolding in the trees."

In August, 1878, a correspondent of the Deseret News wrote from Sunset that for a week the rain had been pouring down almost incessantly, that the whole bottom was covered with water, that some of the farms were submerged and grain in shocks was flooded, that the grain of Woodruff was entirely destroyed, the grist mill of Brigham City

inundated and the grain stacks there were deep in water, with the inhabitants using boats and rafts to get around their farms.

Village Communal Organization

The settlements all established themselves under the United Order. Early in 1876 one of the settlers wrote from Allen's Camp, "It is all United Order here and no beating around the bush, for it is the intention to go into it to the full meaning of the term." This chronicler, John L. Blythe, April 11, 1876, again wrote, "The companies are going into the United Order to the whole extent, giving in everything they possess, their labor, time and talent." In August there was a report from the same locality that "the people are living in a united system, each laboring for the good of all the community and an excellent feeling prevails."

The communal system was given formal adoption at Allen's Camp April 28, 1877, when articles were agreed upon for a branch of the United Order. June 5, 1877, with Wm. C. Allen presiding, there was an appraisal of property and a separation of duties. Henry M. Tanner (who still is in St. Joseph), was secretary, John Bushman foreman of the farm, James Walker water master and Moses D. Steele superintendent of livestock. Niels Nielsen was in charge of ox teams and Jos. H. Rogers in charge of horse teams, harness and wagons. The Church historian has given in detail the manner in which the system worked:

> From the beginning the Saints at Allen's Camp disciplined themselves strictly according to Church rules. Every morning the Saints, at the sound of the triangle, assembled in the schoolhouse for prayer, on which occasion they would not only pray and sing, but sometimes brethren would make brief remarks. The same was resorted to in the evening. They did not all eat at the same table (a common custom followed in the other camps), but nevertheless great union, peace and love prevailed among the people, and none seemed to take advantage of his neighbor. Peace, harmony and brotherly love characterized all the settlers at Allen's Camp from the very beginning.

In August, 1878, Samuel G. Ladd wrote from the new

St. Joseph, that the United Order worked harmoniously and prosperously. In that year manufacturing of brooms was commenced by John Bushman. Up to 1882 each family was drawing from one common storehouse. In 1883 the Order was dissolved at St. Joseph and the stewardship plan adopted. Each family received its part of the divided land and a settlement of what each man originally had put into the Order. Proforma organization of the Order was continued until January, 1887.

Hospitality Was of Generous Sort

From Sunset Crossing Camp, G. C. Wood wrote, in April, 1876, "The brethren built a long shanty, with a long table in it and all ate their meals together, worked together and got along finely." In February, 1878, President Lot Smith wrote the Deseret News in a strain that indicated doubt concerning the efficiency of the United Order system. His letter told:

> This mission has had a strange history so far, most who came having got weak in the back or knees and gone home. Some, I believe, have felt somewhat exercised about the way we are getting along, and the mode in which we are conducting our culinary affairs. Now, I have always had a preference for eating with my family and have striven to show that I was willing to enlarge as often as circumstances require, and the same feeling seemed to prevail in these settlements. We have enlarged ourselves to the amount of forty in one day. We have noticed that most people who pass the road are willing to stop and board with us a week or two, notwithstanding our poor provisions and the queer style it was served up.

In July of the same year, Lorenzo Hatch wrote from Woodruff, "At Sunset, Brigham City and Woodruff, the settlements eat at one table, hence we have no poor nor rich among us. The Obed camp also had gone into the United Order in the fullest sense in May, 1876."

Brigham City's Varied Industries

Ballenger, in September, 1878, was renamed Brigham City, in honor of President Brigham Young. Its people were found by Erastus Snow in September, 1878, with a

remarkable organization, operating in part under the United Order system. There was a fort 200 feet square, with rocky walls seven feet high. Inside were 36 dwelling houses, each 15x13 feet. On the north side was the dining hall, 80x20 feet, with two rows of tables, to seat more than 150 persons. Adjoining was a kitchen, 25x20 feet, with an annexed bakehouse. Twelve other dwelling houses were mentioned, as well as a cellar and storehouse. Water was secured within the enclosure from two good wells. South of the fort were corrals and stockyards. The main industry was the farming of 274 acres, more than one-half of it in wheat. A pottery was in charge of Brother Behrman, reported to have been confident that he could surpass any of the potteries in Utah for good ware. Milk was secured from 142 cows. One family was assigned to the sawmill in the mountains. J. A. Woods taught the first school. Jesse O. Ballenger, the first leader, was succeeded in 1878 by George Lake, who reported that, "while the people were living together in the United Order they generally ate together at the same table. The Saints, as a rule, were very earnest in their endeavors to carry out the principles of the Order, but some became dissatisfied and moved away." Discouragement became general, and in 1881 all were released from the mission. The settlement practically was broken up, the people scattering, though without dissension.

Some went to Forest Dale, and later to the Gila River, and some left Arizona altogether. There was a surplus from the experiment of about $8000, which went to the Church, after the people had drawn out their original capital, each taking the same number of animals and the same amount of property contributed originally. In 1882 only a couple of families were left and an added surplus of $2200 was used by the Church in settling the Gila country. In 1890 only the family of Sidney Wilson remained on the old site of Brigham City. The Brigham City water-power grist mill

built in 1878, a present from the Church, was given to the people of Woodruff, but was not used.

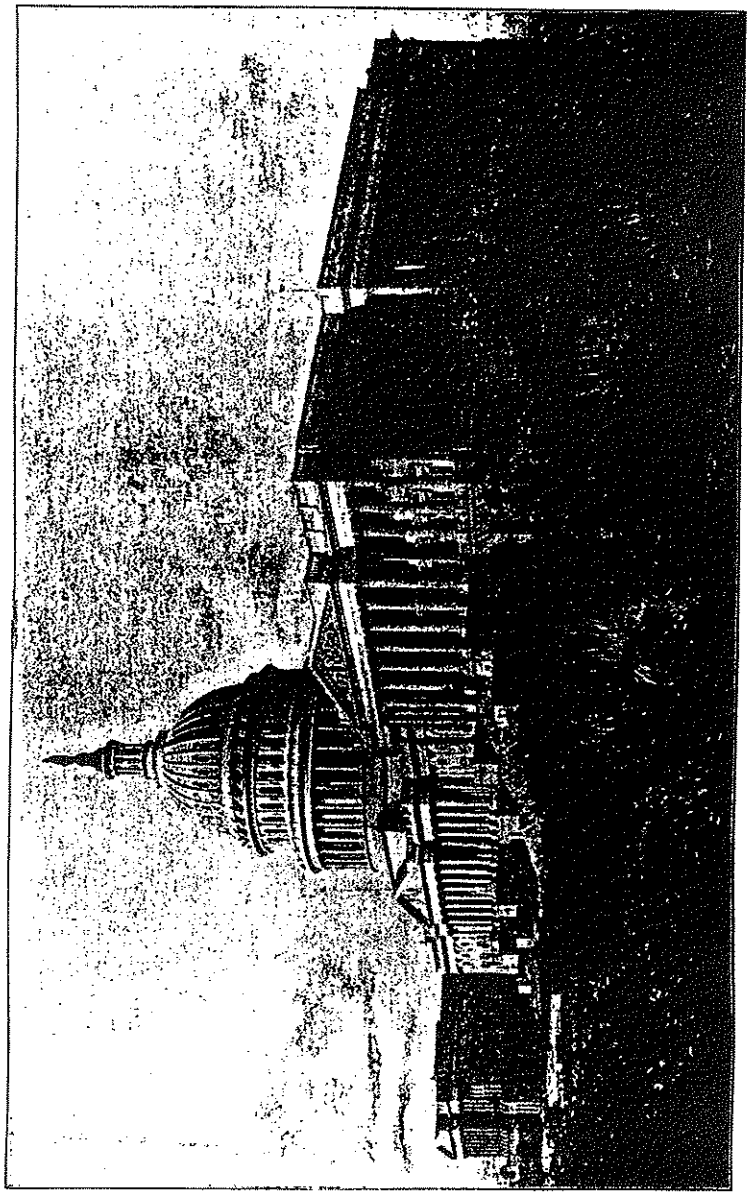
The abandonment of Brigham City should not be blamed to the weakness of a communistic system. There had been frequent failures of crops and there had come a determination to find a locality where nature would smile more often upon the barley, so scouts were sent to the San Juan country in Utah, the Salt River country and to the Gila. George Lake, Andrew Anderson and George W. Skinner constituted the Gila party. Near Smithville they bought land, a transaction elsewhere referred to. Anderson and Skinner, in December, 1880, returned to Brigham City. At that point a business meeting was called at once and the authorities of the United Order approved the purchases made.

January 1, 1878, was announced a census of the settlement of the Little Colorado country. Sunset had 136 inhabitants, Ballenger 277, Allen's Camp 76. Woodruff 50 and Moen Copie 25, a total of 564, with 115 families.

Brief Lives of Obed and Taylor

The settlement of Obed, three miles southwest of St. Joseph, directly south of old Allen's Camp and across the river, bears date from June, 1876, having been moved a short distance from the first camp ground. At that time was built a fort of remarkable strength, twelve rods square. In places, the walls were ten feet high. There were bastions, with portholes for defense, at two of the corners, and portholes were in the walls all around. The camp at the start had 123 souls. Cottonwood logs were sawed for lumber. The community had a schoolhouse in January, 1877, and a denominational school was started the next month, with Phoebe McNeil as teacher. The settlement was not a happy one. The site was malarial, selected against Church instructions, and there were the usual troubles in the washing away of brush and log dams. The population drifted away, until there was abandonment in 1878.

Taylor was a small settlement on the Little Colorado, about three miles below the present St. Joseph, and should not be confounded with the present settlement of the same name near Snowflake. This first Taylor was established January 22, 1878, by eight families, mainly from Panguitch and Beaver, Utah. In the United Order they built a dining hall, a quarter-mile back from the river and organized as a ward, with John Kartchner at its head. But there was discouragement, not unnaturally, when the river dam went out for the fifth time. Then, in July, 1878, members of the settlement departed, going to the present site of Snowflake on Silver Creek. They included a number of Arkansas immigrants. There had been little improvement outside of the stockade and dining hall, and for most of the time the people lived in their wagons.



THE CAPITOL, WASHINGTON

STANFORD'S

COMPENDIUM OF GEOGRAPHY AND TRAVEL

(NEW ISSUE)

NORTH AMERICA

VOL. II

THE UNITED STATES

BY

HENRY GANNETT

CHIEF GEOGRAPHER OF THE UNITED STATES GEOLOGICAL SURVEY

MAPS AND ILLUSTRATIONS

LONDON: EDWARD STANFORD

26 & 27 COCKSPUR STREET, CHARING CROSS, S.W.

1898

CHAPTER X

The Government

CHAPTER XI

Agriculture

CHAPTER XII

Manufactures

CHAPTER XIII

Transportation and Commerce

CHAPTER XIV

Alaska

The Foreign Carrying Trade

In the foreign carrying trade the Americans reached their most prosperous condition about 1820. In that year this nation surpassed all others in the amount of tonnage engaged in foreign commerce. From that time down to the beginning of the Civil War, while the tonnage of the United States did not diminish, but increased, the importance of that country relative to other countries in the foreign carrying trade diminished. Great Britain soon took the lead, and in the extent of its tonnage surpassed the United States and became, as it has been since, the queen of the high seas.

The Civil War brought danger to all vessels flying the American flag. To avoid that danger, or the necessity for paying high insurance rates ("war premiums"), in one way and another, most of the shipping of the United States was, during the war, transferred to foreign flags, mainly to that of Great Britain, and there it has perforce remained, since, under United States laws, made for the protection of the shipbuilding interest, ships cannot be imported.

Thus since 1820 the foreign carrying trade of the United States has diminished relatively to other nations, and since the beginning of the war it has absolutely diminished in tonnage, while all other industries, agriculture, manufactures, mining, and all internal transportation have grown with a rapidity that almost surpasses belief. The reasons assigned for this decadence have been many and various, and various cures have been suggested. The true reason, however, appears to be simply that Americans have found better-paying investments in their country than upon the high seas. They cannot build ships as cheaply as can be done in England,

and they cannot sail them as cheaply, while they must be content with the same freight receipts as the English. Consequently their percentage of return for the investment must be less than that of the English, whereas, by investing within the United States, they can almost certainly obtain a percentage of receipts upon their investment of several times the magnitude. This in a nutshell seems to express the situation. It is different with coastwise or inland transportation. There the American is not obliged to meet the foreigner in competition. His government gives him a monopoly of the carrying trade, and it has accordingly prospered.

In 1890 the total tonnage of vessels in foreign trade entering and clearing at American ports was about 18,000,000 tons each way. Of this only about 4,000,000 tons were under the United States flag; in other words, only two-sevenths of the imports to and exports from the United States were transported under the flag of that country; indeed, British vessels alone carried much more of the exports and imports of the United States than did United States vessels.

Navigable Streams

In treating of the navigability of streams one is dealing with an uncertain and variable quantity. It is necessary, at the outset, to define what is meant by navigability. Some class or classes of vessels must be selected as the test, whether a boat of 10 feet or of 2 feet draft for instance. Again, what stage of water in the river shall be selected, high water, low water, or a medium stage. In order to arrive at some definite result, it will be assumed, in the following sketch of the navigable streams of the United States, that the high water

	Navigable to	Miles.
Tombigbee	...	250
Pearl, Miss.	...	225
Sabine, Tex.	...	40
Neches	...	30
Trinity	...	25
Rio Grande	Presidio	700

The Mississippi system is far more extensive than all others taken together. The navigability of the main stream is interrupted only by the Rock Island rapids, in Illinois; that of the Ohio by the falls at Louisville, Kentucky; and the Tennessee at Muscle Shoals. The two first are passed by canals, while the last has been improved by dams and locks. With these exceptions the navigability of the main river and its principal branches is unbroken.

The following table schedules the navigable rivers of this system :—

	Navigable to	Miles.
Main Mississippi	Cairo, Ills.	650
Upper Mississippi	Minneapolis, Minn.	700
Bayou La Fourche, La.	...	100
Bayou Atchafalaya, La.	...	150
Red River and branches, La.	Gainesville, Tex.	600
Ouachita and branches, La. and Ark.	...	450
Yazoo, Miss.	...	300
Arkansas and branches, Ark.	Wichita, Kan.	600
St. Francis and branches, Ark.	...	300
White River and branches, Ark.	...	400
Ohio River	Pittsburg, Pa.	800
Allegheny, Pa.	...	125
Monongahela, Pa.	...	100
Tennessee, Ky. and Tenn.	...	550
Cumberland, Ky.	...	350
Green, Ky.	...	100
Kentucky, Ky.	...	125
Licking, Ky.	...	125
Big Sandy, Ky.	...	125
Guyandot, W. Va.	...	75
Kanawha, W. Va.	...	150
Wabash, Ind.	...	150

	Navigable to	Miles.
Muskingum, Ohio	...	75
Illinois	...	200
Missouri	Fort Benton	1500
Gasconade	...	50
Osage	...	100
Yellowstone	...	250

The Great Lakes furnish, by the aid of the Welland Canal at Niagara, and the "Soo" canal at the Sault Ste. Marie, an unbroken stretch of navigation from the foot of Lake Ontario to Duluth, at the head of Lake Superior, a distance, roughly measured, of 1050 miles. In addition to this is the stretch afforded by Lake Michigan, which from Mackinac to Chicago is 400 miles.

