# ARCHAEOLOGY IN TUCSON

Vol. 9, No. 4 Newsletter of the Center for Desert Archaeology Fall 1995

# A Thousand Years of Irrigation in Tucson

*by Jonathan B. Mabry and J. Homer Thiel, Center for Desert Archaeology*

Historical photographs, newspaper accounts, and the memories of town elders tell us that the Santa Cruz River flowed through Tucson year-round across a wide flood-plain that held irrigated fields of wheat, alfalfa, cotton, and vegetables as recently as 100 years ago. These same sources describe how, at the turn of the century, a combination of ill-designed diversion ditches, a declining water table due to overgrazing and over-pumping, and a series of unusually large floods resulted in the entrenched riverbed we see today.

Based on recent archaeological evidence, we now know that this also represented the end of at least a thousand years of continuous irrigated agriculture in the middle Santa Cruz Valley. Over the last two decades—but mostly within the last year—

*View of Tucson from Sentinel Peak ("A" Mountain) during the late nineteenth century. The Santa Cruz River flowed year-round between irrigated fields on both sides of the floodplain. The river became entrenched by the 1890s due to a combination of human and natural factors, making gravity irrigation no longer possible. Left of center are the adobe ruins of the San Agustin mission visita (photo no. 12649 courtesy of the Arizona Historical Society).*

Archaeologists working in the floodplain of the Santa Cruz River in Tucson have found many preserved remnants of prehistoric and historic canals. From this new archaeological evidence, combined with the documentary record, the full history of irrigation and agriculture in Tucson is beginning to emerge.

**Early Flood Farming**

Archaeological remains of early villages buried in the historic floodplain, recently uncovered by Desert Archaeology, Inc. (DAI), indicate that "flood farming" was practiced along the banks of the Santa Cruz River by at least 800 B.C. (see 1994 *Archaeology in Tucson,* Vol. 8, Nos. 1 ,3, and 4). The geological contexts of these sites, and the plant remains recovered from them, reveal that fields of maize, and probably squash, beans, and tobacco, were watered by overbank floods during the summer monsoons. Because the predictable annual floods also deposited fresh silt, and because the intervening dry season allowed the water table to subside, no fallow cycle (a temporary abandonment of fields) was necessary to prevent salinization and restore soil fertility.

