# Declaration
# Navigability of the Verde River

Submitted To: Salt River Project
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**October 10, 2014**

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# 1 Introduction and Summary of Opinions

At the request of the Salt River Project Agricultural Improvement and Power District and Salt River Valley Water Users' Association (collectively, SRP), I have made an independent assessment of the navigability[1] of the Verde River[2] to aid in determining ownership of the bed and banks of the river under the equal-footing doctrine. This assessment included review of the expert report and testimony of Dr. Stanley Schumm regarding this matter (Schumm, 2004), and independent review of additional relevant information, including various technical documents that will be cited below, the Arizona Division One Court of Appeals opinion that vacated and remanded for further proceedings the Arizona Navigable Streams Adjudication Commission (ANSAC) 2008 decision on navigability of the Lower Salt River and the U.S. Supreme Court's ruling in the PPL Montana case. My review also included a low-elevation overflight of the Verde River from the confluence with the Salt River upstream to the Beasley Flat area about 5 miles southeast of Camp Verde to gain first-hand knowledge of the present-day condition of the river and the surrounding landscape.

## 1.1 Qualifications

I am a registered Professional Engineer in ten states, including Arizona, with over 30 years of experience in analyzing the behavior of natural and manmade stream channels. I have a Ph.D. in Hydraulic Engineering from Colorado State University with emphasis on river mechanics, and I am currently a Program Manager and Discipline Lead for Hydraulic Engineering in the Surface Water Group of Tetra Tech, Inc. In 1989, I founded Mussetter Engineering, Inc. (MEI), and in 1994, Dr. Schumm joined me as part owner of MEI. From 1986 until his death in 2011, I collaborated with Dr. Schumm on a wide variety of projects related to stream channel processes. I was President and Principal Engineer of MEI during the time Dr. Schumm prepared his report and provided testimony to the ANSAC regarding this matter, and I was generally familiar with the work he performed in preparing the report and testimony. This familiarity was gained, in part, through discussions with Dr. Schumm about the information that he had obtained and the opinions that he was forming from that information. Over the course of my career, I have also performed significant technical work in Arizona related to stream channel processes through which I have gained first-hand knowledge of the climatic, hydrologic and geomorphic conditions in the Verde River.

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[1]Arizona Revised Statutes (A.R.S.) section 37-1101(5) (2003) defines navigability as follows:

> "Navigable" or "navigable watercourse" means a watercourse that was in existence on February 14, 1912, and at that time was used or was susceptible to being used, in its ordinary and natural condition, as a highway for commerce, over which trade and travel were or could have been conducted in the customary modes of trade and travel on water.

In vacating and remanding for further proceedings, ANSAC's 2005 decision that the Lower Salt River was not navigable at the date of Arizona's Statehood (Case No CA-CV 07-0704), the Arizona Division I Court of Appeals concluded that … *ANSAC was required to determine what the River would have looked like on February 14, 1912, in its ordinary (i.e., usual, absent major flooding or drought) and natural (i.e., without man-made dams, canals, or other diversions) condition.*

[2]The reach of the Verde River at issue in this case extends approximately 190 miles from the confluence with the Salt River upstream to Sullivan Lake. This evaluation focused primarily on the approximately 105-mile reach from the confluence to Beasley Flat (**Figure 1**).