On the Pacific side there are few navigable rivers. The Colorado bears steamers only 400 miles from its mouth; the Sacramento of California is navigable for 150, and its branch, the San Joaquin, for 100 miles. The Columbia is navigable for 500 miles, and its main branch, the Snake, for 100 miles only, while the Willamette is navigable for 125 miles. Altogether the navigable length of the rivers of the country, roughly measured in direct lines, not by following the details of their often crooked courses, is no less than 14,100 miles. Following their sinuous courses, doubtless the total length exceeds 20,000 miles. Of the straight line extent of navigable waters the Mississippi has by far the lion's share, as with its branches it has a navigable extent of 9200 miles, which, when all its curves and windings are followed, swells to nearly 15,000 miles.

Canals

In the early part of the present century, before the advent of the railway, many of the states of the American Union were seized with a fever for public improvements, and several of them carried out extensive works. Prominent among them was the building of canals. Among these states were prominent New York, New Jersey, Pennsylvania, Maryland, Virginia, Ohio, and Indiana. Partly at public and partly at private expense a large number of canals were built at this time. Most of them have, however, since been abandoned, having succumbed to the competition of the railway. In 1890 the total mileage of canals in operation was but 2700, and the tonnage which they conveyed during that year was about 21,000,000 tons. The principal of these canals now in operation is the Erie Canal, extending from Buffalo, in Western New York, to Albany, on the Hudson River. A project is now (1896) on foot for deepening and widening this canal to enable large lake vessels to traverse it.

Railroads

The railroad made its advent before the world about 1830, sixty-five years ago, and as an agency of transportation it has grown up with this country. In these sixty-five years a railroad system has been constructed in this country aggregating 178,708 miles, representing an expenditure of more than $11,000,000,000 of capital. Nearly one-sixth of the entire wealth of the country is invested in railroads. In mileage of her railroads the United States leads the whole of Europe, and indeed all the rest of the world. There is probably no nation which, in comparison with her area, population, and wealth, has as complete and well arranged a system of railway transportation as this. The rapidity of its growth is but one of its startling features. Since the beginning there has been no year in which some railroads have not been built, and

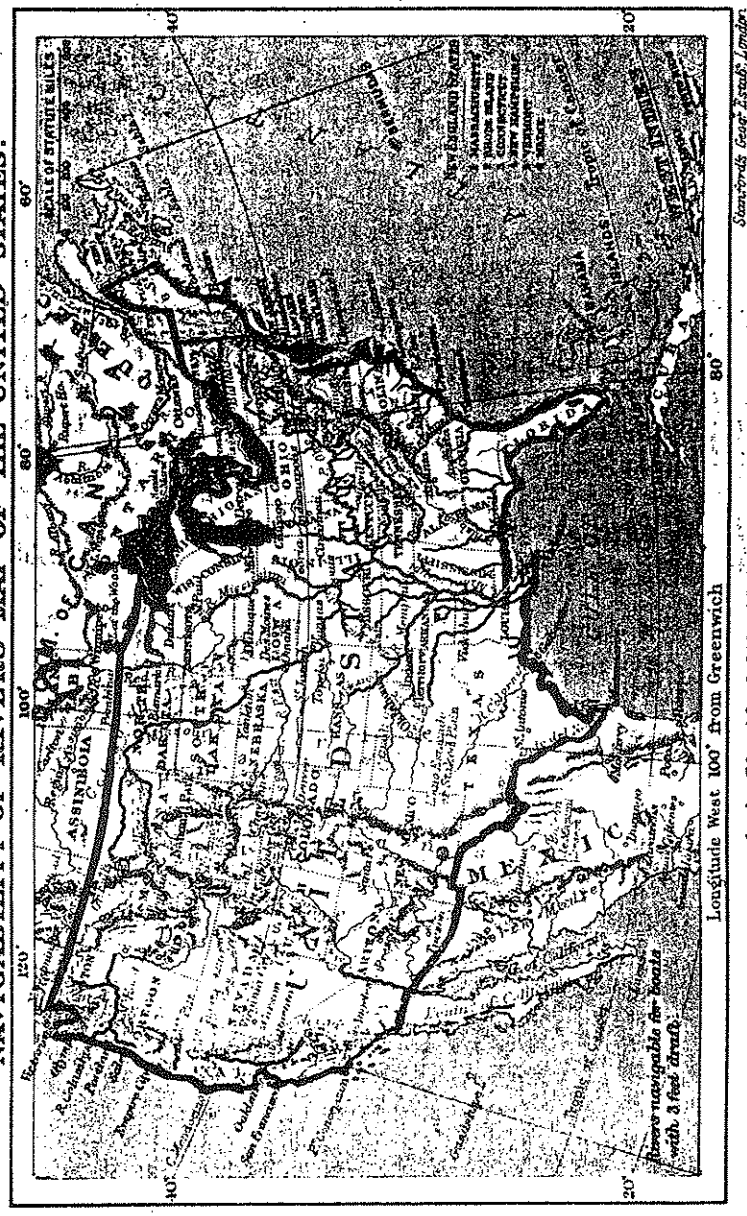
stage is referred to, and that streams having three feet in depth will be regarded as navigable. Under these premises the following are the resources of the country in internal navigation.

On the Atlantic coast the navigable portions of the rivers are short, but in general they increase in length southward. The following table lists the principal of them, with a rough estimate of their navigable lengths, measured as straight lines:—

	Navigable to	Miles.
Penobscot, Me.	Bangor	30
Kennebec, Me.	Augusta	50
Connecticut, Conn.	Hartford	40
Hudson, N.Y.	Albany	150
Delaware, N.J. and Pa.	Trenton	75
Potomac, Md.	Georgetown, D.C.	100
Rappahannock, Va.	Fredericksburg	90
York, Va.	...	50
James, Va.	Richmond	75
Roanoke, N.C.	Weldon	75
Pamlico, N.C.	...	50
Neuse, N.C.	Goldsboro	100
Cape Fear, N.C.	Fayette	100
Waccamaw, S.C.	...	75
Great Pedee, S.C.	...	100
Santee and branches	Columbia	150
Savannah, Ga.	Augusta	125
Altamaha and branches, Ga.	Milledgeville and Macon	300
St. John's, Fla.	Sanford	125
		1860

Navigable rivers flowing to the Gulf of Mexico are few in number, and, with the exception of the Mississippi, are not long. The larger ones are as follows:—

	Navigable to	Miles.
Apalachicola, Fla. and Ga.	...	75
Flint, Fla. and Ga.	...	125
Chattahoochee, Fla. and Ga.	...	125
Mobile, Ala.	...	25
Alabama	Montgomery	150



NAVIGABILITY OF RIVERS MAP OF THE UNITED STATES.

Stanford's Geog.l Estab.t, London

London: Edward Stanford, 26 & 27, Cockspur St, Charing Cross, S.W.

Regional Hydrogeology of the Navajo and Hopi Indian Reservations, Arizona New Mexico, and Utah

By M. E. COOLEY, J. W. HARSHBARGER, J. P. AKERS, *and* W. F. HARDT

With a section on Vegetation
By O. N. HICKS

HYDROGEOLOGY OF THE NAVAJO AND HOPI INDIAN RESERVATIONS ARIZONA, NEW MEXICO, AND UTAH

GEOLOGICAL SURVEY PROFESSIONAL PAPER 521-A

Prepared in cooperation with the Bureau of Indian Affairs and the Navajo Tribe

UNITED STATES GOVERNMENT PRINTING OFFICE, WASHINGTON : 1969

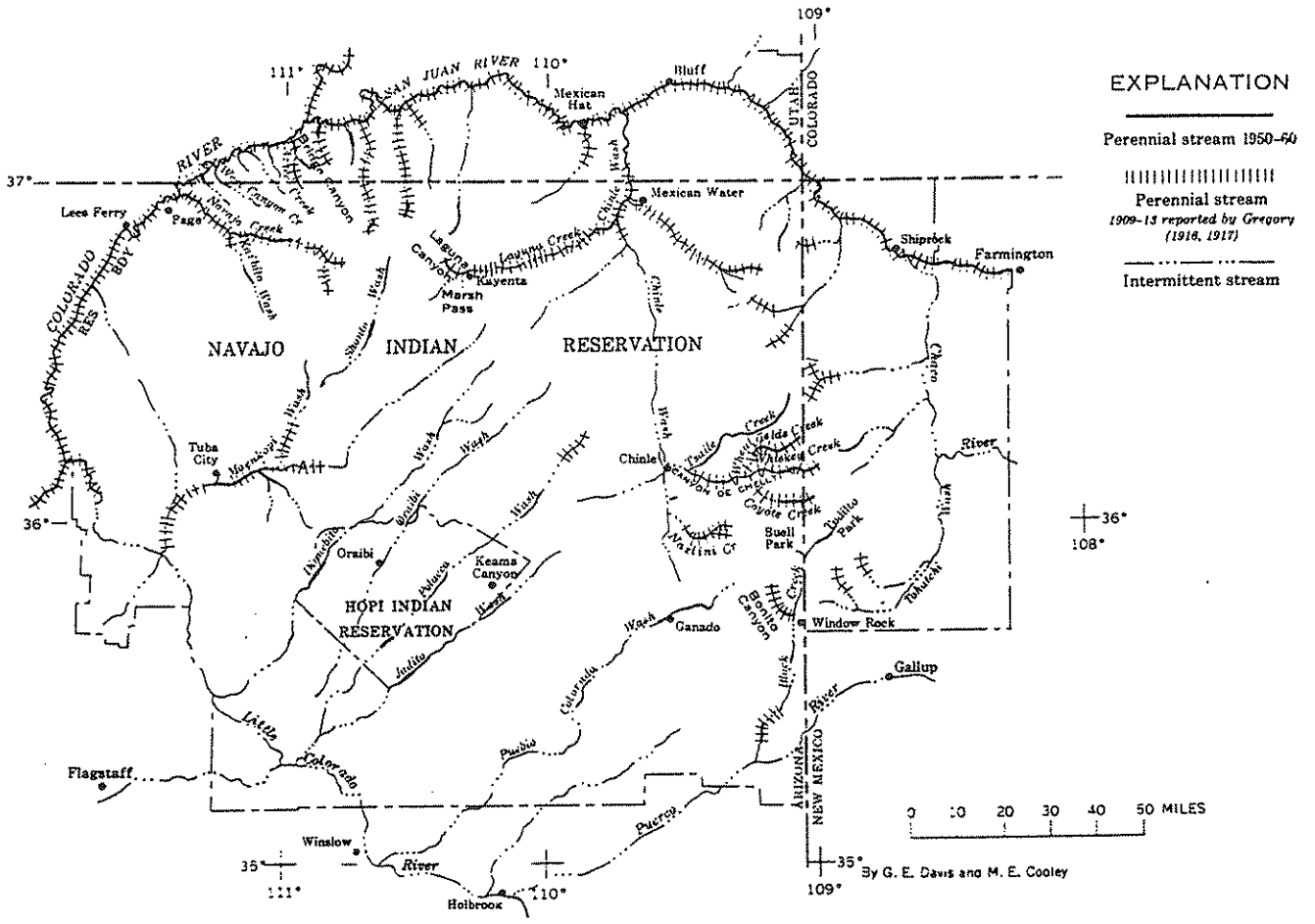


FIGURE 16.—Map showing perennial streams during 1909–13 and 1950–60.

ative of what occurred on the reservations, yearly runoff from 1930–55 was above the 1897–1955 median of the reconstructed virgin runoff only 8 years, whereas it was below the median 18 years (Alfonso Wilson, U.S. Geol. Survey, written commun., 1960).

GROUND-WATER HYDROLOGY

The ground-water hydrology of the Navajo country is controlled by five large hydrologic basins—Black Mesa, San Juan, Blanding, Henry, and Kaiparowits basins (pl. 5). Locally, ground water is exchanged between some of the basins. Part of the water in southwestern San Juan basin moves across a low structural divide into Black Mesa basin, and, similarly, some water from Black Mesa basin overflows into Blanding basin. The area of each basin, in square miles, within the boundaries of the reservations are: Black Mesa, 12,200; San Juan, 6,200; Blanding, 3,100; Kaiparowits, 2,900; and Henry, 1,100.

The main areas of recharge to the ground-water reservoirs are on the highlands along the divides between the basins. Movement of ground water in each hydrologic basin is downdip from the highlands and toward the Colorado, Little Colorado, and San Juan River and their larger tributaries rather than toward the centers of the structural basins. Natural discharge of ground water is to these streams and to about 1,00 springs and numerous seeps. Artificial discharge is about 1,400 (1961) drilled wells and 550 dug wells utilized chiefly for domestic and stock water.

RECHARGE

Recharge to aquifers in the Navajo country is directly from precipitation and from ephemeral streams or indirectly from interformational leakage. Direct recharge to the aquifers in the consolidated sedimentary rocks is controlled principally by the permeability of the rock, the structural and physiographic expression, the amount of fracturing, and the altitude of the water-bearing strata; by the presence or absence of surficial deposits; and by the duration, type, and amount of precipitation. The mantles of surficial deposits are recharged by direct precipitation, by influent streams, and by discharge from the consolidated aquifers. Recharge from inte

DEPARTMENT OF THE INTERIOR

UNITED STATES GEOLOGICAL SURVEY

GEORGE OTIS SMITH, DIRECTOR

WATER-SUPPLY PAPER 249

SURFACE WATER SUPPLY OF THE UNITED STATES

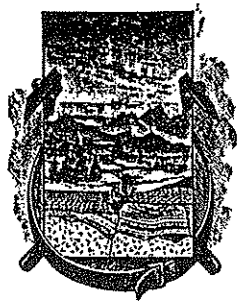
1907–8

PART IX. COLORADO RIVER BASIN

PREPARED UNDER THE DIRECTION OF M. O. LEIGHTON

BY

W. B. FREEMAN AND R. H. BOLSTER



WASHINGTON

GOVERNMENT PRINTING OFFICE

1910

Daily gage height, in feet, of La Plata River near La Plata, N. Mex., for 1907 and

[John Smith, Frank Williams, observers.]

