1-22-04

On January 22, 2004, the attached 10 pages were handed to me by Jon Fuller as the replacement for Section 6 of the Santa Cruz River Report, in Tucson, Arizona.

George Mehnert, January 26, 2004

SUMMARY

The following is a summary of the key findings of the following sections of this report addressing the archaeology, history, hydrology, hydraulics, geomorphology, and land use of the Santa Cruz River from the confluence with the Gila River to the headwaters. Refer to Figure 1 for a map of the Santa Cruz River basin showing the location of the place names mentioned in the text. The most pertinent findings relative to the legislatively mandated evidence of navigation or evidence of susceptibility to navigation are compiled to provide information to support a determination by others of navigability or non-navigability of the Santa Cruz River. This report does not make a recommendation or conclusion regarding title navigability of the Santa Cruz River.

Evidence of Navigation

Archaeological Evidence

Archaeological data augment the historical record of potential river uses at statehood by providing an extended record of river conditions, use of river water, climatic variability, and cultural history along the river. The investigation of the archaeological record focused on prehistoric uses of the river as evidenced by settlement patterns, the presence of canals for irrigated agriculture, and transportation and/or trade routes on or along the river.

Settlement Patterns- The archaeological literature documents prehistoric settlements distributed both temporally and spatially throughout the Santa Cruz River valley. Late Archaic sites (2000- ca. 100 B.C.) were located in floodplains, areas adjacent to floodplains, or alluvial fans. During the Archaic-Hohokam transitional stage (ca. 50 B.C.-A.D. 425), settlement patterns, consisting of agricultural hamlets in floodplain settings and camps in bajada areas, reflected a subsistence strategy based on floodwater farming of maize, hunting, and foraging in the bajada and upland zones. During the Hohokam Pioneer period/late Early Formative period (A.D. 425- 750), the Hohokam emerged as a regional culture with the Tucson Basin becoming a local node in the Hohokam regional system.

Shifts in settlement patterns through time are evident. By the end of the Hohokam Colonial period (A.D. 750- 950), an expanding populationsettled most villages along secondary rather than primary drainages of the Santa Cruz River in the Tucson Basin. Settlement locations further shifted away from floodplains during the late Hohokam Sedentary period (A.D. 950- 1150) partly due to entrenchment - progressive degradation of the streambed - and cienega - marsh - formation. As a result, non-riverine agricultural features began to appear on terraces and bajadas. There was continued use of non riverine agricultural systems as well as floodwaterfarming during the Hohokam Classic period (A.D. 1150- 1400).

Irrigated Agriculture- Prehistoric populations took advantage of potential agricultural areas as conditions allowed, partly because the floodplain environment of the river was highly variable. Arroyo fan deltas and discontinuous gully fan environments had floodwater agricultural potential and Hohokam settlers appeared to locate in those areas for the purpose of optimizing farming conditions.

Certain archaeological investigators suggest that the floodplain environment and surface hydrology of the river was not conducive to canal irrigation, but limited canal or ditch irrigation would have been feasible near cienega environments. Others believe that canals may have been present on a small scale, possibly in association with the primary villages. In fact, recent archaeological findings indicate farming villages near Tucson were using surface water to irrigate crops as long as 2000 to 3000 years ago. These same people supplemented theirdiet with fish caught from the river. More recently, 300 to 400 years ago, Indians were still irrigating crops with surface water near Tucson, San Xavier, and Tubac. This practice continued during the period of the development of the Spanish missions ofsouthern Arizona and well into the period of Anglo settlement.

Transportation and Trade- The archaeological record indicates that the Tucson Basin became a local node in the Hohokam regional trade system. Interregionalexchange is evident by the presence of Mogollon ceramics from the mountainous regions to the east and by shell artifacts from the Sea of Cortez. Further, the Santa Cruz River was the line of communication for the dissemination of new types of pottery, notably, Rincon

polychrome vessels among others. Vessels of this type were found at the north and south extremities of the river. The river valley functioned as a communication, transportation, and trade corridor in prehistoric times. No evidence was found to suggest that the early inhabitants of the valley used boats on the river.

Historical Summary

Historical data provide information on actual river uses at the time of statehood, and also provide information on whether river conditions would have supported navigation. The historical investigation focused on use of the river and adjacent areas in historic times, with special emphasis on the establishment, growth, and development of towns, irrigation systems, commercial activities, and developments.