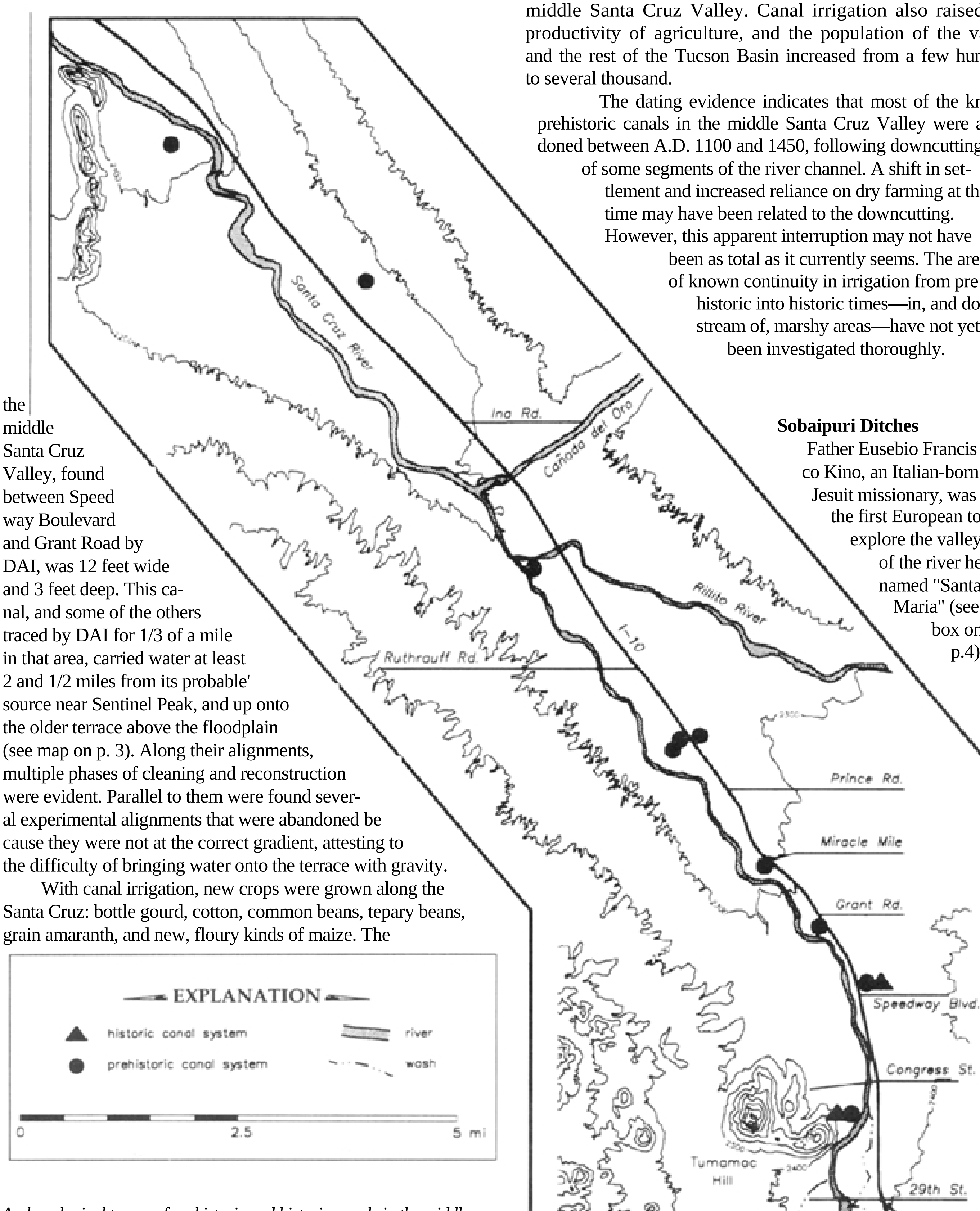
**Hohokam Canals**

After almost 2,000 years of flood farming in this manner, the first canals were built in the Santa Cruz floodplain. A canal found recently by Statistical Research, Inc., may date to before A.D. 750, making it the earliest known canal in the Tucson Basin. However, based on prehistoric sherds contained in canal sediments and radiocarbon dates of charcoal inclusions, most of the currently known prehistoric canals in the middle Santa Cruz Valley (see map on p. 2) were constructed between about A.D. 950 and 1100—coinciding with the peak period of Hohokam canal building in the Phoenix Basin.

Contrary to what archaeologists had predicted, all the prehistoric canals of the Santa Cruz Valley were not short, shallow ditches. Some were as large as some of the major Hohokam canals in the Phoenix Basin, and rivaled them in their skillful engineering. The largest known prehistoric canal in the middle Santa Cruz Valley, found between Speedway Boulevard and Grant Road by DAI, was 12 feet wide and 3 feet deep. This canal, and some of the others traced by DAI for 1/3 of a mile in that area, carried water at least 2 and 1/2 miles from its probable' source near Sentinel Peak, and up onto the older terrace above the floodplain (see map on p. 3). Along their alignments, multiple phases of cleaning and reconstruction were evident. Parallel to them were found several experimental alignments that were abandoned because they were not at the correct gradient, attesting to the difficulty of bringing water onto the terrace with gravity.

With canal irrigation, new crops were grown along the Santa Cruz: bottle gourd, cotton, common beans, tepary beans, grain amaranth, and new, floury kinds of maize. The lack of salt accumulation in irrigated soils in the Phoenix Basin indicates that a fallow cycle was practiced by the Hohokam in that region, and suggests that it was also practiced in the middle Santa Cruz Valley. Canal irrigation also raised the productivity of agriculture, and the population of the valley and the rest of the Tucson Basin increased from a few hundred to several thousand.

The dating evidence indicates that most of the known prehistoric canals in the middle Santa Cruz Valley were abandoned between A.D. 1100 and 1450, following downcutting of some segments of the river channel. A shift in settlement and increased reliance on dry farming at that time may have been related to the downcutting. However, this apparent interruption may not have been as total as it currently seems. The areas of known continuity in irrigation from pre historic into historic times—in, and down stream of, marshy areas—have not yet been investigated thoroughly.




*Archaeological traces of prehistoric and historic canals in the middle Santa Cruz Valley (map by Catherine Gilman and Geo-Map, Inc.).*

**Sobaipuri Ditches**

Father Eusebio Francisco Kino, an Italian-born Jesuit missionary, was the first European to explore the valley of the river he named "Santa Maria" (see box on p.4).

