Prehistoric Bajada "Hanging" Canals of the Safford Basin: Small Corporate Group Engineering in Southeastern Arizona

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Ongoing archaeological survey in the arid **Safford** Basin has disclosed a series of exceptional small **prehistoric** canals (**Figure 1 — Lancaster 2015**) that greatly expanded our knowledge of water management engineering and agricultural intensification in the American Southwest.

These highly unusual canals are found in an area where other older and contemporaneous water management schemes are also present, including: conventional lowland riverine canals (**Neely and Murphy 2008**), extensive non-irrigated terraced and gridded fields (**Doolittle and Neely 2004**), numerous check-dams, and grouped arrays of agricultural mulch rings and rockpiles.

Fifty-nine **bajada** canal systems and segments have been identified to date, many of which are shown in **Figure 1**. The longest are about 9.5 kilometers, and the total length of all systems exceeds 112 kilometers (ca. 70 miles).

These canals have been difficult to date since our study has been based solely on surface survey. We have depended on **stratigraphy**, surface artifact finds, and associated prehistoric sites to provide temporal parameters. While a few canals may date as early as ca. A.D. 800, the vast majority appears to originate after ca. A.D. 1250 with some persisting until ca. A.D. 1450.

The canal systems differ from the prehistoric canal systems found in the vicinity of Phoenix and elsewhere in the Southwest in that they obtained their water from the **Pinaleño** Mountain **bajada** drainages which are fed by runoff, springs, and artesian sources, rather than from rivers.

They are also unusual in that they traverse the vertically undulating to severely erratic uplands of **basin and range** topography rather than being restricted to a

nearly level riverine floodplain. Some carry their water load from over 1650 m down to just above the floodplain of the **Gila River** at about 900 m. The difficulty in the original excavation of these systems is further intensified by the very rocky nature of much of the terrain that they traverse.

In more level terrain, the canals are of the traditional type — narrow and linear excavations into the ground surface that slightly cross cut the contours of the landscape at a broadly obtuse angle. In other locations within the same canal system, they appear as "perched" or "hanging" canals traversing the sheer sides of mesas, with some coursing 60 meters above the adjacent basin floor **(Figure 2)**.

The canals often create the illusion of water flowing uphill in that the mesa top slope is usually somewhat steeper than the rate of fall of the canal itself. In these latter cases, **the perched or hanging segments are designed to follow the most direct route** and are essentially independent of their surrounding terrain. This reduces the energy input needed to excavate additional canal length to follow the irregularities of the topography. Such construction would also reduce water loss through seepage and evapotranspiration.

After reaching a mesa top through a long, gentle, and an evidently carefully calculated optimal grade, and then continuing as far as possible along the usually flat but gently sloping ground surface, the canals will typically "fall off" the far end of the mesa in steep but apparently highly controlled and nondestructive cascades descending in nearly vertical constructions similar to **French Drains**.

Canal cross-sections **(Figure 3)** at the ground surface vary from 0.30 m to one meter, and 20 to 40 centimeters in depth. Atypical examples may range as much as two to three meters in width.

As with many of the **Gila River** area bottomland canals, the historic inhabitants of the greater Safford area refurbished some of these prehistoric canals, and several reaches of the canals still flow to this day. However, most retain enough integrity to be recognized as having a prehistoric origin. In particular, short "low energy" segments remain extant and highly suggestive of prehistoric origins.

Portions of most of the systems remain almost pristine, and are currently filled with fine-grained sediments. These systems are located mostly on **Arizona State** and **Coronado National Forest** lands that remain largely undeveloped.

While often of difficult access, as there are few roads and fewer mesa top trails, major canal portions are usually easily traced on foot and by satellite imagery such as **Acme Mapper**. Unfortunately, both historic and modern constructions and land modifications, mostly near the terminus of the canal, have negatively affected these systems.

A number of unusual constructions were incorporated into some of these canal systems; three examples are: first, an aqueduct, about one and a half meters in height and 80 meters long, was built to bridge a "saddle" in the topography that was associated with a prehistoric segment of the Lebanon Canal.

The second example is at a point where the primary Frye Mesa Canal is situated near the top edge of the mesa, a branching "counterflow" canal was excavated down the mesa slope at an acute angle apparently to irrigate fields lying below and behind the point of branching. Alternately, several distant canals may yet verify this as a viable source.

The third example is a three meter wide and two meter deep segment of the Allen canal. Due to its size we have referred to it as the **"Culebra"** cut.

Several canal systems illustrate elaborate methods of purposeful switching of the water routes from canals to natural drainages, and then back to canals. In sum, these systems appear to represent a major understanding and a very careful exploitation of the topography and hydraulic fundamentals, as well as attention to extreme energy and use efficiency.

In one example involving Ash Creek and Mud Springs canyons, the canal route clearly crosses a watershed saddle in a uniquely optimal manner. A second watershed crossing is suggested but not yet verified at the head of Frye Creek, and a third appears a distinct possibility further west.

The discovery of these canals and our continuing survey in the **Safford** Basin suggests that the basin was a prehistoric population center and a major supplier of cultivated crops. Their use seems to be primarily long distance water delivery to fields, but in certain areas the canals also apparently supplied water to small habitation sites and complexes.