During the historical period, the Santa Cruz River was an important transportation route for Native Americans, missionaries and Spanish explorers, colonizers and wanderers, miners and cattlemen, and new residents. It provided a well-established route from the south and the east into present-day Arizona as far as Tucson, providing water, forage, and food for the traveler. The river also provided water, wood, food, and shelter for the people who lived near it. Farmers diverted the surface water of the river. Millers, both of flour and ore, powered their grinders with Santa Cruz water. Entrepreneurs dammed the river, and the lakes that were created were used by the public for fishing, boating, picnicking, and swimming. Much of the settlement in southern Arizona, to date, is within the valley of the Santa Cruz River.

Probable Condition of the River in 1912- At the time of statehood, the river was probably still perennial - flowing year round - in some of the reaches that had historic surface flow, but intermittent - flowing only during portions of the year - in more areas than previously. An important difference was that the vegetative structure of the valley was much different, and the entrenchment - the progressive degradation of the streambed - of the river meant that surface waters visible in 1912 were much lower than 25 years earlier. In many areas riparian vegetation had been cut for wood or lumber, and farms or homes used much of the water riparian trees had formerly used.

The U.S. Geological Survey Streamgage Summaries report that essentially the entire flow of surface waters from the river were diverted both at the Nogles and Tucson gaging stations by irrigation ditches (USGS 1907, 1912). Agricultural water use in the Tubac, Tucson, and San Xavier areas used most of the available surface water and also intercepted groundwater and subsurface flow. Diversions and pumping also diminished flows on tributaries, especially the Rillito River. In 1910, the University of Arizona Agricultural Experiment Station estimated that flow from the Rillito River reached the Gila River 1 in 15 years (Smith, 1910).

The upper reach of the Santa Cruz River, located in Santa Cruz County, has its headwaters in the San Rafael Valley of southeastern Arizona. Historically, the river consisted of shallow flows similar to present conditions. The river through Mexico still flowed dependably. From the border downstream to the Sonoita Creek confluencethe Santa Cruz River was dry much of the time because of diversions. With the addition of Sonoita Creek waters downstream of the confluence, there was again surface flow visible in the river. Much of that water was diverted for agriculture along the river downstream of Calabasas to the north.

The middle Santa Cruz River reach is defined as that portion of the river located in Pima County. In this reach, the springs were drying up in the San Xavier area and diversions and pumping took most, if not all,the flow. A high water table still supported a lush mesquite bosque south of the mission. The City of Tucson and many others had dug wells in numerous locations, some as far south as San Xavier, which intercepted flow and lowered the groundwater table. In 1915, the first year such measurements were systematically taken, the Santa Cruz River and the Rillito River flowed less than half the year. Through Tucson the deeply entrenched channel carried some flows, but all of the low flow was diverted before the Congress Street bridge. Springs and groundwater still supported some agriculture downstream of Tucson, but there was little perennial flow.

The lower Santa Cruz River, in Pinal County downstream of Marana, continued to have little flowing water exceptin years of high rainfall.

Navigation Accounts- Although the river valley was an important transportation route, it was not normally used for navigation except for the following accounts found in the literature:

- A land speculator portrayed the river at Calabasas (downstream of Nogales) as capable of floating steamboats in the 1880s. This, however, was pure fiction but gave rise to the belief that surfaces, occasionally even today, that the river was navigated by large ships.

- During the 1880s, Silver Lake (a manmade lake just south of downtown Tucson on the Santa Cruz River) was a popular recreation area, featuring boating, fishing and swimming. A paddle boat on the lake was a major attraction. Boating both by rowing and sail was popular in the lake and upstream. Silver Lake was damaged by a combination of floods in the late 1880's, and finally destroyed in 1890. The dam itself was reported standing until the floods of 1900. Based on the limited information availdble, other conditions (possibly the increase in other water diversions) made the existence of a reservoir behind the dam impossible.

- In December 1914, during a flood period, a group of adventurers attempted to float the Upper Santa Cruz River, but weregrounded. The boat was later located buried in mud. Also in the 1914 flood, numerous people were stranded on rooftops and windmills near Sahuarita. The Arizona National Guard went to rescue them with an inflatable boat, but the current was too strong and the effort was unsuccessful. Later the people were rescued with horses.