During his first visit in 1692, Kino found Piman-speaking Sobaipuri people at the village of Bac south of Martinez Hill, and the following year, at the village of Tucson near the foot of Sentinel Peak. The basalt dikes formed by these volcanic hills forced the underground flow to the surface to create marshes ("cienegas" in Spanish) that were ideal for shallow ditches intercepting the high water tables. Springs in the marshes were also tapped, and downstream, where the river flowed on the surface, water was diverted by brush weirs into canals. Between Sentinel Peak and the Rillito, on the east bank of the river, the inhabitants of the village of Oiaur also irrigated crops in the floodplain.

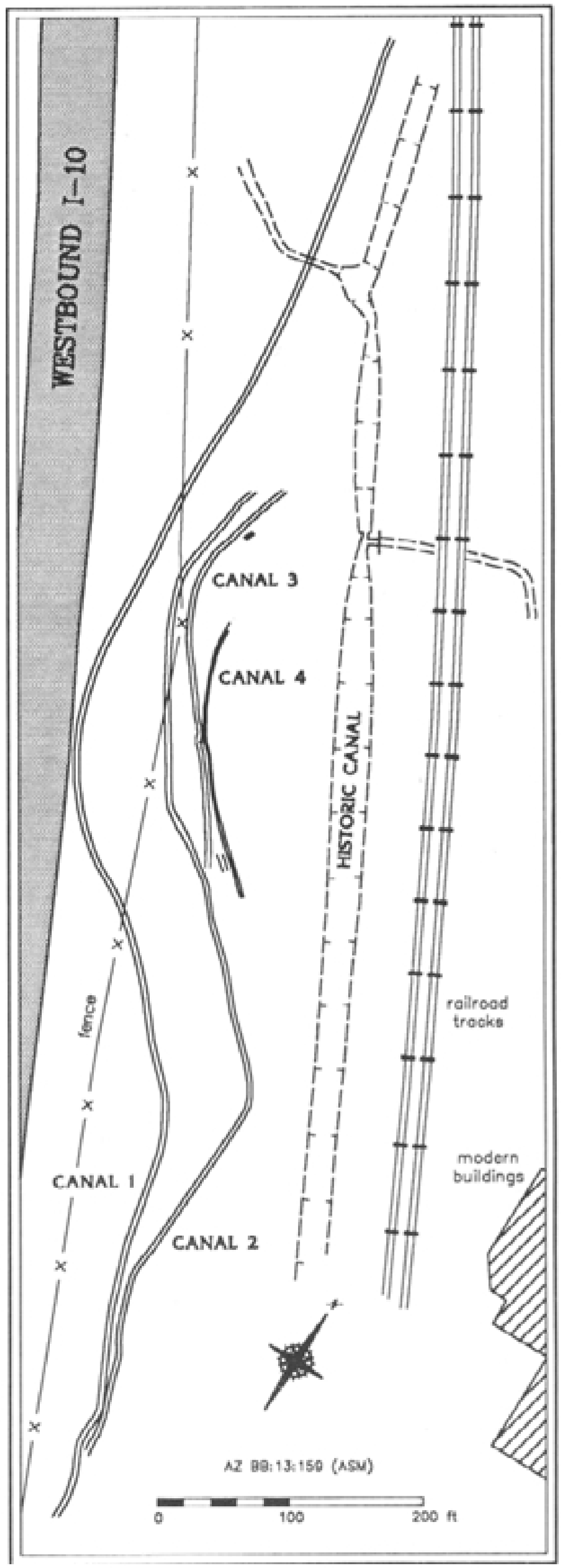
These irrigated oases supported sizeable populations. On November 23, 1697, the Spanish explorer Captain Juan Mateo Manje, traveling with Father Kino, described the scene in his diary: "…after going six leagues, we came to the settlement of San Agustin del Oiaur. . . Here the river runs a full flow of water, though the horses forded it without difficulty. There are good pasture and agricultural lands with a canal for irrigation." He counted 750 people in 186 houses, and at San Xavier, another 830 inhabitants subsisting from irrigated fields. In 1699, Father Kino described the irrigated agriculture at San Xavier (and exaggerated its potential): "The fields and lands for sowing were so extensive and supplied with so many irrigation ditches running along the ground that… they were sufficient for another city like Mexico."

**Spanish Acequias**

Father Kino introduced wheat and cattle to the village of Bac by 1695, and after he established a mission there in 1701, Jesuit missionaries introduced other Old World crops and livestock, such as barley, peaches, and sheep, to complement the native summer crops and wild food resources of the Sobaipuri and Papago (now known as the Tohono O'odham). The initial church site at San Xavier was adjacent to an existing canal ("acequia" in Spanish). Irrigation was also practiced in the floodplain between the mission and the Rillito.