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.
1907.											
1							3.0	1.0	2.6	1.0	.7
2							3.0	2.0	2.4	.8	.7
3							3.0	3.0	2.2	.8	.7
4							2.8	1.0	2.2	.8	.7
5							2.8	1.0	2.2	.7	.7
6							2.6	1.0	2.2	.7	.7
7						3.5	2.4	1.0	2.2	.7	.6
8						3.5	2.4	1.0	2.2	.7	.6
9						3.4	2.2	1.0	2.2	.7	.6
10						3.4	2.0	1.0	2.0	.7	.6
11						3.4	2.0	1.0	2.0	.7	.6
12						3.3	1.6	1.0	2.0	.7	.6
13						3.2	1.6	1.0	2.0	.7	.6
14						3.2	1.5	1.0	2.0	.7	.6
15						3.1	1.5	1.0	2.0	.7	.6
16						3.1	1.3	1.0	2.0	.6	.6
17						3.1	1.3	1.2	1.8	.6	.7
18						2.8	1.3	1.2	1.8	.6	.7
19						3.4	1.2	1.2	2.9	.6	.7
20						3.6	1.2	1.2	2.2	.6	.6
21						3.2	1.2	5.0	2.0	.6	.6
22						3.2	1.0	3.0	1.8	.7	.6
23						3.1	1.0	2.6	1.8	.7	.6
24						3.1	1.0	2.2	1.6	.7	.6
25						3.2	1.0	3.0	1.6	.7	.6
26						3.2	4.5	2.6	1.6	.7	.6
27						3.3	3.0	2.2	1.4	.7	.6
28						3.2	2.4	2.2	1.2	.7	.6
29						3.1	1.0	5.15	1.0	.7	.6
30						3.1	1.0	3.3	1.0	.7	.6
31							1.0	2.8		.7	
1908.											
1	0.5	0.7	1.3	1.8	1.5	1.4	0.7	6.6			
2	.5	.7	1.4	1.6	1.6	1.2	.6	.7			
3	.5	1.0	1.2	1.5	1.6	1.0	.6	.6			
4	.5	3.5	1.2	1.6	1.6	1.0	.6	.7			
5	.5	1.9	1.2	1.8	1.5	1.0	.6	.6			
6	.6	1.6	1.4	2.0	1.5	1.0	.6	3.2			
7	.6	1.4	1.4	1.9	1.5	1.0	.6	.6			
8	.5	1.4	1.2	2.0	1.5	1.0	.6	.6			
9	.5	1.4	1.2	1.9	1.6	1.0	.6	.5			
10	.5	1.6	1.6	1.9	1.6	1.2	.6	.5			
11	.5	1.6	1.0	1.8	1.5	1.4	.6	.6			
12	.5	1.4	1.8	1.9	1.4	1.2	.6	.6			
13	.6	1.2	1.3	1.8	1.4	1.2	.5	.6			
14	.6	1.2	1.4	1.9	1.3	1.2	.6	.6			
15	.6	1.0	1.6	2.0	1.2	1.2	.6	.5			
16	.6	1.2	1.8	2.2	1.2	1.0	.7	3.2			
17	.6	1.2	1.8	2.4	1.2	1.0	.7	.8			
18	.6	1.2	2.0	2.2	1.4	.8	.7	2.2			
19	.6	1.2	2.0	2.2	1.6	.7	.6	2.0			
20	.6	1.4	2.2	2.4	1.8	.7	.6	5.6			
21	.6	1.4	2.4	2.0	1.6	.7	.6	2.4			
22	.7	2.0	2.4	1.8	1.6	.7	2.6	1.8			
23	.7	3.0	2.4	1.8	1.8	.7	.6	2.0			
24	.7	2.5	2.2	1.6	1.5	.7	.6	2.0			
25	.7	1.6	2.0	1.6	1.3	.7	.6	1.8			
26	.7	1.8	1.8	1.5	1.2	.7	.6	1.6			
27	.7	1.8	1.8	1.5	1.2	.7	.5	1.4			
28	.7	1.4	2.0	1.4	1.2	.7	.5	1.0			
29	.7	1.4	1.8	1.4	1.0	.7	3.0				
30	.7		1.9	1.3	.9	.7	.5				
31	.7		2.0		1.2		2.0				

NOTE.—Gage out of water August 29 to December 8, 1908. During this period the average flow about 1 second-foot per day. New gage established December 9, 1908.

LITTLE COLORADO RIVER DRAINAGE BASIN.

DESCRIPTION.

The country drained by Little Colorado River consists of a high plateau with an elevation over 4,000 feet above sea level, extending from the Continental Divide in northwestern New Mexico westward to the San Francisco Mountains in Arizona and from the Grand Canyon of the Colorado southward to the Mogollon Mesa. The greater part of this plateau is composed of rolling plains with a few inches of soil at the surface underlain by rock. Through this plateau the river winds northwestward to its junction with the great Colorado. The run-off from approximately 6,000 square miles of the drainage basin finds its way into the Little Colorado above the mouth of Rio Puerco, the largest tributary, which joins the main stream 2 miles above the town of Holbrook, Ariz. Both the Little Colorado and Puerco are flashy streams, seldom clear even during low stages. They have shifting sandy bottoms, and where not confined in canyons the stream beds are wide with abrupt earth banks. The discharge fluctuates greatly, being insignificant in dry seasons. The floods are short and violent and carry large quantities of silt in suspension.

The following stations have been maintained in this river basin:

Little Colorado at St. Johns, Ariz., 1906–1908.
Little Colorado at Woodruff, Ariz., 1905–1908.
Little Colorado at Holbrook, Ariz., 1905–1908.
Silver Creek near Snowflake, Ariz., 1906–1908.
Silver Creek at Canyon Station, Ariz., 1906.
Woodruff ditch at Woodruff, Ariz., 1906.
Chevelon Fork near Winslow, Ariz., 1906–1907.
Clear Creek near Winslow, Ariz., 1906–1908.

LITTLE COLORADO RIVER AT ST. JOHNS, ARIZ.

This station, which was established April 18, 1906, to determine the amount of water available for irrigation, is located at the south end of the town of St. Johns, one-half mile above the dam and county bridge. The bed of the stream is clean, sandy, and shifting. Frequent measurements are necessary to properly determine the daily flow at this station. The results given in the following tables were furnished by the United States Reclamation Service:

Discharge measurements of Little Colorado River at St. Johns, Ariz., in 1907 and 1908.

[By W. D. Roncher.]

Date.	Gage height.	Discharge.	Date.	Gage height.	Discharge.	Date.	Gage height.	Discharge.
	Feet.	*Sec.-ft.*	1907.	*Feet.*	*Sec.-ft.*	1907.	*Feet.*	*Sec.-ft.*
[illegible]	4.65	67	February 27	4.94	92	April 26	4.60	69
[illegible]	4.75	80	March 6	4.91	75	April 30	4.56	69
[illegible]	4.66	54	March 13	5.00	87	May 6	4.30	51
[illegible]	4.53	36	March 19	5.11	127	May 30	4.27	49
[illegible]	4.60	40	March 23	5.40	430			
[illegible]	4.87	70	March 29	5.66	260	1908.		
[illegible]	4.92	89	April 1	5.60	259	July 21[a]	1.10	54
[illegible]	4.86	69	April 13	5.50	220			
[illegible]	4.84	68	April 19	5.10	150			

Daily gage height, in feet, of Little Colorado River at St. Johns, Ariz., for 1907 and 1908.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.
1907.											
1	4.61	4.73	4.94	6.20	4.58	4.14	3.87	4.18	4.85	3.23	3.70
2	4.50	4.81	4.94	6.27	4.55	4.07	3.90	4.24	4.57	3.23	3.70
3	4.60	4.77	4.93	5.77	4.45	4.04	3.90	4.54	4.80	3.22	3.63
4	4.72	4.77	4.94	5.82	4.30	4.04	3.90	4.25	5.40	3.22	3.51
5	4.65	4.76	4.94	5.78	4.32	3.99	3.89	4.27	4.46	3.22	3.80
6	4.67	4.83	4.92	5.45	4.29	3.97	3.89	4.20	5.60	3.21	3.89
7	4.68	4.88	4.95	5.65	4.26	3.94	3.86	4.17	5.40	3.20	3.89
8	4.68	4.92	5.02	5.75	4.22	3.92	3.83	4.23	5.00	3.19	3.89
9	4.68	4.86	5.04	5.73	4.19	3.90	3.81	4.34	4.52	3.18	3.89
10	4.73	4.88	5.02	5.75	4.16	3.90	3.80	4.25	4.11	3.18	3.89
11	4.71	4.85	4.96	5.72	4.14	3.90	3.79	4.20	3.97	3.18	3.89
12	4.73	4.82	4.99	6.70	4.11	3.90	3.78	4.38	3.99	3.16	3.89
13	4.70	4.82	4.98	5.60	4.10	3.89	3.77	4.35	3.79	3.16	3.91
14	4.69	4.82	4.90	5.70	4.00	3.88	3.78	4.20	3.68	3.16	3.93
15	4.70	4.85	4.93	5.46	4.11	3.87	3.77	4.17	3.68	3.16	3.89
16	4.68	4.88	4.93	5.35	4.11	3.86	3.77	4.08	3.55	3.18	3.89
17	4.68	4.87	4.96	5.27	4.09	3.85	3.78	4.45	3.73	3.20	3.89
18	4.67	4.90	4.97	5.18	4.08	3.84	3.77	4.42	3.70	3.22	3.91
19	4.64	4.91	5.05	5.12	4.04	3.84	3.77	4.22	3.53	3.22	3.91
20	4.64	4.86	5.30	5.10	4.03	3.84	3.77	4.45	3.46	3.22	3.91
21	4.66	4.84	5.65	5.08	4.02	4.43	3.79	6.10	3.41	3.22	3.89
22	4.62	4.85	6.05	5.07	4.01	4.42	3.83	5.65	3.39	3.22	3.91
23	4.53	4.85	6.37	5.03	3.99	4.36	4.25	5.14	3.36	3.30	3.89
24	4.55	4.94	6.20	4.95	3.97	4.26	4.05	4.84	3.34	4.12	3.89
25	4.57	4.97	6.13	4.83	3.94	4.22	4.62	5.72	3.31	4.08	3.89
26	4.61	4.95	6.07	4.68	3.93	4.21	5.00	5.08	3.29	4.00	3.89
27	4.64	4.95	5.97	4.58	3.93	4.14	4.62	6.58	3.27	3.94	3.89
28	4.60	4.94	5.85	4.52	4.02	3.98	4.43	5.35	3.25	3.88	4.05
29	4.60	.....	5.68	4.50	4.05	3.95	4.28	4.80	3.24	3.79	4.09
30	4.60	.....	5.63	4.56	4.25	3.91	4.16	5.55	3.24	3.76	3.91
31	4.62	.....	5.59	.....	4.27	.....	4.07	5.30	.....	3.75	.....
1908.											
1	3.94	4.10	4.41	4.50	3.51	3.31	3.22	0.97	1.13	0.75	0.77
2	3.92	4.10	4.40	4.53	3.45	3.30	3.22	2.15	.85	.75	.77
3	4.00	4.10	4.38	4.50	3.45	3.29	3.22	1.52	.88	.75	.75
4	4.03	4.24	4.44	4.50	3.42	3.28	3.21	2.45	.83	.75	.75
5	4.00	4.38	4.50	4.53	3.40	3.28	3.20	1.60	.95	.75	.75
6	4.02	4.32	5.15	4.80	3.40	3.28	3.20	.94	.90	.75	.75
7	4.00	4.27	5.08	4.90	3.49	3.23	3.20	.89	.94	.72	.80
8	4.02	4.22	4.78	4.80	3.55	3.17	3.20	.82	.95	.71	.80
9	4.05	4.14	4.47	4.74	3.70	3.16	3.20	1.88	.99	.71	.80
10	4.00	4.10	4.37	4.70	3.62	3.15	3.20	5.10	1.00	.70	.80
11	3.97	4.05	4.31	4.64	3.51	3.15	3.20	1.60	1.00	.70	.80
12	3.95	4.05	4.25	4.57	3.49	3.14	3.30	.92	1.10	.70	.80
13	3.95	4.04	4.25	4.53	3.43	3.14	3.22	1.10	1.05	.70	.80
14	3.95	4.02	4.20	4.52	3.39	3.16	3.40	1.28	.88	.70	.80
15	3.96	4.01	4.31	4.50	3.34	3.19	3.35	1.00	.80	.70	.80
16	4.00	4.02	4.75	4.44	3.32	3.18	4.08	1.05	.80	.70	.80
17	4.03	4.05	5.15	4.38	3.32	3.18	8.75	.90	.87	.70	.80
18	4.03	4.07	5.50	4.30	3.32	3.18	4.00	3.69	.80	.71	.80
19	4.02	4.03	5.75	4.20	3.35	3.17	2.25	2.13	.80	.74	.80
20	4.01	4.00	5.85	4.17	3.35	3.16	1.30	1.85	.80	.76	.80
21	4.02	4.11	5.25	4.05	3.34	3.16	1.13	1.90	.80	.76	.80
22	4.05	4.14	5.13	3.93	3.33	3.19	1.02	1.05	.80	.75	.80
23	4.06	4.35	5.05	3.84	3.48	3.22	.93	1.40	.80	.75	.80
24	4.02	4.88	5.01	3.86	3.41	3.21	2.25	.92	.81	.75	.77
25	4.00	4.46	5.10	3.85	3.40	3.20	.94	1.18	.80	.75	.75
26	4.00	4.37	5.14	3.78	3.39	3.22	.90	.90	.80	.75	.75
27	4.00	4.35	5.20	3.72	3.38	3.22	1.29	.89	.77	.75	.75
28	4.04	4.33	4.82	3.62	3.38	3.22	2.15	1.25	.75	.75	.75
29	4.05	4.40	4.78	3.57	3.35	3.22	2.10	1.02	.75	.75	.75
30	4.08	.....	4.73	3.56	3.32	3.22	1.02	1.00	.75	.75	.75
31	4.10	.....	4.60	.....	3.32	.....	1.00	1.14	.....	.77	.....

Daily discharge, in second-feet, of Little Colorado River at St. Johns, Ariz., for 1907.

Day.	Jan.	Feb.	Mar.	Apr.	May.	Day.	Jan.	Feb.	Mar.	Apr.	May.
1	64	53	88	386	70	10	60	75	76	193	37
2	54	70	86	403	68	17	60	76	80	178	35
3	63	67	80	286	60	18	58	80	82	161	34
4	78	67	85	296	54	19	50	80	127	149	33
5	67	66	85	288	51	20	50	75	183	144	32
6	70	73	75	216	49	21	57	68	259	141	32
7	73	83	80	269	47	22	50	68	350	138	30
8	74	89	95	281	43	23	36	68	428	130	29
9	74	75	100	278	41	24	37	90	386	118	29
10	80	75	95	281	39	25	39	95	368	100	27
11	82	72	85	275	37	26	42	92	356	81	27
12	74	68	92	508	37	27	45	92	331	70	27
13	68	68	80	248	36	28	41	90	302	65	32
14	64	68	75	270	35	29	41	.....	265	69	33
15	64	60	70	218	37	30	41	.....	254	60	46
						31	43	.....	245	.....	48

a These discharges were obtained by the indirect method for shifting channels.

Monthly discharge of Little Colorado River at St. Johns, Ariz, for 1907.

Month.	Discharge in second-feet.			Run-off (total in acre-feet).
	Maximum.	Minimum.	Mean.	
	82	36	58.0	3,570
	95	53	75.4	4,190
	428	75	173	10,600
	a 554	65	210	12,500
	70	27	39.8	2,460

a Maximum recorded discharge for the month, April 2, 1907.

LITTLE COLORADO RIVER AT WOODRUFF, ARIZ.

This station, which was established March 16, 1905, and was discontinued December 31, 1908, was located about 100 yards below the crossing of the Holbrook-Winslow wagon road and one-fourth mile below the Woodruff dam.

The station equipment, which was carried away by the flood of November 26 and 27, 1905, was replaced March 24, 1906. The object of the station was to determine the amount of water available for irrigation. The bed of the stream is sandy and shifting, and frequent measurements are required to determine the daily flow.

The results published in the following tables were furnished by the United States Reclamation Service.

Discharge measurements of Little Colorado River at Woodruff, Ariz., in 1907.

[By Newman, Wakefield, and Conner.]

Gage height.	Discharge.	Date.	Gage height.	Discharge.	Date.	Gage height.	Discharge.
Feet.	*Sec.-ft.*		*Feet.*	*Sec.-ft.*		*Feet.*	*Sec.-ft.*
0.50	50	February 4	1.30	203	March 19	0.80	63
.70	74	February 7	1.20	161	March 26	1.00	174
1.80	170	February 7	1.20	176	April 2	1.50	266
4.90	1,010	February 13	1.00	60	April 9	1.50	260
1.70	164	February 18	1.00	63	April 16	.20	62
1.00	51	February 26	.80	67	April 23	.20	54
1.10	42	March 5	1.00	215	April 30	.20	44
2.60	457	March 12	.80	62			

Nine discharge measurements were made during the remainder of 1907 and 1908.