- Occasionally, in recent times, a canoer or rafter has floated the river during flood time. Tubers floated the Santa Cruz River in the 1970s during flood time. The Tucson Weekly featured a canoer traveling the effluentdominated stretch in July 1990, a trip which he repeated during flood time for theTucson Weekly photographer. TheTucson Citizen reported canoes on the Rillito River during the 1990 flood. The same canoers havealso traveled on the Santa Cruz and Agua Caliente at various times in the 1990s. These canoers stated that when they also traveled the river during the winter of 198990, it was "a reasonable canoeing river", but when they made the trip in the summer, itwas "more like the Grand Canyon" in terms of difficulty. They are knowledgable with regard to local boating groups, but are unaware of any attempts to boat the upper Santa Cruz River, although they state that it is certainly feasible. Canoers state that the Santa Cruz is just barely navigable by canoe with 4" of water, but that the channel topography is a limiting factor as sand bars are frequent.

- There are no stories of boating at any time on the lower Santa Cruz, although during one high flood eventTucsonan Sam Hughes expressed, in his opinion, that the river was "big enough to float a steamboat all the way to the sea."

- There are no records of ferry service anywhere on the river. Fords and crossable washes are marked on numerous maps. When the bridges went out during floods, people were stranded and had to wait until the river could be crossed by horse. No evidence of boats being used to cross the river at flood time were found.

- No evidence was found of the river being used to transport goods such as logs.

- John Spring recorded in his diary that there was an old Mexican settler who had carved a canoe to cross the upper Santa Cruz River when flooding made it too high to cross on the road. According to Spring, this is the origin of the name for that area of the Santa Cruz Valley, "La Canoa."

Changes in the River- The three distinct sections of the river had very different histories. The upper and middle reaches, located in Santa Cruz and Pima Counties respectively, were used extensively by native peoples, Spaniards, and later Americans. The lower reach, located in Pinal County, had much less dependable water and was used much less. Because of underlying geology and the fact that population eventually centered in the Tucson area, the middle Santa Cruz experienced much more extreme changes than either the upper or lower sections in terms of location of perennial flow.

Some portions of the river remain perennial to this day. Other reaches north of Nogales and Tucson have more water now than they did at the time of statehood due to wastewater effluent flow. Many of the perennial sections of the river, however, have been lost. The perennial waters near San Xavier persisted until 1949, and supported native fish until at least 1937. The section of the river near Tucson probably had some perennial flow in 1912, but at this time the river was deeply entrenched. Therefore, the water table was already lower than it was before entrenchment began after the floods of 1890. The United States Geological Survey kept data on streamflow at certain measuring points on the Santa Cruz River. By 1910, it was reported that the entire base flow of the river at both the Mexican border, and near the Congress St. Bridge in Tucson, was diverted for agriculture.

The upper Santa Cruz River in Santa Cruz County, including the headwaters in the San Rafael Valley, has been relatively stable. Perennial flow existed in many places

here, as well as some cienegas. The geology changes north of Tubac, and the river frequently went
subsurface there throughout history, as it presently does. However, the historical perennial reaches at San Xavier and Tucson are gone.

The lower Santa Cruz River in Pinal County never supported perennial flow. In fact, it was only during rare flood events that water from the upper Santa Cruz River reached the confluence with the Gila River. Early explorers said that the river through Pinal County had a nearly indistinguishable channel, and maps showed a discontinuous channel there. This section of the river remains relatively unchanged in terms of the absence of perennial flow. The lower Santa Cruz River flows only in response to precipitation events.

The biggest changes in the valley have been along the middle Santa Cruz River, especially from Tucson to Tubac, because of population growth, mining, and agriculture. This combination of events has led to loss of perennial water, an increase in groundwater withdrawal, and an extensive change in the vegetative structure there.

Evidence of Susceptibility to Navigation

The hydrology and geomorphology of the Santa Cruz River have experienced both subtle and dramatic changes in their character since the time of Statehood. These changes have resulted from a combination of climate change, human activities, and geomorphologic processes.

Hydrology

Historically (circa the 1890s), the Santa Cruz River was perennial from its source to Tubac. Climate change since the turn of the century, combined with the extensive groundwater pumping for irrigation and the flow diversion for municipal use that began near the international border during the 1930 to 1950 drought period, has resulted in no flow in the channel in Sonora, Mexico, and discontinuous flow in the channel near Nogales, Arizona. The 1913 gage record at Nogales, the earliest in that region, indicated that by the time of statehood, the Santa Cruz River near Nogales was no longer perennial, but instead had continuous flow during the winter and occasional flow during the spring, summer and fall. The 1913 winter discharge averaged about 15 cubic feet per second (cfs), except for an increase caused by a rainfall event that ranged from 35 to 174 cfs. A survey of the daily data for the rest of the Nogales record indicated that, during wet years, there were only a few days of noflow conditions. During dry years, there were entire months that passed with no flow recorded in the channel. At present, naturally occurring perennial reaches occur only in the uppermost part of the river in the San Rafael Valley. The perennial reach north of Nogales results from the discharge of sewage effluent from the Nogales International Wastewater Treatment Plant that begn in 1972.