In 1757, in the wake of Piman revolts and Apache raids, the priest and colonial soldiers at San Xavier attempted to move the mission to a more defensive position at San Cosme (the first Spanish name for Tucson). Malaria and an Indian attack soon forced them to retreat to San Xavier, however. Although the mission at San Cosme had no resident priest after its first few months, and thereafter was only a visita of San Xavier, a fortified residence and a small chapel built there in 1771 and 1772 were the first European-style structures built within the boundaries of modern Tucson (see photo on p. 4).

In addition to the irrigated gardens and orchards within the grounds of the Tucson visita, the Sobaipuris and Papagos living in the vicinity also irrigated fields on the river's west side. After the garrison of the presidio at Tubac was transferred to the east side of the river in 1775, where downtown Tucson is today, the eastern floodplain was also irrigated by Spanish settlers. Increasing competition for the water of the Rio Santa Maria led to a 1776 agreement that guaranteed threefourths for the Indian villages and one-fourth for the presidio. In the 1790s, however, the Indians' share was reduced to one-half.
Gerónimo de la Rocha's 1780 map of the Pimería Alta shows,
south of the mission visita at "Tucson" and the new Tucson presidio, a dam diverting water from the river into an acequia through the mission visita. The historic canals found by DAI near the foot of Sentinel Peak (see map on p. 2) may include some of the acequias built near the San Agustin mission in the late eighteenth century.




*Prehistoric canals, probably built in the eleventh century ,traced for a third of a mile between Speedway Blvd. and Grant Rd. On the east side I-10. The "East Side Canal," built in 1895-96, follows the same alignment on the edge of the terrace above the floodplain (map by Geo-Map, Inc.)*

*A woman washing clothes in the Santa Cruz River below the ruin of the Convento of the San Agustin mission visita, 1894 (photo no. 21969 courtesy of the Arizona Historical Society).*

**A Sonoran Irrigation Community**

After Mexico gained independence from Spain in 1821, and new settlers began to arrive from the south, the traditional Sonoran system of irrigated agriculture was established in Tucson. Mediterranean winter crops of wheat, barley, chick-peas, lentils, onions, and garlic followed the native summer crops of corn, beans, squash, pumpkins, chili peppers, tobacco, and cotton. The three "acequias madres" (mother canals) were maintained as common property by a "común de agua" (irrigator community), and an elected "zanjero" (overseer) supervised water distribution. The irrigation schedule was flexible, with water turns arranged according to varying crop needs, and water shortages were shared proportionally. First use of water was reserved for fields south of the "hospital road" (later St. Mary's Road), while fields to the north were irrigated only during relatively wet years. This northern area grew hay and was used as pasturage for cattle. The canal alignments, field boundaries, and property lines of this traditional irrigation system are recorded on a map surveyed during the Civil War for Colonel David Fergusson of the United States Army (see map on p. 5).

Mexican rancheros irrigated cattle pastures in the valley south of Tucson. In 1849 Jose Maria Martinez, former comandante of the Tucson presidio and a famous Apache fighter, cleared land east of San Xavier, on the west side of the river, and cut a ditch to the spring called "Punta de Agua." The Acequia de Punta de Agua irrigated his field west of what came to be known as "Martinez Hill," and the "Agua de la Misión" acequia irrigated fields of the Papagos at the mission.

Anglo forty-niners passing through on their way to the California gold fields described the farmlands near Tucson and San Xavier as "rich and fertile to the extreme." In 1852, John Russell Bartlett, conducting a survey of the new border after the Mexican-American War, was impressed by the scene that greeted him in Tucson: "irrigating canals in every direction, the lines of which are marked by rows of cottonwoods and willows, presenting an agreeable landscape."

**Anglo Water Development Schemes**

The 1854 Gadsden Purchase opened the territory south of the Gila River to Americans, and newly arriving "Anglos" impounded the river at several points to provide heads of water to power flour mills. Agriculture was the next focus of Anglo attempts to profit from water development (though Hispanic businessmen were also partners). In the early 1880s, Samuel Hughes, W. C. Davis, and Leopoldo Carillo purchased floodplain land upstream of the traditional fields. They cleared them for new fields and excavated deep ditches to increase the water supply to the vegetable gardens of their tenants, mostly Chinese who had arrived as railroad workers in 1880.