Amazing Arizona!

Historical Markers

in Arizona

Vol. II

ARIZONA
Development Board
1521 W. JEFFERSON ST • PHOENIX

F O R E W O R D

HISTORICAL MARKERS

VOLUME II

The Arizona Development Board herewith presents the text and historical background for 100 Historical Markers for use along Arizona highways.

One for each of Arizona's 14 counties has been cast, sponsored originally by the Arizona Development Board. Some others contained in this publication have also been sponsored and are in place.

This publication, in two volumes, is prepared with the thought in mind that many Arizona fraternal organizations, civic clubs, etc. will sponsor the placement of the markers to better inform motorists of the historical lore of Arizona.

The historical background and text for the markers was compiled by Bert Fireman, Arizona newsman and historian. In accordance with Arizona statutes, which places in the State Department of Library and Archives, responsibility for the authenticity of historical markers, this list of 100 markers has been reviewed by Mrs. Alice Good, head of the Department of Library and Archives, and approved.

The Arizona Highway Department, cooperating in this venture with the Arizona Development Board, will install the markers in concrete and will supervise the technical work involved.

Bernard M. Mergen

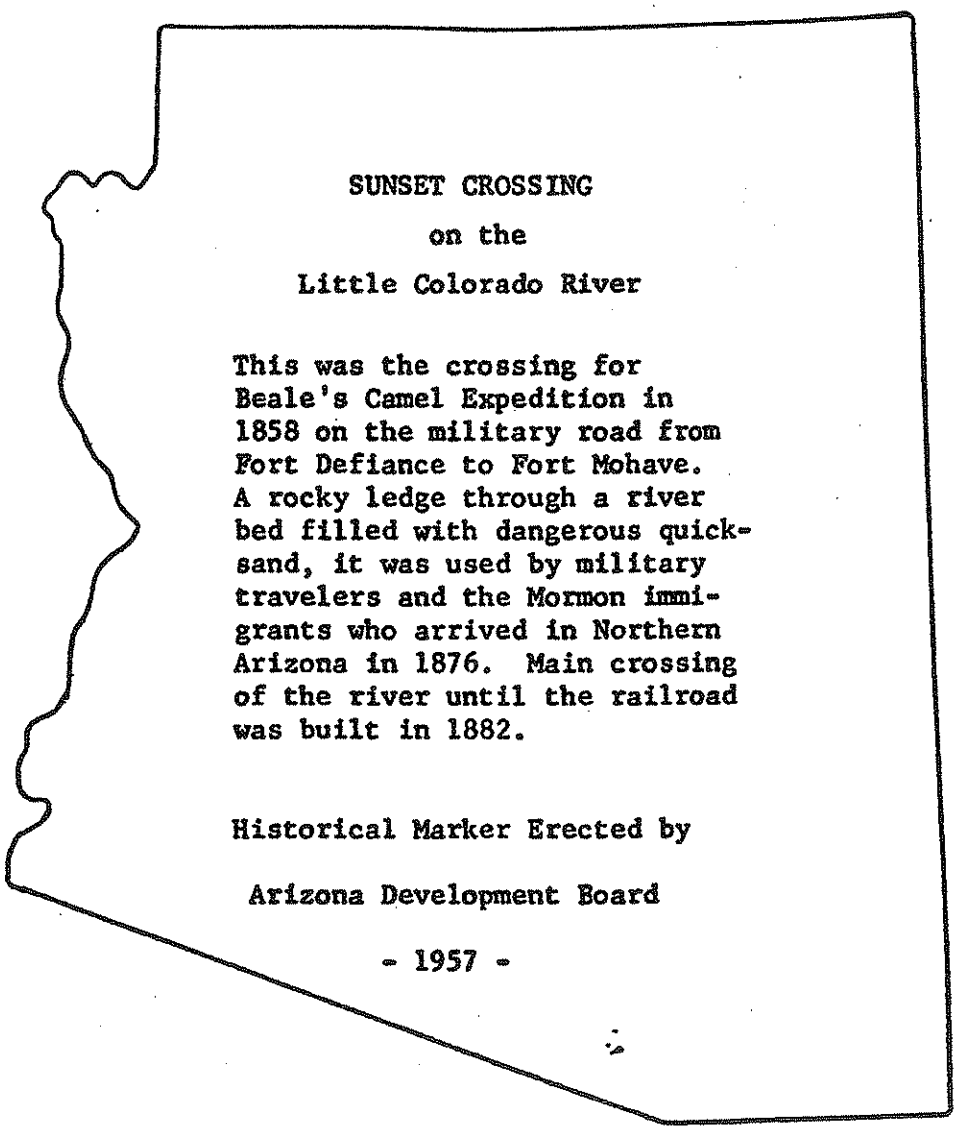
Bernard M. Mergen
Manager

NAVAJO COUNTY

Historical Site - Sunset Crossing, 1858-1882

Location of Site - Approximately six miles east of Winslow on Little Colorado (three miles east of confluence of Cottonwood and Clear Creeks with Little Colorado)

Marker Location - South side of U.S. 66 about six miles east of Winslow, on rise or hill overlooking river



SUNSET CROSSING

on the

Little Colorado River

This was the crossing for Beale's Camel Expedition in 1858 on the military road from Fort Defiance to Fort Mohave. A rocky ledge through a river bed filled with dangerous quicksand, it was used by military travelers and the Mormon immigrants who arrived in Northern Arizona in 1876. Main crossing of the river until the railroad was built in 1882.

Historical Marker Erected by

Arizona Development Board

- 1957 -

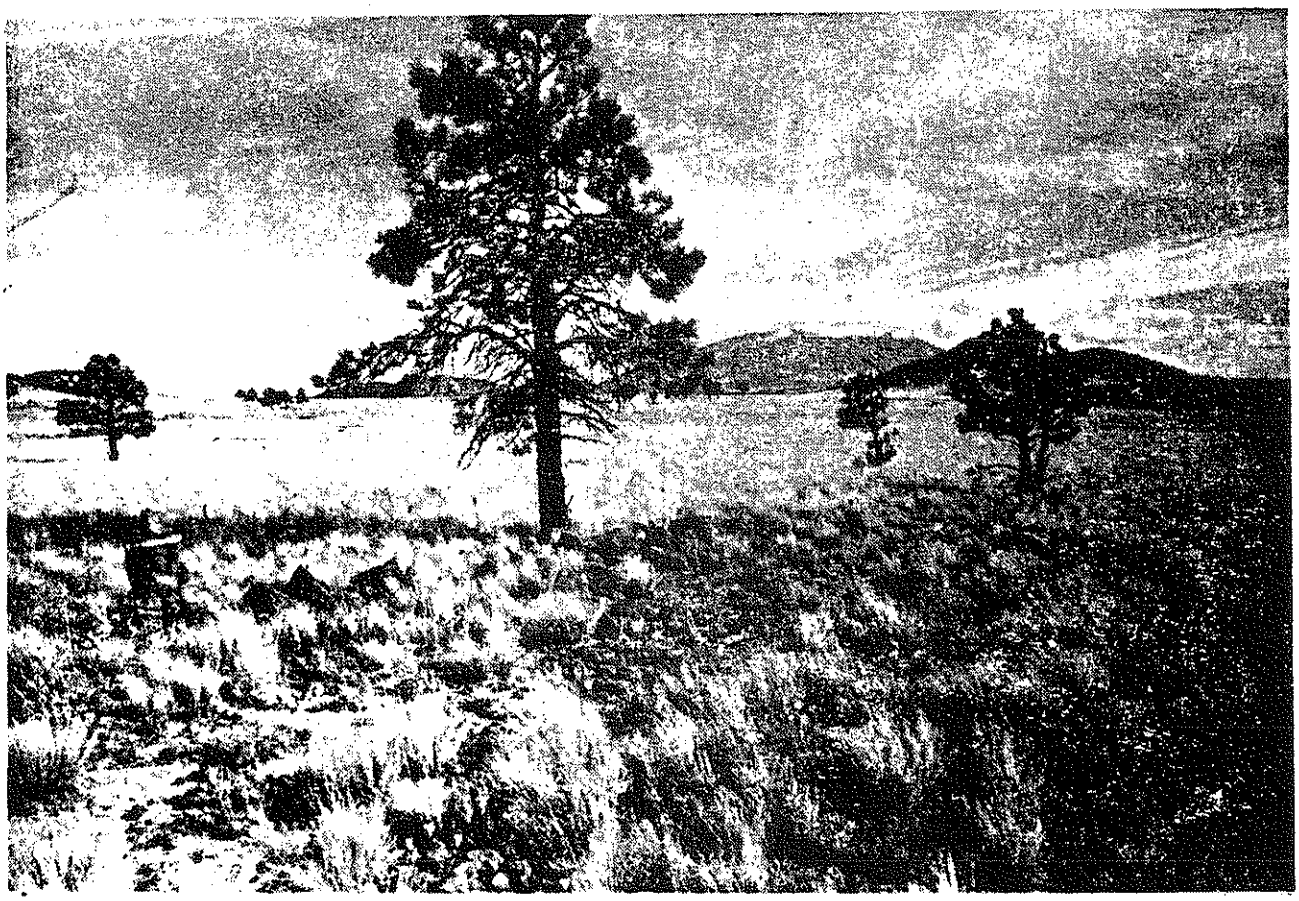
NAVAJO COUNTY

Sunset Crossing

Sunset Crossing was the best crossing of the Little Colorado during much of the year. A rocky ledge crossed the stream from bank to bank, permitting wagons and stock to cross without the danger of quicksand very prevalent along the Little Colorado. This crossing was used by Beale's Camel Expedition in 1858, becoming a regular stop on the military road he surveyed and built from Fort Defiance to Fort Mohave. It appeared on army maps and subsequently was mentioned by other expeditions, including the Wheeler party in 1870. It was used by Arizona's first territorial officials arriving from Santa Fe in 1863.

When the Mormons began their migrations out of Utah in the mid-70s, they used Sunset Crossing en route from the Colorado crossing at Lee Ferry to the new settlements along the Little Colorado, Silver Creek and Central Arizona. A small settlement of Sunset was established about three miles downstream from the crossing in 1876.

Sunset Crossing was used interchangeably with Horsehead Crossing near Holbrook by travelers on the road from Santa Fe to the Verde settlements and Prescott. Sunset Pass was in the mountains about 20 miles to the southwest. Until the Atlantic and Pacific Railroad was built in 1882, this crossing was universally used for east-west transportation through Northern Arizona.



A GUIDE TO THE BEALE WAGON ROAD THROUGH THE KAIBAB NATIONAL FOREST

BY

JACK BEALE SMITH

The History and Significance of the Beale Road.

During the 1850s the United States Government involved itself in appropriating money for exploration in the American West. one such planned expedition was the construction of a wagon road along the Thirty-fifty parallel. This job was awarded to former Navy Lieutenant Edward Fitzgerald Beale. In 1857 Congress appropriated $50,000 for the construction of a road from Fort Defiance, New Mexico Territory, to the Colorado River. The following year an additional $150,000 was appropriated to complete the construction along the Thirty-fifty parallel form Fort Smith, Arkansas to the Colorado River. This wagon road became the first federally funded interstate highway to be built in the western part of the United States. The road was built for the purpose of shortening the distance from the East to California.

Beale's first trip in 1857 started from Camp Verde, Texas, where he picked up twenty-two camels to use as an experiment. The government wanted to see if these animals would be feasible for use in the desert Southwest. From that point they went to El Paso, Texas, then up the Rio Grande River to Albuquerque, New Mexico Territory. As Beale's party neared the junction between Fort Defiance and Zuni Pueblo, he found it wiser to go due west to Zuni rather than to Fort Defiance. The fort was located a considerable distance out of the way to the north, so he built the road pass the old pueblo. He then proceeded to explore northern Arizona as far west as the Colorado River.

His second trip started from Fort Smith, Arkansas, in October, 1858, with a construction crew of 50 men, which was increased to 100 near modern day Flagstaff, Arizona. Entering Indian Territory (Oklahoma) the most they had to do was to build a few bridges over rivers & creeks that were otherwise difficult to cross. They then passed through Texas and the territories of New Mexico, Arizona, southern Nevada, and on to California constructing whatever was necessary to get wagons through. This included removing rocks out of the roadway and building dams around spring so they would hold more water.

Lieutenant Edward Beale was a mover and doer in the West and truly an outstanding American. Although he was born on the family farm called Bloomingdale in the District of Columbia on February 4, 1822 he grew up with politics in the nations capitol and ever after was in touch with the Washington scene wherever he found himself. At the age of fourteen he enterd the Navy where

he would eventually earn the rank of Lieutenant. Beale proved himself daring and resourceful during the Mexican War in 1848, when he crawled through enemy lines and ran forty miles barefooted to San Diego to warn Commodore Stockton of Colonel Kearney's defeat at the Battle of San Pasquel. During the years 1848-50 Beale made eight transcontinental trips carrying dispatches from California to Washington, D.C. and back. On one such trip he brought the first official news of gold discoveries in California to Washington. To accomplish this feat he disguised himself as one of the local inhabitants and road alone across Mexico fighting off bandits much of the way.

In 1852 he was appointed Superintendent of Indian Affairs for California and Nevada, a post he held until he was given the job of building a wagon road to California in 1857.

At the outbreak of the Civil War, President Lincoln appointed him Surveyor General of California. Beale was also directly responsible for stopping the Confederate movement in that state. During the war he constructed a toll road from Bakersfield to Los Angeles, California. At one point in the road, he engineered a cut in the San Fernando Mountains which was approximately 100 feet deep to allow wagons to pass through easily.

In the 1870s he was appointed by President Grant as Ambassador to Austria-Hungary. He retired in Washington D.C., where he died in April, 1893 at the age of seventy-one.

The wagon road that Beale laid out from 1857 to 1860 was a remarkable piece of work which took his name in recognition of his efforts. Through Arizona it encountered the widest variation of terrain and the most serious obstacles. The road entered Arizona a few miles west of Zuni Pueblo and moved westward through the modern communities of Holbrook, Joseph City, Winslow, Leupp, Flagstaff, Seligman, Peach Springs, Hackberry, Kingman, Goldroad and the Rivera; most of these, which subsequently sprang up with the railroad, were located along the old road. These later routes confirmed the wisdom of Beale's choice of a route through Arizona.

The road was used extensively during the years 1858-1883. Large immigrant trains moved over this road to California. Many of these travelers took time to write diaries of their adventures. One such individual was John Udell, who traveled over the Beale Road in the summer of 1858. Udell's trip was made in the interval between Beale's surveys before the actual road construction was completed. Information concerning this adventurous trip is contained

in the pages of the book called "John Udell: The Rest of the Story." by the author of this book: See Bibliography.

By the spring of 1859, Lt. Beale was back in Arizona with a construction crew of 100 men. Work for the Arizona section was completed by the late summer of 1859. During the summer of 1860 Beale made an inspection of the road and suggested that an additional $100,000 be spent on building bridges over the major rivers and across Canyon Diablo. He also suggested that large stock tanks be built along the way to ease the pressure of finding water as the traveler moved over the road. Congress did appropriate the money for the project. However the Civil War began in the spring of 1861 and the money was never realized for the completion of this project.