The Santa Cruz River historically had several springs and cienegas within its channel from Tubac to Tucson, and a marsh at its confluence with the Gila River near Laveen. Even in the historical record, only the very largest floods were sustained from the headwaters to the confluence with the Gila River. A review of the daily discharge record indicated that there was some semblance of baseflow, with an average of about 12 cfs during the fall and winter of 1912-1913, at the Tucson gage. Such continuous flow for months at a time was not seen again in the years that followed, though there were periods of several weeks that experienced continuous or nearly continuous flow during very wet winter seasons. The Laveen gage recorded nearly yearround flow from its beginning date in 1940 until June of 1956, when it began to measure zero flow for weeks at a time. During the 1940 to 1956 period, the daily flow averaged about 3 cfs during low flow conditions, and had peaks as high as 5060 cfs during wet periods. By 1960, the Santa Cruz at Laveen was also experiencing no flow conditions for months at a time.

Not only have the locations of surface flows changed since the time of statehood, but also the seasonality and magnitude of flows in the Santa Cruz River have changed in response to shifts in the hydroclimatology of the region. Though the majority of flow events occur during the summer season, the magnitude and number of annual peak discharges that occurred in the fall and winter were higher before 1930 and after 1960 than during the 1931-1959 period. For example, six of the seven largest floods at Tucson occurred after 1960, indicating that the magnitude of flood peaks has increased in the past few decades.

In evaluating the susceptability of the Santa Cruz River to navigation in historic times, it is important to be cognizant of the significant changes that have occurred in the river. The current condition of the river is not representative of the conditions that existed at statehood. Human activites, as well as climate change, have had notable effects on the peak flows of the Santa Cruz River, especially in the lower basin. Since 1962, the construction of flood control channels in the washes of the lower Santa Cruz River basin has resulted in thereduction of floodplain storage and infiltration losses, therefore reducing the attenuation- the downstream decrease of the flood peak- of peak discharges. For example, the attenuation of peak flows was greater during the 1962 floods than during the 1983 floods because water was able to spread out over the broad flow zones in the lower reaches of the Santa Rosa and Santa Cruz washes. In contrast, much of the floodwater during the 1983 floods was efficiently transmitted downstream by the flood-control channels.

Geomorphology

The geomorphology of the Santa Cruz River upstream of Marana is quite different from that of the lower Santa Cruz River downstream of Marana. The river has a well defined, often entrenched, channel in its upper reaches that contrasts strongly to the ill defined system of braided channels that exist north of Rillito Peak at the northern end of the Tucson Mountains. Both the upper and lower reaches of the Santa Cruz River have experienced dramatic changes resuting from a combination of both natural geomorphic processes and human activities. Three types of lateral change- 1) meander migration, 2) avulsion and meander cutoff, and 3) channel widening- and two types of vertical change- aggradation and degradation of the channel bed- have

occurred. While arroyo development is the most obvious type of channel change to occur since the 1890s in the upper Santa Cruz River, most of the initial channel incision occurred before the time of statehood. Since 1912, various reaches of the upper Santa Cruz River have been dominated by such processes and activities as: meander migration and cutoff, channel widening, arroyo widening, channelization, and the vegetational effects of sewage effluent discharge. The channel locations in different reaches have changed spatially on the order of a few feet to a few thousand feet, depending on the processes that resulted in the change, and often change could be detected from one year to the next.

The lower Santa Cruz River, downsteam of Marana, experienced changes of a completely different magnitude from the upper Santa Cruz River. Changes in the location of the channel in the lower basin can be measured in miles, and, due to the nature of the causes of the changes, the timing spans decades. Before the construction of Greene's Canal in 1910, the river transformed from a relatively deep, well-defined channel to a broad, flat, extensive alluvial plain at a point in the Marana area. Now that transition point occurs near Chuichu, Arizona. The construction and subsequent flood damage of Greene's Canal has resulted in other dramatic geomorphic changes. Prior to and during the floods of 1914-1915, flood flow had the opportunity to follow routes down the North Branch of the Santa Cruz Wash and McClellan Wash. After the development of the arroyo in Greene's Canal, the bulk of subsequent flood flows have had westerly paths.