The impounding of water in reservoirs and the increased water use by the upstream entrepreneurs diminished the supply to the downstream Mexican-American farmers, who fought for their water rights in court. However, the defendants defeated the 1884-1885 court challenge by citing the western U.S. water law of "prior appropriation" as superceding local

## The Changing Names of Tucson and the Santa Cruz River

At the time of Spanish contact in the late seventeenth century, the Piman name for the small settlement at Tucson was *schookson* or *schook-shon,* meaning "at the foot of the black [?]." "Tucson" became the Spanish written form. Many contemporary scholars and Piman speakers believe the name referred to the black volcanic hill known historically as Sierra de la Frente Negra, Sentinel Peak, and Warner's Hill, and known today as "A" Mountain.

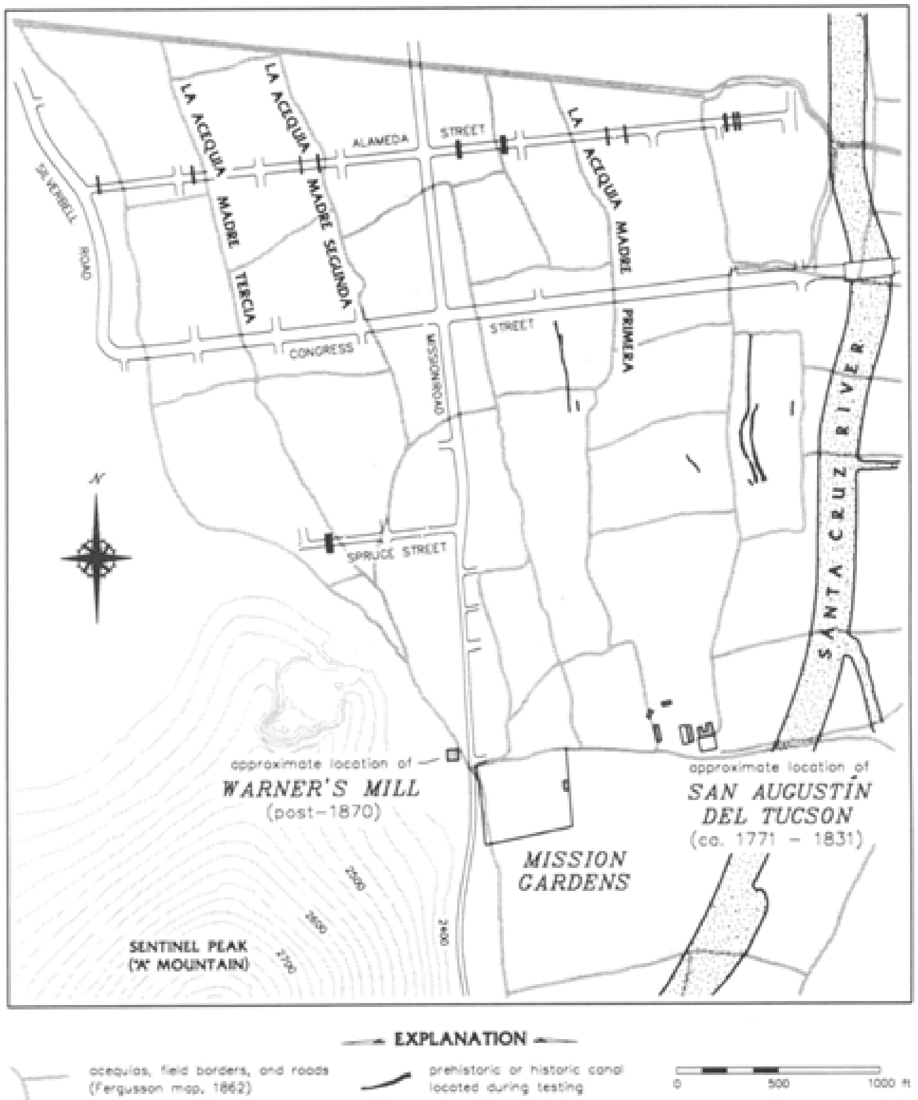
On his 1695-1696 map of northwestern New Spain, Father Kino labeled the closely spaced villages of Bac, Tucson, and Oiaur in the middle Santa Cruz Valley as "San Xavier," "San Cosme," and "San Agustín." In his diaries and letters he usually combined the Spanish and Piman names (San Xavier del Bac, San Cosme de Tucson, San Agustin de Oiaur), During the Spanish period, the mission visita at Tucson changed names several times, being referred to as "San Cosme" from the 1690s through the 1750s, "San Jose" in the 1760s, and "San Agustín" from the 1770s until 1831, when it was abandoned.

Kino named the Río Santa María after the patron saint he had assigned to the village of Soamca near its headwaters. The Santa Cruz River acquired its modern name gradually after 1787, when the presidio of Santa Cruz de Terrenate was relocated from the upper San Pedro Valley to Soamca.

customs (the defendants had purchased some of the oldest fields in the valley). This ruling represented the beginning of the end of the traditional system of irrigated agriculture in the Santa Cruz Valley.