In the summer of 1861, Joseph Reddeford Walker, the famous mountain man who would discover gold in the Prescott, Arizona area two years later, came through the Kaibab Forest with several other prospectors. Their main reason for leaving California was to avoid being placed in prison because of their Southern views and attempts to get California to succeed from the Union. They searched for the legendary canyon of gold that was supposed to be located somewhere north of the San Francisco Peaks near modern day Flagstaff, Arizona. They were, however, unsuccessful and moved on eastward to New Mexico.

During the spring of 1863, Mormon missionaries, led by Jacob Hamblin, came down from Utah crossing the Colorado River at Pierce's Ferry. Here they met Lewis Greeley, the nephew of Horace Greeley who had coined the fraise "Go West Young Man. Go West.", which seams to have applied to his nephew. Greeley was allowed to join the expedition and they moved onward. Following an Indian trail through the Music Mountains they continued eastward through Cataract Canyon the home of the Havasupai Indians, and on to the Hopi Villages. Before leaving Utah President Brigham Young had instructed Hamblin to go to the San Francisco Peaks and look for the Beale Road. In this they were quite successful finding it just west of Wild Bill Hill. They paused and hunted in the area for two days killing two Antelope which they dried the meat in preparation for their homeward trip. Moving out on the 24th of August 1863 they traveled on the Beale Road for four days before they turned northward to Utah.

During the years 1867-68, extensive survey work was done in northern Arizona by the Union Pacific Railroad. This expedition was headed by General William Jackson Palmer. The Beale Wagon Road was surveyed by this party throughout the Kaibab Forest as the possible line for the railroad. In April of 1868,

several members of the survey party scratched their initials on the rocks around Laws Spring. The initials "J.B. U.P.R.R. Ap. 1868" appear on the rock above the words "Laws Spring."

During the 1870s, Mormons, along with other travelers, began moving into northern Arizona. Several Mormon parties used the Pierce Ferry route to Hackberry Arizona; these families then traveled the Beale Road to the settlements on the Little Colorado River. Several of these families kept diaries as they traveled along the road. For example, diaries were kept by John Bushman and Ida Hunt which incidentally was Morris Udall's grandmother, in April of 1877. Both diaries mentioned stopping at Laws Spring, and finding a rancher living in Spring Valley near Bear Spring.

Large cattle and sheep drives also used this route. During the years 1857-1883, it is conservatively estimated that well over 1,000,000 head of sheep were brought through northern Arizona. In the early 1870s the famous Colonel Francisco Chavez, who had guided the first Governor and party to Prescott in 1863, brought newly introduced Merino Sheep from California to his ranch in New Mexico. Several such drives numbered 40,000 head apiece.

Historians have given much attention to the famous Texas cattle drives to Abilene and Dodge City, Kansas, but have failed to record equally impressive drives from Texas to the southwest and to California. A conservative estimate is that 600,000 head of Texas longhorn beef were driven through northern Arizona to California from 1858 to 1878.

Use of the road for westward migration lasted about twenty-six years, from 1857-1883. As a route for driving livestock, its usefulness extended much beyond 1883. For local travel the road was used until modern times. For example, the portion between Holbrook and Flagstaff was used continuously until the early 1930s. A portion of the road on the Hualapai Reservation was used until the mid 1940s. The Beale Road from Seligman to Kingman was the main road before paving occurred in the late 1930s. Use of the road started with the flood of westward migration and continued until after World War II, a remarkable record of longevity lasting some eighty-eight years.

A comparison of the Beale Wagon Road with the famed Oregon trail is helpful. Both were major routes of westward travel and commerce. The Oregon Trail, and its off-shoot California Trail, are well-known; the Beale Road is not so well-known or even recognized. Yet it is probable that the Beale Road rivaled, or exceeded the California Trail as an immigrant route to California after 1867. As a route for stock, the Beale Road would appear to exceed the

northern route in numbers of animals driven over it both ways. Lieutenant Beale predicted that the route would be well-used and serve its purpose for many, many years. And so it was. It is remarkable that much of this road still exists today. It constitutes a historic relic of major importance.

A HISTORY OF THE SANTA FE RAILROAD IN ARIZONA TO 1917

by

Herbert Andrew Misbey, Jr.

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

University of Arizona

1 9 4 6

Approved: Edward S. Ellis
Director of Thesis

13 March 1946
Date

in less than a day and a night with good horses.[18] Farther west various contractors were pushing the work as rapidly as possible, although they were hampered by a shortage of labor.[19] Five miles east of Flagstaff was the headquarters of John R. Price and Company, the largest contractor on the line, with fifty-four miles of the roadbed under construction. Continuing westward along the route were the camps of Fisher, Bryant, Shinfield, Woodruff, Gorland and Simms. Work was in progress as far west as the only tunnel on the road, a three-hundred-foot passage cutting through a spur in Partridge Creek Canyon, eleven miles west of Williams.[21]

The terminus of the Atlantic and Pacific Railroad was at Sanders, Arizona, on August 31, 1881. The month of August was a trying one for the railroad builders--with the elements seeming to conspire against them. Washouts were an everyday occurrence, and, to add to the unprecedented rain, the Apaches went on the warpath. The railroad company had a strong force of men at work rebuilding the road, but, as fast as a break would be repaired, the floods would wash it out again. At the end of August, the road between Albuquerque and Sanders was impassible. Brigham City

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18 Ibid., August 12, 1881.

19 Ibid., June 24, 1881.

20 Ibid., August 12, 1881.

21 Ibid., June 24, 1881.

(Winslow), although only seventy-five miles from Sanders, could be reached by mail and telegraph only by sending all the way around by way of Albuquerque, Deming (New Mexico), Maricopa, and Prescott--a circuit of nearly one thousand miles.[22]

The depredations committed by the Apaches during August, 1881, created quite a panic. A band of the Indians took some twelve to fifteen scalps near El Rito, about one hundred and twenty-five miles from Sanders, and the telegraph operators on the Atlantic and Pacific line from Sanders to Albuquerque threatened to abandon their stations if not furnished with arms and ammunition. Although they were characterized as "mostly 'tender-feet,' recently from Chicago," the company sent them the required arms.[23]

In spite of obstacles, the work went on, and, by December 3, 1881, the steel rails reached Brigham City. This Mormon settlement of some eight hundred families was given the name of Winslow after General E. F. Winslow, Vice-President and General Manager of the Atlantic and Pacific and President of the Saint Louis and San Francisco Railroad Company. A single passenger train a day began service between Albuquerque and Winslow. With the road being constructed at the rate of ten miles a week,[24] Canyon Diablo,

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22 Ibid., September 9, 1881.

23 Ibid.

24 Weekly Arizona Democrat, December 23, 1881.

MEASUREMENTS.

All measurements of specimens are in millimeters.

All MAMMALS collected by Field Agents of the Division are measured in accordanc with the following instructions:

(1) The TOTAL LENGTH is the distance between the tip of the nose and the end the tail vertebræ. It is taken by laying the animal on a board, with its nose again a pin or upright post, and by straightening the back and tail by extending the hi legs with one hand while holding the head with the other; a pin is then driven i the board at the end of the vertebræ.

(2) THE LENGTH OF TAIL is the length of the caudal vertebræ. It is taken erecting the tail at right angle to the back, and placing one point of the dividers the backbone at the very root of the tail, the othe at the tip end of the vertebræ.

(3) The HIND FOOT is measured by placing one point of the dividers against end of the heel (*calcaneum*), the other at the tip of the longest claw, the foot be flattened for this purpose.

In measuring the hind foot in dry skins, the foot is first wrapped in wet absorb cotton until the toes can be straightened.

U. S. DEPARTMENT OF AGRICULTURE
DIVISION OF ORNITHOLOGY AND MAMMALOGY

NORTH AMERICAN FAUNA

No. 3

PUBLISHED BY AUTHORITY OF THE SECRETARY OF AGRICULTURE

[Actual date of publication, September 11, 1890]

Results of a Biological Survey of the San Francisco Mountain Region and Desert of the Little Colorado, Arizona

1. General Results, with special reference to the geographical and vertical distribution of species
2. Grand Cañon of the Colorado
3. Annotated List of Mammals, with descriptions of new species
4. Annotated List of Birds

BY DR. C. HART MERRIAM

5. Annotated List of Reptiles and Batrachians, with descriptions of new species

BY DR. LEONHARD STEJNEGER

WASHINGTON
GOVERNMENT PRINTING OFFICE

higher temperature at a given altitude on the north side than on the south side, because the plateau level (base-level) on the north side carries up the temperature. Many years ago Humboldt cited an instance of this kind in the Himalaya. The temperature on the north side of this lofty range is much higher than on the south side at the same elevation; or, to state it differently, the snow line and the timber line on the north side are about 900 meters (3,000 feet) higher than on the south side. This is due to the great height of the Thibetian Plateau as compared with the altitude of base level on the south side, and is in opposition to the influence of slope-exposure. By slope-exposure is meant the inclination of the surface of the earth in relation to the angle of reception of the sun's rays. The sun strikes the east side of a hill or mountain in the early part of the day, the south side a little later, the southwest and west sides in the afternoon, when its heat is greatest, and the northwest and north about sundown or not at all. But in case there is a high plateau on the north side, the heat from the plateau will force the timber line up. Therefore, of the influences under consideration, base-level is more powerful than slope exposure.

About half a century ago the elder Binney, in a work which he did not live to see published, made the following observation:

"The relations which the different levels of elevation bear to the parallels of latitude, although as interesting to the zoologist as to the botanist, have not yet been made the subject of examination in this country. But the Rocky Mountains * * * offer, in the great extent of their table-land and in the height to which they rise, a vast field of research to future naturalists, where they will be able to solve many of the most important questions connected with the geographical distribution of the terrestrial mollusks of our country."*

If the word 'mollusks' in the above quotation be changed to the more comprehensive word 'life,' Binney's remarks may be regarded as a prophecy fulfilled, in part at least, by the present Biological Survey of San Francisco Mountain. At the same time it should be remembered that the present report is little more than an announcement of the general conclusions resulting from a brief survey of a limited area, and that anything approaching a final discussion of the subject must be deferred until similar surveys of many regions result in the accumulation of a multitude of facts now unknown. As the late Leo Lesquereux once said of his favorite study:

"This science is in its infancy; and the childhood of science is marked, like that of man, by a series of trials and failures, from which strength and proficiency are derived. The first astronomers did not measure the distance from the earth to the fixed stars, nor weigh the planets by the diameter of their orbits."†

*Amos Binney, The Terrestrial Mollusks of the U. S., 1851, vol. 1, 116–117.

†A Review of the Fossil Flora of North America. Bull. U. S. Geol. and Geog. Survey Terr., No. 5 (2d series) Jan., 1876, 248

CLIMATE OF THE SAN FRANCISCO MOUNTAIN REGION OF THE LITTLE COLORADO, ARIZONA.

The traveler in the Plateau region of Arizona is awed by the grandeur and energy with which the processes of nature manifest themselves. The multitude of volcanic craters and lava cones, culminating in San Francisco Mountain, attest the former activity and intensity of the subterranean forces; the Grand Cañon of the Colorado, the most stupendous chasm known, is a gigantic illustration of the surface forces now in operation—of the cutting power of water and the carving power of sand; while the terrific thunder-storms and cloud-bursts which shake the very foundations of the earth in their fury, shattering the tall pines with the lightning, and sending mighty torrents down the hillsides to plow deep gorges in the desert, serve to indicate the resistless energy of the forces of the air.

In its climatological aspects the Plateau region of Arizona presents a field of surpassing interest and diversity, and problems of the utmost importance to physiography and to agriculture may be there advantageously studied. Climates which usually characterize widely remote regions are here brought near together, appearing in successive strata from the desert levels to the summits of the mountains, thus permitting their several effects to be comprehended at a glance, and their differences contrasted. In a general way it may be said that the climate of the region abounds in extremes. Protracted periods of drought are interrupted by deluges of rain; and the snows of winter suddenly give place to the intense heat of summer. As a natural consequence, most of the mammals and all of the reptiles and batrachians hibernate for longer or shorter periods, even on the desert.

It is not the purpose of the present essay to discuss meteorologic conditions further than is necessary to indicate in a very general way the peculiarities of temperature and humidity which characterize the several zones herein defined.

TEMPERATURE.

The tropics are characterized by great uniformity of temperature, the daily and yearly fluctuations being insignificant. The absence of a marked fall in temperature at night is due in great part to the large quantity of moisture in the atmosphere. This moisture acts in two ways: (1) by diminishing the loss of heat by radiation; (2) by directly increasing the temperature of the atmosphere. As stated by Wallace, "the warmth given off by the heated earth is very largely absorbed by it [the aqueous vapor], thus raising the temperature of the air; and as it is the lower strata of air which contain most vapor, these act as a blanket to the earth, preventing it from losing heat at night by radiation into space." (Tropical Nature, 1878, p. 9.)

The excessively dry atmosphere of Arizona acts in exact[illegible]e opposite way, interposing no obstacle to free radiation and presenting no medium to retain the heat given off at night. Hence the change in temperature from day to night is always great. The summer heat of Arizona, except on the high mountains, is greatly in excess of the summer heat of the tropics, while the winter temperature is vastly lower, and sudden contrasts are common.

The law of latitudinal equivalent in altitude was discovered in the last century and was early formulated by Humboldt. Omitting reference to local disturbing influences and seasonal variations, it may be stated as a general proposition that temperature decreases from the equatorial zone to the poles at an average rate of a little less than 1° Fahr. for each degree of latitude; and from base-level to higher altitudes, at the average rate of about 3° Fahr. for each 1,000 feet of elevation. In temperate and cold regions the differences due to latitude and altitude are greatest in winter and least in summer. It follows that places having the same mean annual temperature may have widely different summer temperatures; and conversely, that places receiving the same amount of summer heat may have widely different mean annual temperatures. The significance of these facts becomes apparent in studying the distribution of life, for, as will be shown later, the distribution of species in temperate and cold regions is governed in the main by the temperature of the warm season, the mean annual temperature being of little consequence.

It has just been stated that the mean average decrease in temperature with altitude is about 3° Fahr. for each 1,000 feet. The exact rate in any particular case may be obtained by dividing the difference in temperature of the extremes by the difference in altitude. The Signal Service records show that the actual rate of decrease in midsummer on the Colorado Plateau is 4°.* At this rate the temperature of the summit of San Francisco Mountain in summer would be 20° Fahr. lower than that of the cedar belt and 35° lower than that of the Painted Desert.

Seven life zones are described in the following pages as crowded into the narrow space between the arctic-alpine summit of San Francisco Mountain and the torrid desert of the Little Colorado, only 40 kilometers (about 25 miles) distant. Each of these zones has a distinctive temperature during the period of growth and reproduction—a period of less than three months' duration at the summit, but extending over half the year on the desert. Unfortunately, the time spent in any one of the several zones was insufficient to furnish the thermometric data necessary for the determination of its distinctive temperature. Therefore the only way in which it is possible to obtain information on this

* Denver and Pike's Peak were selected for this computation because of their proximity to the San Francisco Mountain region and because they afford a vertical range of about 2,750 meters (9,000 feet).

subject is by examination of the records of the [illegible] stations in the same or corresponding zones. Data from several such stations may be found in the publications of the United States Signal Service and in Schott's Tables, published by the Smithsonian Institution.* Compilation of these data leads to interesting results. Fort Apache, in Arizona, and Fort Wingate, just over the line in New Mexico, are in the piñon belt of the Great Plateau, Apache near the lower, and Wingate near the upper, limit of this zone. They are 232 kilometers (145 miles) apart. The mean temperature for the five months (April to August, inclusive), assumed to cover the period of reproduction in this belt is found to be 65.6° Fahr. at Fort Apache, and 65.07° at Fort Wingate, showing a really remarkable agreement over this part of the piñon belt. The mean temperature of the same period at Holbrook, on the edge of the Little Colorado Desert (at the junction of the Puerco and Little Colorado), 121 kilometers (77 miles) from Fort Apache, is a little above 70° (70.9°) Fahr. Albuquerque, in the valley of the Upper Rio Grande in New Mexico, though on the other side of the Continental Divide and 309 kilometers (192 miles) distant, has essentially the same altitude and essentially the same summer temperature (70.1° Fahr.).