Survey in Lefthand Canyon (near the west boundary of our survey—**Neely 2005**) and Marijilda Canyon (near the east boundary of our survey—**Neely** In Preparation) has recorded a rather heavy population scattered along the canals, but the sites are nearly all small. To date, survey along most of the other canals has recorded only a few small sites.

These findings provide evidence in the form of agricultural intensification and settlement that point to a sociopolitical organization based on the collaboration and collective action of small corporate groups rather than a more complex social stratification and socio-political structure. These finding parallel a study by **Hunt et al. (2005)** focusing on the nearby **Hohokam** area.

Ceramics and house remains from contemporary habitation sites indicate both trading activity as well as actual residence by several of the prehistoric cultural groups of the Southwest including the master canal builders of the Phoenix area, the Hohokam **(Purcell and Clark 2008)**. It seems likely that the canals were engineered and constructed by the local Safford Basin inhabitants due to the presence of conventional lowland riverine canals dating as early as ca. 190 B.C. **(Huckleberry 2005** and **Neely and Murphy 2008**).

As the associated sites, with **Salado** ceramics and architecture, date to the period of ca. A.D. 1250-1450, the hanging canal systems appear to have largely been engineered and constructed by the northern migrants. However, due to the

apparent near absence of canal systems in the four-corners area, the Hohokam presence noted above **(Purcell and Clark 2008)** makes us wonder if the Hohokam residents may have at least in part assisted in engineering the later more sophisticated canal constructions.

The engineering involved in the planning and construction of these canals seems utterly phenomenal considering the lack of leveling instruments and metal tools. It would appear possible that pilot extensions of the canals themselves could have served as **water levels** in spite of the tedious and time-consuming application involved.

Engineering can be defined as a sense of the fitness of things. Aptly meeting this criterion, the Safford Basin bajada canal systems are a highly sophisticated innovation that is superbly energy optimal and a brilliant engineering solution for reliable water transport and delivery over the **basin and range** topography of the area. They are a phenomenal prehistoric adaptation to an arid environment to irrigate agricultural fields distant from once apparently abundant water sources.

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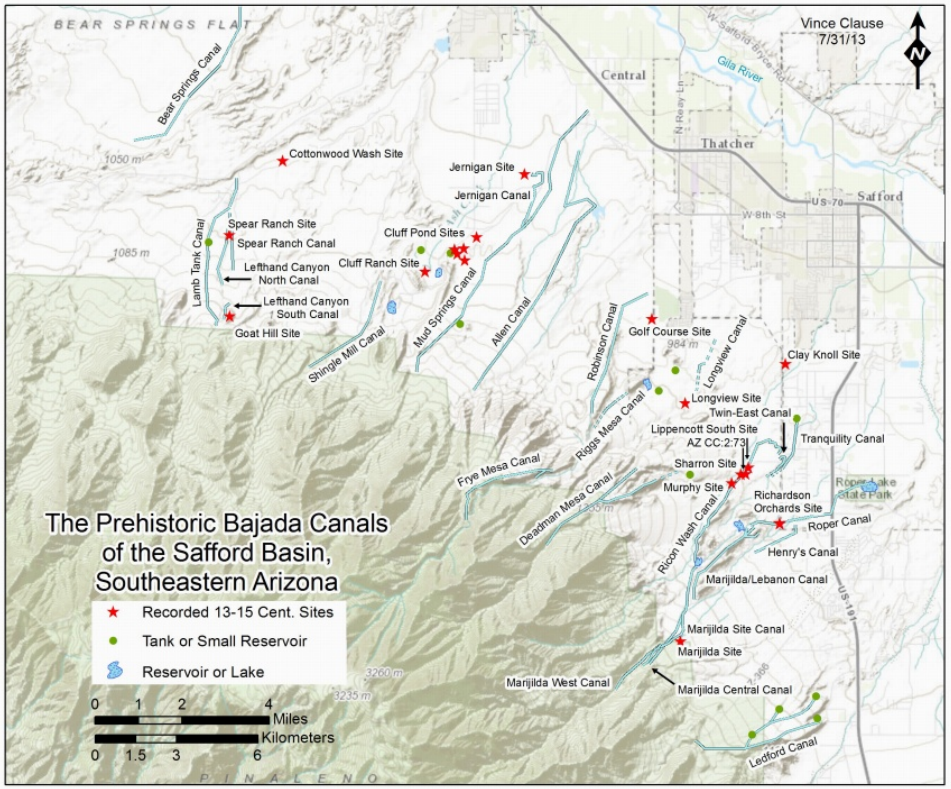

Figure 1. Locations of some of the bajada sourced canals recorded to date.

Figure 2. Hanging canal (middleground) flowing from right to left along the west side of the long and narrow mesa landform near the mouth of Marijilda Canyon. At this point, the canal is about 50 meters above the basin floor. The canal coursing upslope illusion is discernible.

Figure 3. Looking down canal at the narrow, nearly completely filled channel of the Robinson Canal as it routes along the steep side of a mesa on its way to fields on Robinson Flat. Note the illusion of the canal coursing upslope.