In place of the irrigation community, corporations competed for the river's water. By 1891, in addition to the three old ditches (then called the El Cumoso, Misional, and Del Rey acequias), 33 other ditches comprising a total length of 56 miles had been constructed in the Santa Cruz floodplain by corporate enterprises. During this swirl of land speculation and water development schemes in the late nineteenth century, the current form of the Santa Cruz River, a dry bed up to 20 feet below the top of the banks, was created by a combination of human error and natural disasters.

Attempting to increase the water supply to his fields north of the hospital road, Sam Hughes constructed a new, deep ditch in 1887 to intercept the subsurface flow. Large floods during the next four years caused the ditch to downcut to the water table lowered by drought and overgrazing, and caused the headcut to erode rapidly southward. Steady progression of the headcut and the channel's increasing width were reported with alarm in the newspaper. By 1910 the headcut coalesced with another downcut segment near San Xavier, resulting in the deeply incised river channel of today. The effect on irrigated agriculture was disastrous: the downcutting of the main channel stranded canal intakes above the river, and other flood channels severely damaged canals.




*Historic canals (acequias) built during the Spanish and Mexican periods in the floodplain near "A" Mountain. Below the surface, archaeologists have found canals near the alignments shown on a Civil War-era map (map by Geo-Map,Inc.)*

In 1891, Frank and Warren Allison began work to repair the irrigation system on the west side of the river. They built a new reservoir near the old Warner Dam site and a ditch that extended north to Stevens Avenue (later Congress Street) by 1895 (see photo on p. 6). At first the project was a success, but soon their 1,160 acres of fields were accumulating crop-damaging salts from intensive, uninterrupted irrigation. The unlined, 12-foot-wide historic canal on the east side of 1-10 north of Speedway Boulevard, recently investigated by DAI (see map on p. 3), is probably a remnant of the "East Side Canal" constructed by the Allisons in 1895-1896 after much of their land on the west side became too salinized for agriculture. From their new 10- to 15-ft-deep artesian wells at the foot of Sentinel Peak, the brothers built a flume that carried water across the river to the east bank. The water in this five-mile-long canal powered a new flour mill just north of what is now Speedway Boulevard. It then irrigated their land to the north, which they called "Flowing Wells" after a new source of water they located there. The Tucson Canal Company, incorporated in 1896, financed construction of a canal south of the Allisons', tapping a source near the San Xavier mission.

In 1902 the Allisons sold their property to Levi Manning, a surveyor and businessman who became Tucson's mayor in 1905. He further developed the well field below Sentinel Peak, drilling new wells to tap the now 20-ft-deep subsurface flow of the river. The East Side Canal soon became known as "Manning's Ditch." By 1910, four main canals fed by Manning's wells were irrigating the floodplain west of Tucson.

A group of Chicago and British investors bought part of Manning's land in 1911. Upstream of Manning's Ditch, they developed the "Crosscut"—a line of 19 new wells across the floodplain, ranging from 45 to 150 feet deep and connected underground by a horizontal shaft. Calling themselves the Tucson Farms Company, they also installed electric pumps; replaced the old flume across the river with a 4-foot-diameter concrete siphon below the riverbed; extended Manning's Ditch to a total length of seven miles; lined some canal segments

*The Allison brothers' West Side Canal was built in the early 1890s to revive irrigated agriculture after the river became entrenched (photo 110. 4250 courtesy of the Arizona Historical Society).*

with cement; and added reinforced concrete headgates, drop structures, and lateral turnouts. The company peddled the land to Midwestern farmers for $200 to $300 an acre, but it was not a financial success. In 1922 a group of farmers formed the Flowing Wells Irrigation District and assumed control of the Crosscut and distribution system. A large flood in 1940 destroyed most of these waterworks, bringing an end to irrigation in the middle Santa Cruz Valley near Tucson.

**Conclusion**

The long history of irrigation in the middle Santa Cruz Valley includes both impressive achievements and disastrous mistakes. By constructing canals on the older terrace above the floodplain, prehistoric and historic hydraulic engineers were able to maximize the irrigated area. There was continuity in irrigation from prehistoric into historic times in, and downstream of, the marshy cienegas near Point of Mountain, Sentinel Peak, and Martinez Hill, and nineteenth-century canals often followed the same alignments as eleventh-century ones. The scale of some of the prehistoric canals, and their multiple phases of construction and repair, represent significant labor investments over many centuries. The several superimposed channels along each alignment of the prehistoric canals, and the high berms composed of sediments dredged from historic canals, indicate that siltation was a constant problem requiring frequent canal cleaning.