Data are wanting for the determination of the distinctive temperatures of the several zones of San Francisco Mountain above the cedar and piñon belt, but they may be obtained hypothetically by substituting those from remote stations in the same zones. For instance, the temperature of the summit of Mount Washington, in the timber-line or subalpine zone of the east, during the season of reproduction (June to August, inclusive), is 46.15° Fahr., which may be assumed to agree very closely with the temperature of the subalpine zone of San Francisco Mountain. Similarly, the corresponding temperature of Pike's Peak, Colorado, in the arctic-alpine zone, is 38.23° Fahr. But Pike's Peak is more than a thousand feet higher than San Francisco Peak, hence it is necessary to add about 4° Fahr. to the temperature of the former to make it represent that of the latter, which would then be in round numbers 42° Fahr.

Therefore, though the actual mean temperatures of the several zones of the San Francisco Mountain region during the season of reproduction are unknown, it is possible to arrive at very close approximations to these temperatures by utilizing the records from distant stations in the same life areas. By this process the following means have been obtained. While not supposed to represent the actual means for each zone, they are believed to fall within the normal range of variation between the upper and lower borders of the zones to which they

* The observations here referred to were taken at different periods and by voluntary observers. [illegible] probably, the extreme precision and uniformity attained by the trained observers of the Signal Service; at the same time, most of them may be relied upon as sufficiently exact for purposes of comparison.

severally pertain, and are therefore provisionally subscribed as a step toward a goal as important as it is difficult to attain.

Table of assumed limits of temperature for the several zones during the period of vegetation.

Zones.	Cent.	Fahr.
Arctic-alpine zone	4	39.2
Subalpine or timber line zone	7	44.6
Hudsonian or spruce zone	10	50
Canadian or fir zone	13	55.4
Neutral or pine zone	16	60.8
Pinon or evergreen zone	19	66.2
Desert zone	22	71.6

In attempting to ascertain the temperature of climatic zones, in connection with the distribution of their characteristic forms of life, it should be borne in mind that the recorded temperatures are taken *in the shade*, while the plants and diurnal animals of non-forested areas, particularly of deserts and prairies, *live in the sunshine*, and consequently endure much higher temperatures, as well as much greater extremes than indicated by the recorded observations. In attempting, therefore, to ascertain the quantity of summer heat necessary for a particular species, it should be first noted whether the species inhabits areas exposed to the full heat of the sun or dense forests where the sun's rays rarely penetrate; and in the case of animal life it should be noted also whether the species is diurnal or nocturnal, and the temperature observations should be made accordingly.

A series of carefully conducted meteorologic observations, made with special reference to temperature and humidity, and carried on simultaneously in the spruce belt of the mountain and on the Painted Desert, or, better still, in each of the seven zones herein defined, would be productive of information of much scientific and economic value.

HUMIDITY.

The Plateau region of the interior of North America is noted for its scanty rain-fall, and the same may be said of Arizona as a whole. The annual precipitation and mean humidity are greatest on the high mountains and least on the low plains and deserts. Thus San Francisco Mountain has many times the rain-fall of the Little Colorado Desert, near by, and the quantity of aqueous vapor in the air is correspondingly higher. Evaporation is retarded by the clouds which frequently rest upon the summit, and by the dense spruce forests which protect the soil from the direct rays of the sun, enabling it to retain enough moisture to permit the growth of plants requiring a humid atmosphere for their existence.

There are two rainy seasons on the San Francisco Mountain plateau: one in summer, usually in July or August, the other in mid-winter. The summer rainy season is characterized by daily thunder-showers. As a rule, several such showers occur each day, and not infrequently several may be seen at the same time from any of the volcanic cones. The area covered by each is very small, its diameter rarely exceeding half, or even a quarter of a mile; and its duration is brief, though the rain-fall may be considerable. The accompanying thunder is often terrific, and the lightning vivid and destructive. Tall pines are shattered on every hand, and cattle are frequently killed; three were killed by one stroke near our camp about the middle of August. The showers almost always take place in the day-time, and are most common at midday and in the early afternoon. In fact, it is a common saying in this region that it never rains at night. Two partial exceptions to this rule occurred during our stay, one in which an unusually severe and protracted rain lasted from about 3 o'clock in the afternoon until 9 or 10 in the evening; the other, a light shower which actually took place in the night. During the latter part of the rainy season the showers became less frequent, but extended over a larger area and lasted longer. The axis of abundance seems to be between San Francisco and Kendrick Peaks, but the greatest precipitation occurs on San Francisco Mountain, as would be expected from its great altitude. The summit of the mountain is so cold that it is occasionally whitened with snow while rain falls at its base; and hail storms are frequent both on the mountain itself and throughout the plateau region, many sudden storms taking this form.

Over much of the pine plateau the soil consists of decomposed lava, and is so porous that the rain sinks out of sight as it falls, and the atmosphere is so dry and evaporation so rapid that a few minutes after a shower no traces of it are visible.

On the arid desert of the Little Colorado rains are infrequent, but usually of great violence, producing torrents which cut deep washes or 'arroyos' in the sun-baked sand and clay. Sometimes cloud-bursts deluge large areas, flooding the valleys and destroying multitudes of the smaller mammals. Three storms of this character were witnessed, two of moderate size, the third of great dimensions, and striking evidences of a fourth were everywhere noticeable when we reached the region. This latter almost inundated the town of Flagstaff and several other places along the line of the Atlantic and Pacific Railway, and left unmistakable evidences of its volume and force in various directions, the most impressive, perhaps, being the overflow of a crater lake and adjoining crater just east of Kendrick Peak. The track of the torrent that rushed from the sides of this crater, and for a distance through the pine forest beyond, suggested a veritable volcanic eruption.

While following the course of Tenebito Wash across the Painted Desert we saw a heavy rain-storm raging over the high mesas to the

north and east during the entire afternoon of August 14, though not a cloud came between us and the parching sun. Before dark a furious wind—the vehicle of a sand-blast—swept down the wash between the rows of cliffs which mark its course, abating as night came on. About 10 o'clock we were startled by a loud roaring in the north, which at first gave the impression that a severe storm was advancing upon us, but not a cloud could be seen, and the stars shone brightly in every direction. The roaring increased and came nearer until it was evident that something was coming down the bed of the wash; and in a moment a great wave of thick mud rushed past with a tremendous roar, accompanied by a fetid stench. The first wave was about 1½ meters (5 feet) high, but it soon rose to 2½ meters (8 feet), where it remained for an hour, and then slowly subsided. After 3½ hours it was still about 1½ meters (5 feet) deep and running swiftly, and it had not entirely ceased three days later.

Two days afterward (August 16), when at the Moki Pueblo of Oraibi, a furious rain set in about 4 p. m., and lasted more than an hour, flooding the house tops and streets, and parts of the valley below. And yet the desert was as parched next day as if it had never been wet.

The heaviest and most extended rain-fall observed by us occurred September 20, on which date Mr. Bailey and I set out from Little Spring for Moencopie. Heavy leaden clouds began scurrying over the mountain toward the northeast early in the morning, and by noon the entire sky was overcast and had a most ominous appearance. Soon the rain began falling in torrents, and the storm moved steadily eastward from the edge of the lava beds to the Little Colorado, and thence across the desert to the high mesas beyond. Such a deluge I never saw, and we afterwards learned that it extended 160 kilometers (nearly 100 miles) to the south. The gulch in the edge of the lava beds, about 2½ kilometers (1½ miles) east of Black Tank, was full to overflowing; the flat upon which it empties was 1½ meters (5 feet) under water; great lakes appeared in various parts of the desert, and the Little Colorado bottom was completely flooded. And yet all this vast volume of water disappeared in a few hours. A red, sirupy, alkaline mud filled the bed of the Little Colorado for a few days, and pools of similar mud were occasionally found in depressions in the sand-rock all the way to Moencopie. The whole desert, from the San Francisco lava beds on the west to Echo Cliffs on the east, showed that it had been recently deluged, as if by the breakage of some mighty dam, but the water had disappeared.

From the scanty data available, and from the experience of residents of the region, it is safe to infer that the rain-fall was unusually heavy in the Plateau region during the summer of 1889.

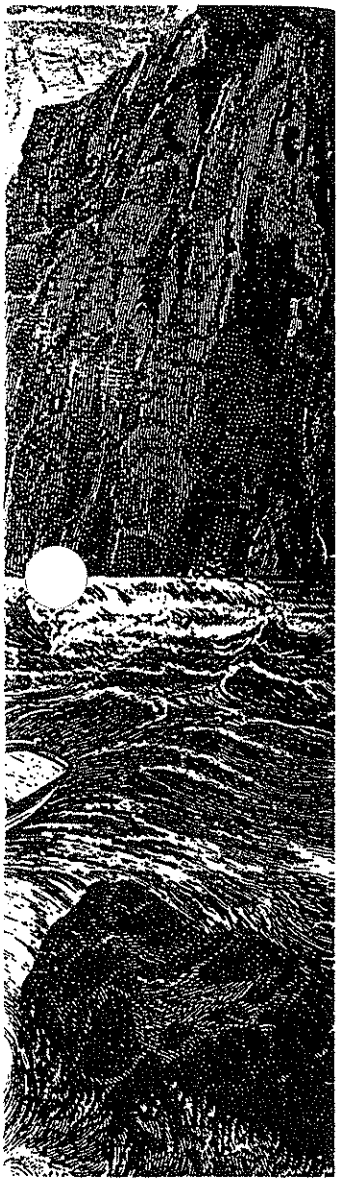
PART II.—GRAND CAÑON OF THE COLORADO, BETWEEN THE KAIBAB AND COCANINI PLATEAUS.

No attempt will be made to define or describe the faunas and floras of the stupendous chasm of the Colorado. Our stay of five days permitted only a hurried reconnoissance, which serves to indicate merely in a general way the more conspicuous features of the region.

The lowest point between San Francisco Mountain and the Grand Cañon is at the end of a narrow arm of the desert near Hull Spring, where the junipers and piñon which border this tongue of desert unite and extend westward in a broad belt, completely separating the pine forest of the mountain plateau from that of the Cocanini Plateau (as shown by the areas colored yellow and green on Map 1). While the San Francisco Mountain Plateau is composed of lava, the Cocanini Plateau is carboniferous limestone. The resulting difference in soil affects the vegetation, and many plants grow in the piñon belt at the cañon which are not found in the same belt on the lava. Among such plants are *Cowania mexicana*, *Berberis fendleri*, *Spiræa millefolium*, *Robinia neomexicana*, and *Yucca baccata*. *Juniperus californicus utahensis* grows there also, but the relation of its presence to the soil is uncertain. The true sage-brush (*Artemisia tridentata*) of the Great Basin here finds its extreme southeastern limit. Large patches of it occur on the south side of the cañon, opposite Point Sublime, but it disappears altogether a few miles away.

At the brink of the cañon opposite Point Sublime, about 2 miles east of the pool or tank known as Cañon Spring, is a dwarf forest of peculiar aspect, and having a uniform height of about 5 meters. It consists of piñon (*Pinus edulis*), cedar (*Juniperus californicus utahensis*), and mountain mahogany (*Cercocarpus ledifolius**), which here equals the juniper and piñon in height and measures 100 to 200 millimeters (approximately 4 to 8 inches) in diameter. Mingled with it are numerous tall bushes of *Berberis fremonti* and the beautiful *Spiræa millefolium*. In places this Lilliputian forest merges into extensive fields of the true sage-brush (*Artemisia tridentata*) and yucca (*Yucca baccata*, which at the time of our visit was ripening its sweet, banana-like fruit), with several kinds of cactuses; while in other directions it gives place to thickets of scrub

*This identification was made in the field. No specimens of the large form were brought back, but specimens of a smaller bush from the Cañon prove to be *Cowania mexicana*.



Powell
OF THE COLORADO

BY WILLIAM CULP DARRAH

PRINCETON
PRINCETON UNIVERSITY PRESS

Library of Congress Catalog Card Number: 51-11671

First Princeton Paperback Printing, 1969

Second Hardcover Printing, 1969

Printed in the United States of America
by Princeton University Press, Princeton, New Jersey

ment polished smooth in many places, in others embossed in a thousand fantastic patterns," the men looked instead at their ragged clothing and were "interested now only in how we shall get through the canyon and once more to civilization though we are more than ever sanguine of success." Continuing this musing Bradley wrote:

> Fortunately we are a happy-go-lucky set of fellows and look more to our present comfort than our future danger and as the cook has a fine lot of beans cooking with every prospect that his sweating and swearing will issue in an ample breakfast in the morning, we shall make our beds tonight and no doubt sleep as soundly as if surrounded by all the comforts of home.

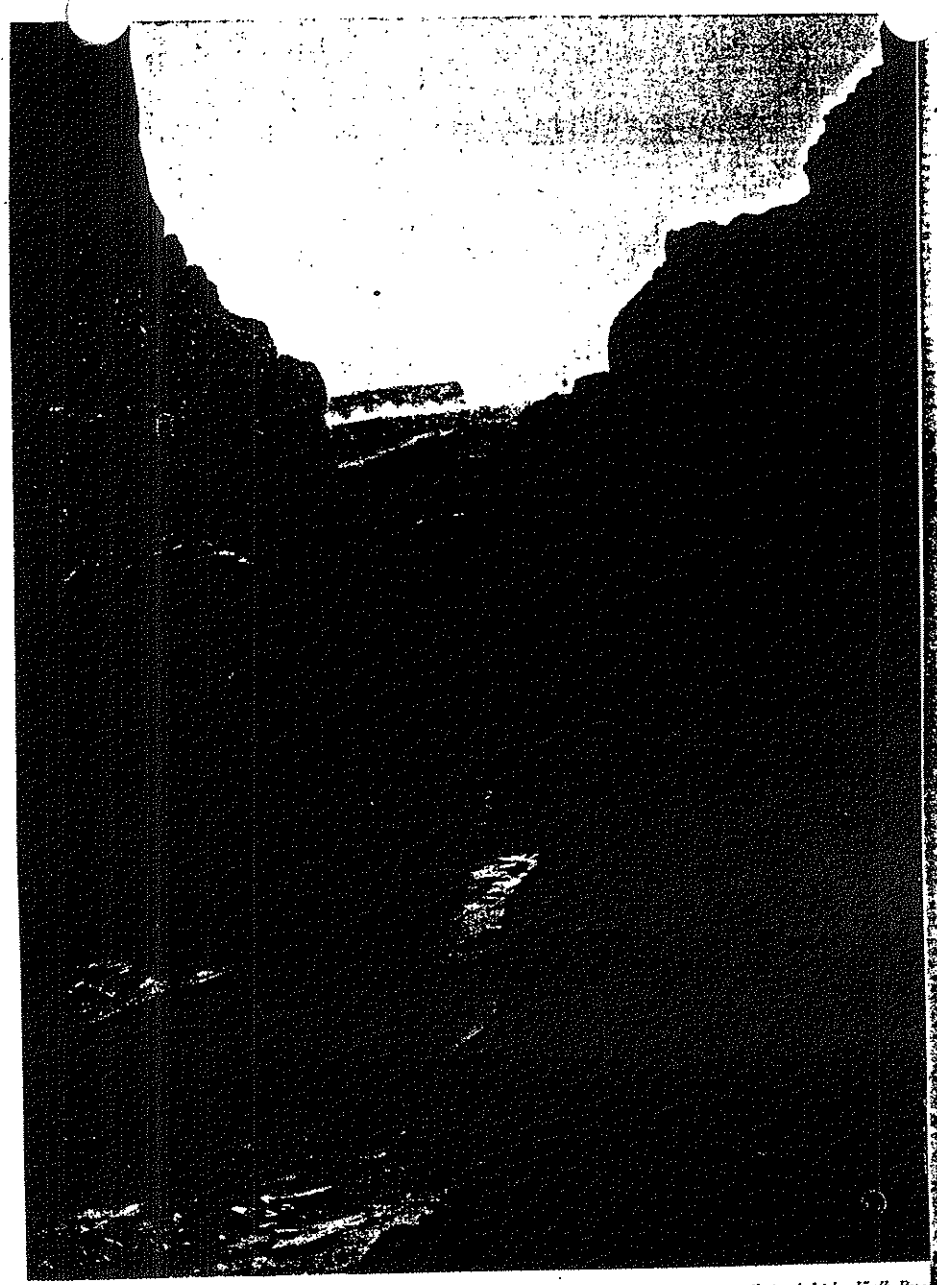
In mid-afternoon on August 10th the party came upon the Little Colorado River, "a loathesome little stream . . . as disgusting as there is on the continent; 3 rods wide and about 3 feet deep, half of its volume and 2/3 of its weight is mud and salt." [15] The canyon walls were nearly four thousand feet high and practically inaccessible. The Major called for a stopover for two or three days to determine latitude and longitude. If James White had gone through the canyons from this point to Callville on a raft, the men figured that they had little to fear from waterfalls below. They derived little comfort from the report. The truth was that the men were discontented, uneasy, and anxious to move on. Bradley wrote in his diary under August 11th:

> If Major does not do something soon I fear the consequences, but he is contented and seems to think that biscuit made of sour and musty flour and a few dried apples is ample to sustain a laboring man. If he can only study geology he will be happy without food or shelter, but the rest of us are not afflicted with it to an alarming extent.[16]

For three chilling days, more like November than August, it had rained in torrents. They were slowly starving. At the moment rain had extinguished the fire and they huddled in the shelter of their boats. When on half-rations they had been mirthful, on quarter-rations, grimly humorous; now, with almost no rations, they were no longer amused. The shredded canvas was too rotten and tattered to shed water and there were but four blankets for the eight men. Their

[15] J. C. Sumner, MS, *Diary;* also G. Y. Bradley, MS, *Diary,* Aug. 10. The Little Colorado brings down a burden of red mud at certain periods of the year when there is water in the upper river. The greater the flow of water, the greater the erosion and corrasion—hence, greater transportation of sediment. At other periods, when the water is low and its velocity diminished, it is perfectly clear at its junction with the Colorado. Seasonal precipitation and spring thaws determine the amount of sediment carried by the tributary streams. Intense local storms influence the type of sediment the stream carries from time to time.

[16] G. Y. Bradley, MS, *Diary,* August 11, 1869.



THE GRAND CANYON AT THE MOUTH OF HA VA SU CREEK

Through the Grand Canyon from Wyoming to Mexico

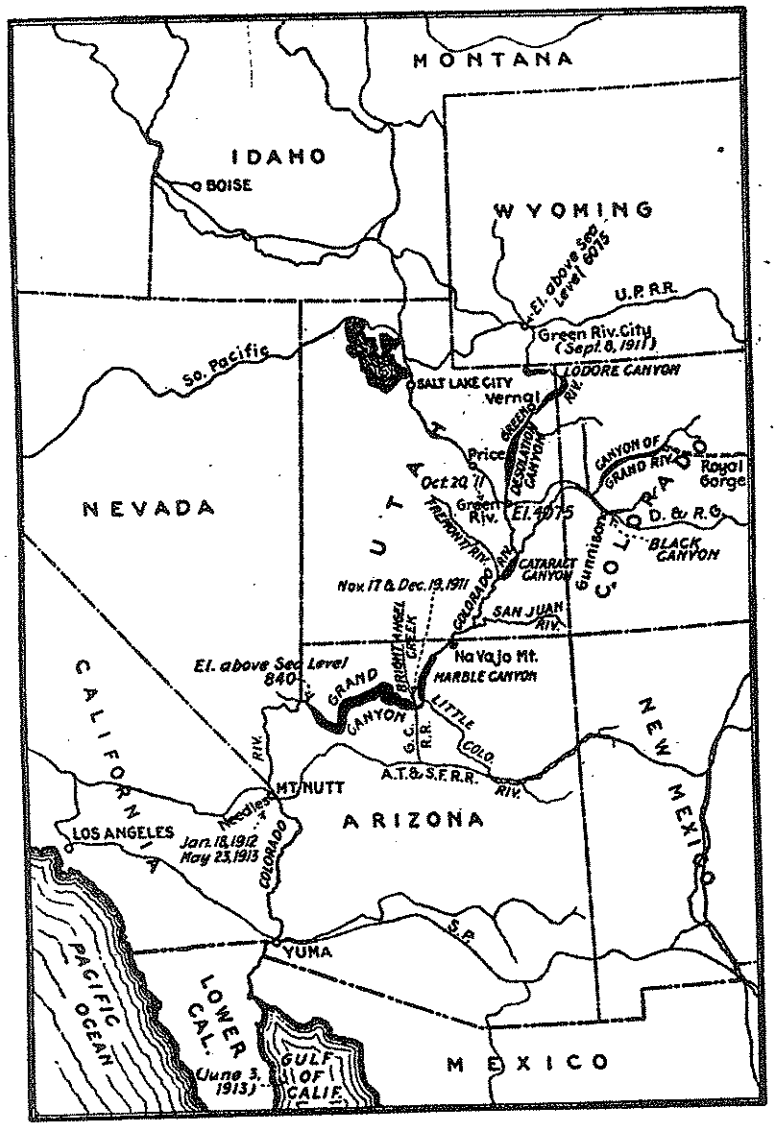
By

E. L. Kolb

With a Foreword by Owen Wister

New Edition
With Additional Illustrations
(72 Plates)
From Photographs by the Author and His Brother

1976
New York
The Macmillan Company
1915



THROUGH THE GRAND CANYON FROM WYOMING TO MEXICO

CHAPTER I

PREPARATIONS AT GREEN RIVER CITY, WYOMING

EARLY in September of 1911 my brother Emery and I landed in Green River City, Wyoming, ready for the launching of our boats on our long-planned trip down the Green and Colorado rivers.

For ten years previous to this time we had lived at the Grand Canyon of Arizona, following the work of scenic photography. In a general way we had covered much of the country adjacent to our home, following our pack animals over ancient and little-used trails, climbing the walls of tributary canyons, dropping over the ledges with ropes when necessary, always in search of the interesting and unusual.

After ten years of such work many of our plans in connection with a pictorial exploration of the Grand Canyon were crowned with success. Yet all the while our real ambition remained unsatisfied.

Butte. Once more we were in a narrow canyon, narrowed by this peak, but a canyon just the same. Soon we were below a wall we once had photographed from the mouth of the Little Colorado; then the stream itself came in view and we were soon anchored beside it. This was the beginning of the Grand Canyon.

CHAPTER XIX

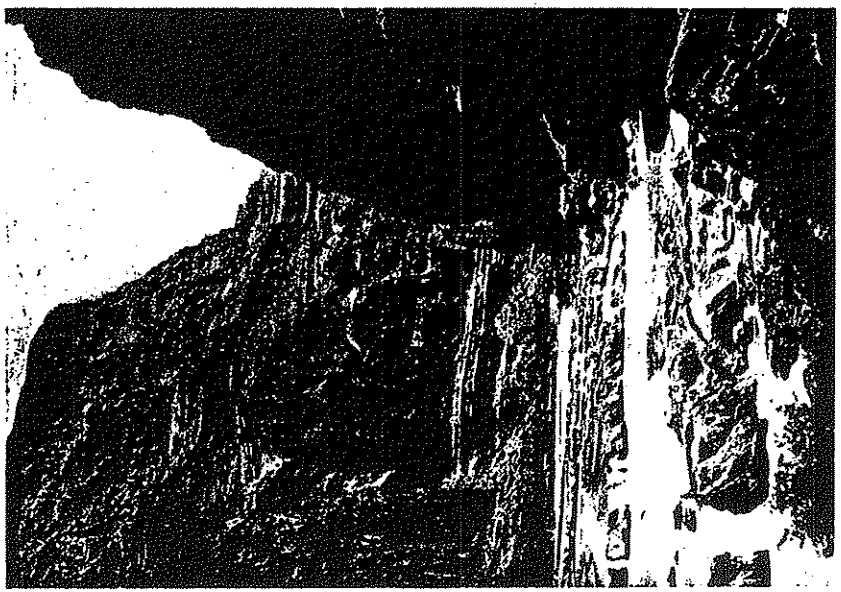
SIGNALLING OUR CANYON HOME

How long we had waited for this view! How many memories it recalled — and how different it seemed to our previous visit there! Then, the high water was on, and the turquoise-tinted mineral water of the Colorado Chiquito was backed up by the turbid flood waters of the Rio Colorado, forty feet or more above the present level. Now it was a rapid stream, throwing itself with wild abandon over the rocks and into the Colorado. There was the same deserted stone hut, built by a French prospector, many years before, and a plough that he had packed in over a thirty-mile trail — the most difficult one in all this rugged region! There was the little grass-plot where we pastured the burro, while we made a fifteen-mile walk up the bed of this narrow canyon! What a hard, hot journey it had been! A year and a half ago we sat on that rock, and talked of the day when we should come through here in boats! Even then we talked of building a raft, and of loading the burro on it for a spin on the flood waters. Lucky for us and for the burro

that we didn't! We understand the temper of these waters now.

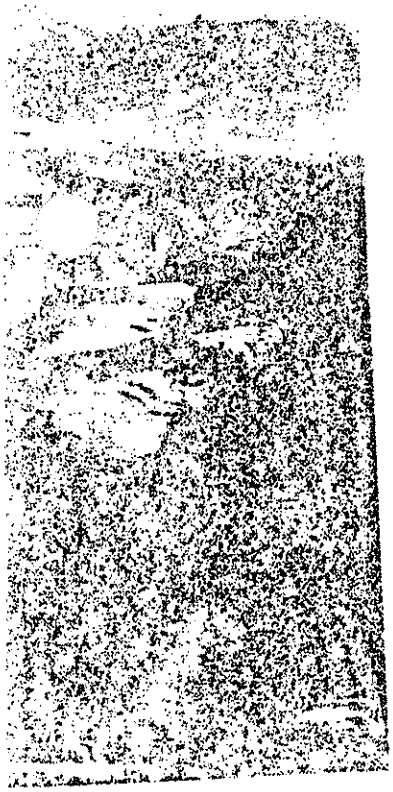
Cape Desolation, a point of the Painted Desert on the west side of the Little Colorado, was almost directly above us, 3200 feet high. Chuar Butte, equally as high and with walls just as nearly perpendicular, extended on into the Grand Canyon on the right side, making the narrowest canyon of this depth that we had seen. The Navajo reservation terminated at the Little Colorado, although nothing but the maps indicated that we had passed from the land of the Red man to that of the White. Both were equally desolate, and equally wonderful. With the entrance of the new stream the canyon changes its southwest trend and turns directly west, and continues to hold to this general direction until the northwest corner of Arizona is reached.

But we must be on again! Soon familiar segregated peaks in the Grand Canyon began to appear. There was Wotan's Throne on the right, and the "Copper Mine Mesa" on the left. Three or four miles below the junction a four-hundred foot perpendicular wall rose above us. The burro, on our previous visit, was almost shoved off that cliff when the pack caught on a rock, and was only saved by strenuous pulling on the neck-rope and pack harness. Soon we passed some tunnels on both sides of the river where the Mormon miners had tapped a copper ledge. At 4.15 P.M. we



CATARACTS OF THE LITTLE COLORADO RIVER.

END OF MARBLE CANYON, FROM THE MOUTH OF THE LITTLE COLORADO.



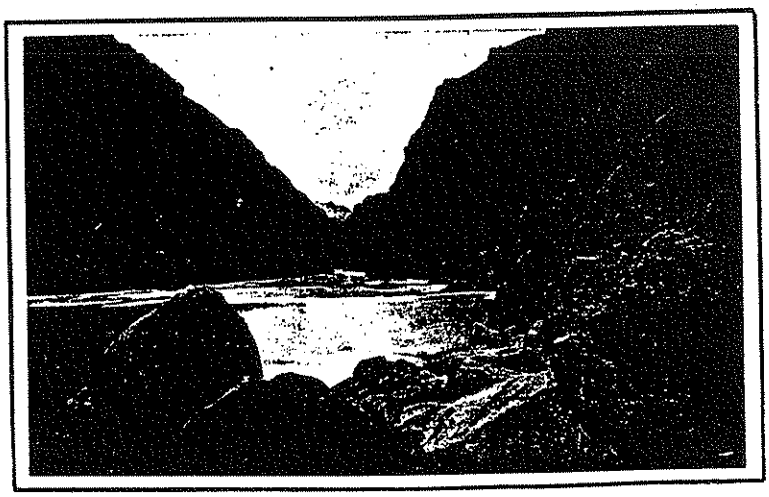
IN & AROUND THE GRAND CANYON

THE GRAND CANYON OF THE COLORADO RIVER IN ARIZONA

REVISED AND ENLARGED EDITION

By GEORGE WHARTON JAMES

WITH NUMEROUS ILLUSTRATIONS



BOSTON · LITTLE, BROWN, AND
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Printers
S. J. PARKHILL & CO., BOSTON, U.S.A.

TO

JOHN WESLEY POWELL

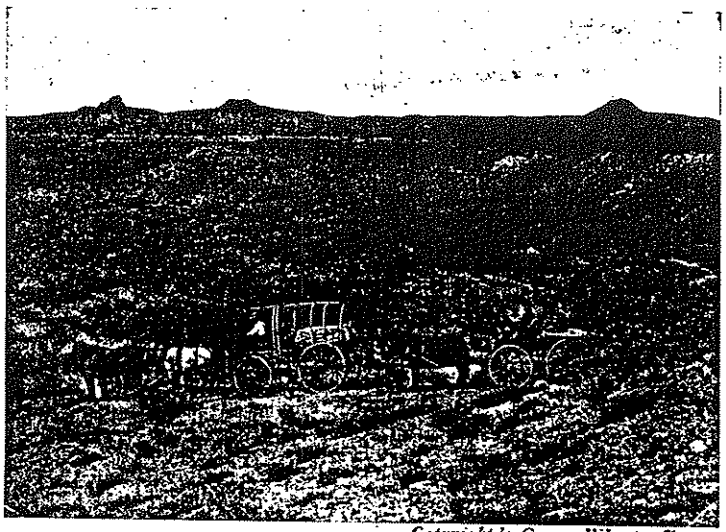
SCHOLAR, WARRIOR, SCIENTIST, GENTLEMAN, FRIEND

DIRECTOR FOR FOURTEEN YEARS OF THE U. S. GEOLOGICAL SURVEY
ORGANIZER AND DIRECTOR FOR TWENTY YEARS OF
THE U. S. BUREAU OF ETHNOLOGY
WHOSE EXPLORATIONS OF THE CANYONS OF THE COLORADO IN THE
INTERESTS OF SCIENCE CONFIRM HIM ONE OF THE BRAVEST,
MOST HEROIC, AND DARING EXPLORERS
OF THE CENTURY

CHAPTER XIX

LEE'S FERRY AND THE JOURNEY THITHER

THE ride from Winslow to Lee's Ferry and the adventures and experiences connected therewith form one of the great memories of my life.