Although Sonoran farmers, and probably their Hohokam and Sobaipuri predecessors, practiced a fallow cycle to prevent salinization, waterlogging, and loss of soil fertility, early Anglo farmers often irrigated intensively without interruption, forcing them to abandon fields after only a few years. By impounding the river to run mills, and by deepening ditches to increase water supplies, nineteenth-century entrepreneurs doomed the traditional system of agriculture and triggered downcutting that permanently ruined the floodplain's potential for gravity irrigation. Today, the perennial river and the rich agricultural lands it irrigated for at least 1,000 years are only recorded in archaeological remains, faded newspapers and photographs, and the memories of Tucson's oldest citizens.

**Acknowledgments**

Prehistoric canals near Tucson have previously been discovered by the Arizona State Museum, and are currently being investigated by Desert Archaeology, Inc., and Statistical Research, Inc. Information from researchers at those institutions benefited the authors. Historical irrigation in this area is intertwined with social and economic history, and this article also relies on the research of leading local historians, including: Bernard L. Fontana, Charles W. Polzer, James E. Officer, Thomas E. Sheridan, and Jack Williams. Julio L. Betancourt and Raymond M. Turner have documented the historical changes in the Santa Cruz River. They and Douglas Kupel have also researched historic water control along the river. The published works of these individuals can be found in the University of Arizona library.

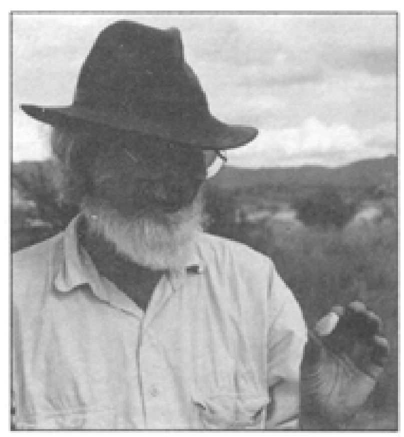
# Cienega Valley Survey Update

*by Michelle Stevens, Center for Desert Archaeology*

The Cienega Valley Survey is being conducted by the Center for Desert Archaeology along Cienega Creek southeast of Tucson. Two principal areas are being investigated: Pima County's Cienega Creek Natural Preserve and BLM's Empire-Cienega Resource Area. Both areas have relatively lush riparian habitats, but the Empire-Cienega Resource Area, being at a higher elevation, also has extensive grasslands.

Since the project began earlier this year, 34 volunteers have surveyed about 3,600 acres. Sixty-two new sites have been recorded, and 18 previously recorded sites have been revisited. Although all of the collected artifacts have not yet been analyzed, preliminary analyses indicate Archaic through Historic period sites are present.

One of the research objectives of this project is to study land-use and settlement patterns during the Archaic and early ceramic periods. Since several deeply buried Archaic sites are already known in this area, a goal of the first field season was to assess the area's potential for yielding Archaic period surface sites. The discovery of several "new" Archaic sites on the surface is encouraging, and confirms our expectations of the area's potential.



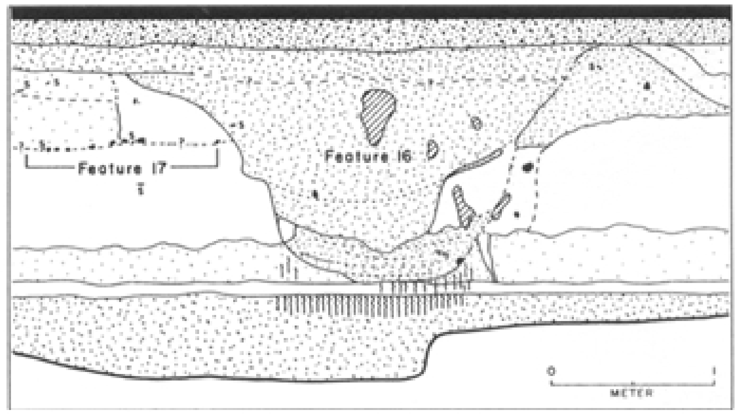
*Bob Conforti with all engraved Oliva shell found at a Classic period site along Cienega Creek*

Although about half of the Cienega Creek County Preserve has been surveyed, we are spending most of this season surveying in the largely unexplored Empire-Cienega Resource Area. If you are a current AIT member and want to volunteer, please call Irina at 881-2244 to sign up for a specific date. To become a member, see page 8. Upcoming survey dates are Sunday, November 19; Saturday, December 2; and Sunday, December 17 (8 a.m. to 5 p.m).