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ON THE WAY TO LEE'S FERRY.

I shall not attempt to give them in detail. A few will give a true picture of an historic section near the Grand Canyon and the Little Colorado River of which few people have any conception.

My driver to this memorable spot was Franklin French, an old pioneer, born in Boston, Massachusetts, whose life had been spent in the West, and who would have been a character for Dickens or Bret Harte. He was good company, especially over the desert country we had to drive. The first portion of the journey I went ahead in another wagon.

Crossing Red Lake, dry at this season of the year, we came to a slough, which ordinarily is dry, but now was filled up with the fine dust blown in by the never-quiet wind of this region, all moistened into a soft and yielding mud by a small stream that made a channel for itself as it sluggishly flowed. John, the driver of the first wagon, on the front seat of which I sat with him, was busy at the moment we reached this treacherous slough, expounding some mining problems to me, and, expecting the moist-looking red mud was the coarse sand generally found, and which easily bears up a heavily loaded wagon, he recklessly drove on. In a moment leaders and wheelers were floundering deep in the quagmire; horses wildly leaping and striving to extricate themselves, the mules wisely resting as they fell, waiting until the slush around them settled somewhat. In the mean time John and myself slipped off all our nether garments and jumped into the yielding mud to release the animals from the harness. As soon as they were free, it was not many moments before they stood on the opposite side of the slough. A chain and double-trees were now brought from the rear wagon, fastened to the end of our submerged wagon-pole, the four animals harnessed, and John took the lines! ! ! ! ! !

Reader, do you know what those six exclamation

points mean? Did you ever hear an Arizona pioneer drive mules? — especially when he was mad? *More* especially when his wagon was stuck in such a horrible mess as we had fallen into? *Most* especially when for his nether garments was substituted a coating of red mud an inch thick?

In my varied experiences I have heard skilled artists in profanity, but compared with this man they were but in the kindergarten, and he a classical scholar, familiar with the profanity of the ages in all tongues.

And how those mules did pull! With that sulphurous stream of expletives striking them with full force, accompanied by vigorous thwacks of a wire-loaded black-snake, it was not long before the wagon and its precious freight were safe on the other side. In apologizing for his vigorous profanity, John explained that nothing but swearing would make mules pull when in such a place, and, said he, "While I was ashamed to use such language in your presence, nothing but the Simon-pure article does with these yere chaps."

Being safe and secure, I felt constrained to excuse him, and serene, though muddy, our caravan proceeded, the other wagon making a short detour around the head of the slough, and thus avoiding all trouble.

In a few more miles we reached the banks of the Rio Colorado Chiquito. The only road was one made by the cowboys, and of all the Chinese puzzles of a road it would outwit the celestial inventor of the most bewildering razzle-dazzle to construct another equal to this. We moved in

every direction, made acute angles, oblique angles, and described curves of every order, several times retracing our steps for long distances towards Winslow. In despair I was about to give up the hope of ever reaching the crossing, when John nerved me to a few more moments' waiting, with the assurance that we were "nearly there."

We reached and crossed the dirty red stream at last, and there made our first noon camp.

In order to test the muddy qualities of the stream, and also to enjoy a swim, if one were possible, one of the gentlemen and myself determined to undress and enter the river. One plunge convinced us of the vast amount of matter it held in solution, and the swift current decided for us the question of swimming. We were compelled to strike out, and make for the other bank, walk back on a mud flat, and then recross to where our clothes were. As we emerged we found ourselves fairly coated with a fine red paint, which nothing but plenty of clean water would remove. This we did not have, so scraping with sticks the fine mud off as well as we were able, we dressed, and rejoined the party, who were now about ready to proceed.

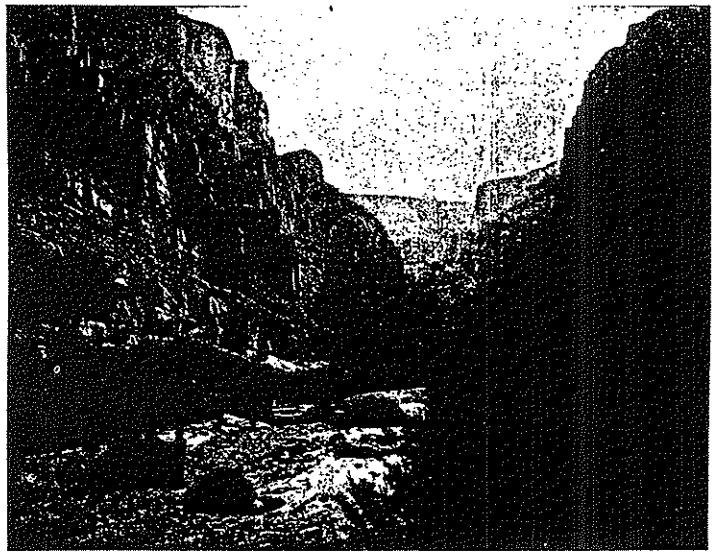
For a long way our route lay alongside the Little Colorado River. We passed on the west side of Volz's Crossing — where once I had a party delayed for nearly two days, owing to a ten-feet rise in the river during the night — on to Wolf's Crossing and Trading Post, and in turn passed Black and Grand Falls. Black Falls, in reality, is but a long stretch of slight cascades, the river-bed formed of and filled with rough boulders of lava

and basic rock, so that the muddy red waters are churned into creamy foam for the distance of nearly half a mile, and thus set off in contrast the black of the rocks. The scene is not unlike that of the upper cataracts of the Nile, but on a reduced scale. Grand Falls is more of a genuine waterfall, but unless it is in flood time, there is not enough water to cover the width of the crest of the precipice over which it dashes, and thus make an effective scene. In flood time, however, it is a miniature Niagara.

All along the banks of this stream, variously known as the Flax River, the Salt River (the Havasupais still speak of it as the Salt River, because here their Hopi friends used to obtain salt), the *Colorado Chiquito*, and its English equivalent, the Little Colorado, are the ruins of a large number of homes of people who, long ages ago, here found shelter from worse enemies than the barrenness of a desert, — enemies whose fierce hostility led them to seek protection in caves and cliffs and desert places of this character. What a piteous life it must have been! Nothing grand, picturesque, or beautiful to soothe the horror and awfulness of it; fearful of the attacks of blood-thirsty and persistent foes, both by day and by night; in a region where nothing could grow; the dumping ground of volcanoes, and fired and scorched by pitiless lava flows, — I never picture the life of those wretched, hunted people of the past but a sob of pity rises within me, and tears well up in my eyes.

And to give vividness to the horror, every time I have crossed this desert I have been caught in a dreadful storm. On this occasion it was such a

one as I had never seen before, and I hope I may never see again. From pure cobalt or rich turquoise blue the sky gradually changed to ashen gray, then lowering black, and then fiery red. Clouds were drifting in from the north. When the



IN THE "BOXING" OF THE LITTLE COLORADO.

lightning began it was on three sides, and all at once a wild, fierce glare everywhere. Occasionally these sheets of lightning were followed by vindictive zigzag flashes, which in the north struck from zenith to nadir. By this time the wind was blowing a perfect hurricane, and the thunder rolled fiercely in accompaniment to the wild raging of the wind.

But these were only premonitions! For an hour or more they continued, the Storm King lashing himself into greater and greater fury, until, all at

once, his fierce anger become uncontrollable, and the *crisis* came. The heavens split wide afar, the flood-gates were opened, and down came many waters. Not in drops did the rain descend, nor torrents even, but in rivers, in Niagaras! The hills were water-washed everywhere, and deep canyons were cut even into solid rock. With such a tempest twice a year even, gathering rills into streams, streams into rivers, rolling with fierce rapidity over the rocky slopes, the water charged with sand, possibly stones, and, as the velocity increases, large fragments of rock, there is no wonder that this whole country is barren and cut, sawed, seamed, and scarred, and made as rugged in face and feature as the hero of a hundred desperate hand to hand battles. It seems as if the evil powers of nature concentrated all their fury, deadly hatred, and most awful vindictiveness in this corner, — an area of perhaps one hundred miles in circumference, — for in summer it is blazing with tropic heat, in the fall deluged with frightful floods, in winter cursed with cutting snow blizzards, and in spring the scene of dire battles fought with fierce winds laden with blinding sand. Hence, at all times it is desolate and accursed. And he is wise — unless he be a true explorer and investigator, willing to endure all hardships in his chosen work — who shuns closer acquaintance with its awful desolation, wind-swept wastes, and water-cut surface.

This barren desolation continues as far as Willow Spring, a Navaho Indian trading store. Near-by a number of "hogans" may be seen, where the women are hard at work at their looms, weaving

blankets. Two or three of these weavers have considerable skill and ability, and some of the finest blankets of the tribe are made here.

This is the nearest settlement of any kind to the junction of the Little Colorado River with the Grand Canyon. It was undoubtedly by Willow

INTERIOR OF NAVAHO HOGAN.

Spring that Cardenas with his handful of soldiers was led by the crafty Hopis, who did not wish the Spaniards to obtain too favorable an impression of the Colorado River region, or gain access to their beds of salt near the junction of the lesser and greater rivers. No other presumption can account for their not being guided by the Hopis down the old Salt Trail — to which reference will be made in a later chapter — to the very edge of the water.

Poor Cardenas! thou and thy thirsty soldiers are not the only ones who have been misguided by

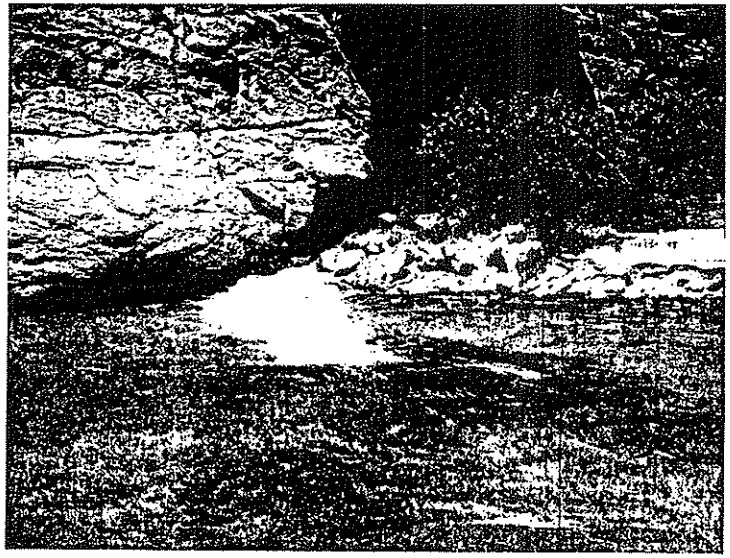
wily and suspicious Indians, or deceived by their constant protestations of good faith.

This corner of country near the mouth of the Little Colorado River is seamed with canyons, ravines, and gulches. It is a genuine "Beled-el-ateuch"—land of thirst—and may well be designated an "interminable country of desolation." There is no water for miles, and except immediately after a rain-storm, when water is caught in a few natural rock pockets, or during the storms of winter, when patches of snow may be found, it is impossible to get even an Indian, used to the sandy deserts in Arizona, to ride across it, much less undertake to guide a stranger over its waterless and pathless miles.

In looking over the country from Echo Reef, one sees a thousand hills of all sizes and materials, — sandstone, sandy clay, blue marl, — and the rock, cut, washed, scarred, and carved by all the uninterrupted forces of nature, that in such places as these seem to enjoy their work of creating desolation.

If one follows the windings of the Little Colorado River, about sixty miles of walled-in, boxed-up canyon are presented, every mile of it grand, stupendous, overpowering. During the dry season, the upper portion of this canyon is almost dry, often entirely so, the light flows of water from the sources in the Arizona White Mountains disappearing in the sand and gravel soon after their appearance. But about twenty miles from the junction of the Little Colorado River with the main Colorado River, nearly parallel with Kohonino Point, there flows out a large body of water at the

base of the canyon wall that makes a stream of considerable size. This water is strongly impregnated with mineral, and is blue in appearance, and when free from the mud and filth of the upper



MINERAL SPRING IN THE CANYON OF THE LITTLE COLORADO.

waters of the Little Colorado, offers an unspeakably beautiful spectacle as it flows on to join the waters of the great river below. There has been much conjecture as to the source of this large stream. I am satisfied, from extended observation on the Kohonino Plateau, between the Little Colorado Canyon and the San Francisco Mountains, that it has its rise in the water-soaked slopes of the latter. Indeed, in several places I have found holes in the rock on this plateau, into which the

if the uplift continues long enough, all the strata thus deposited are exposed, and perhaps also the archæan and plutonic rocks beneath. This is what we actually find to be the case in the Grand Canyon.

At the mouth of the Little Colorado clear evidences of uplift and subsidence are seen in connection with the non-conformable strata of the pre-carboniferous era. Here, with a thickness of about five hundred feet, strata are found, in a *tilted* condition, upon which are *horizontally* deposited the several thousand feet of the carboniferous era. To the geologist the history of these strata is easily read. It tells of ten thousand feet of rock substance deposited horizontally upon the plutonic formations æons ago. In the uplift that followed their deposition they were tilted. While thus thrust out and tilted, denudation began. This undoubtedly was rapid and fierce, for ninety-five hundred feet were removed and washed down by the river.

But the non-scientific reader asks: How do you know ninety-five hundred feet of strata were removed from this region? With only five hundred feet left how can you assert that there were once ten thousand feet? In other words, How do you measure strata that are no longer there?

The answer is simple. One could take books that are but a foot high and an inch thick, and, standing them in a tilted position, lay them together, as in Fig. A, side by side, for a mile. Yet they would be but a foot in height. But if these same books were placed one above another, as in Fig. B,

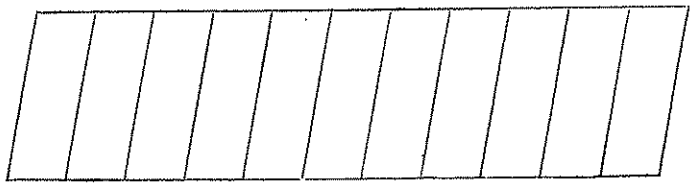


FIG. A.

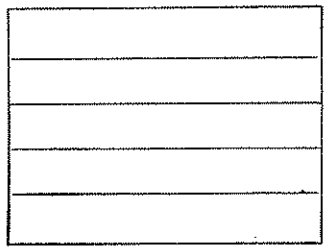


FIG. B.

they would no longer be a foot, but a mile high. Now, instead of dealing with books, deal with immense layers of rock five hundred or more feet in thickness and covering vast areas, deposited originally one above another as the books are piled in Fig. B to a thickness of ten thousand feet. Then slowly tilt this mass over until the rocks are sloping, as are the books in Fig. A, but of course reaching far up into the air. Let the forces of erosion gnaw away at them for the centuries, and by the time they are submerged again into the ocean bed, they are mere fragments of their former selves. Yet if their measurement be taken *longitudinally*, it is apparent that this must have been their height when originally deposited *horizontally*. Consequently, though now they are but five hundred feet horizontally, their longitudinal measurement being ten