CANAL GEOMORPHOLOGY

# Reading the Stories of Ancient Canals

*by Andrea K. L. Freeman, Center for Desert Archaeology*




*Cross-section of a buried prehistoric canal found on the west side of the Santa Cruz River beneath Alameda Street. The U-shaped profile and mineral stains below are common characteristics of prehistoric canals in the Sonoran Desert.*

Geomorphology is the study of the characteristics, origin, and development of landforms. Since a canal is a landform very similar to a river, canal geomorphology is very much like river geomorphology. Geologists who study rivers are interested in understanding how rivers are formed, how they maintain their channels, and what factors change the shape or direction of the river channel. Canals differ from rivers because they are produced, maintained, and abandoned by people; however, their similarities allow archaeologists to use geology as a tool for understanding ancient irrigation systems.

**Shape and Size**

Canal shape can indicate the use of a canal segment and sometimes the age of the canal. Prehistoric canals are usually U-shaped in cross-section. Although some historic canals, particularly smaller distribution canals, have a U-shaped cross-section, most main canals built during the historic period are trapezoidal. Historic canals are usually wider and deeper than prehistoric canals, and the width-to-depth ratio is usually much larger.

These wider canals were more efficient, and represent improvements in canal engineering unfamiliar to prehistoric canal builders. Canal size, shape, and number can also provide information about the magnitude of past agricultural systems. Canal size, shape, and slope are critical factors for estimating the amount of water that can be delivered by a canal system, which determines how much land can be irrigated.

**Sediments and Stratigraphy**

The sediments found within canals usually conform to the overall shape of the canal. Sediments filling a U-shaped canal will take on a "U" shape, and sediments filling a trapezoidal canal will tend to be more horizontal. These sediments are influenced by the river from which 'the canal draws water, and the speed with which that water enters the canal system.

When water is initially drawn from a river, it enters the canal rapidly. Only the larger particles will settle to the bottom, so coarse sands and gravels are usually deposited in canals when they are first used. Slow or stagnant water, characteristic of infrequently used or abandoned canals, will allow finer particles, like clay and silt, to settle to the bottom. These sediments are often removed during canal maintenance, so the sediments that we see often represent only the last use of the canal. The types of sediment found in canals can help archaeologists understand whether the people using them were successful at building and maintaining efficient canals.

The geomorphic context of canal placement can also offer useful information about human decision making. For example, in our study of historic acequias along Alameda Street, we discovered that many of the historic canals were excavated into former channels of the Santa Cruz River. These ancient channels provided topographic depressions into which canals could be built with considerably less effort.

**Minerals**

Stains from the oxidation of iron and manganese minerals are often found at the base of canals. Their presence indicates waterlogged conditions where water is stagnant, plant growth is present, and no fresh, oxygenated water is entering the system. These conditions are often characterized by dark, clayey deposits; red or orange "rust-like" stains from mineral oxidation; and small, black nodules of manganese or iron.

Changes in the agricultural use of the land and the frequency of canal use may have created the ideal conditions for these minerals to accumulate. Historic accounts of land use west of the Santa Cruz River suggest that certain crops required less irrigation than others. Political disputes over water rights affected the availability of water to parts of the canal system, and also influenced the effort made to maintain canals that were not in use. Since lower water applications and canal abandonments would lead to stagnant water and plant growth, the presence of iron and manganese deposits at the base of canals may mark periods characterized by changes in land use and political conditions.

**Shells**

Shells of freshwater mollusks (gastropods) and smaller "ostracodes" can provide information about canal siltation and water salinity. The presence of the shells of these animals marks the silting up of a canal. As the flow rate decreases and salt content increases with evaporation, species adapted to higher salinity appear in the sediments.

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**ADDRESS CORRECTION REQUESTED**

*An engraved Oliva shell was recently found at a Classic period site along Cienega Creek (see survey update on page* 6).

## Time to Renew?

If your address label indicates that your *Archaeology in Tucson* membership has expired, please renew promptly to remain eligible for all activities, newsletters, and discounts on T-shirts and Center for Desert Archaeology publications.

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ACKNOWLEDGMENTS
The lead article was reviewed by William Doelle. Michelle Stevens took the photographs of Bob Conforti and the *Oliva* shell. Donna Breckenridge edited, formatted, and provided creative ideas. This newsletter and the summer issue were mailed by Irina Hynes.

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