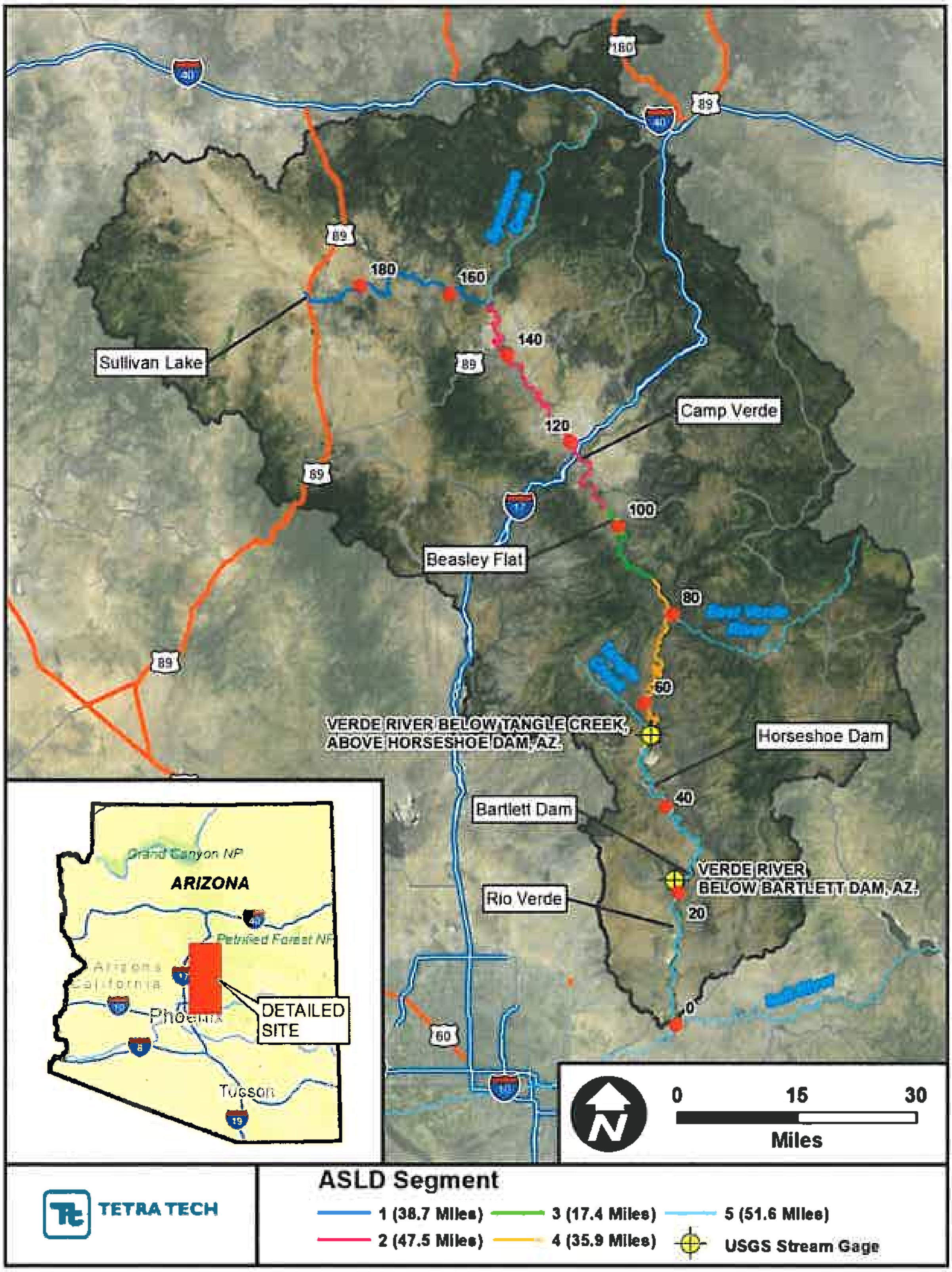


Figure 1. Vicinity map showing the Verde River between the confluence with the Salt River and Camp Verde, along with key features.

## 1.2 Opinions

Based on my review of Dr. Schumm's report and background material, independent review of other background material, my knowledge of the climatic, hydrologic and geomorphic conditions along the Verde River, results from a study of three typical sites that was conducted under my supervision in 2003, observations during an aerial overflight of the portion of the reach from the Salt River confluence to the Beasley Flat area about 5 miles south of Camp Verde, and my knowledge of processes in arid stream channels, I agree with the opinions that were expressed by Dr. Schumm in his report and testimony, and offer the following clarifications and additional opinions for ANSAC's consideration in this matter:

1. The portion of the Verde River between Beasley Flat and the head of Horseshoe Reservoir is confined within a relatively narrow canyon in which the planform, longitudinal profile and width of the river is controlled by bedrock outcrop and by older, erosion-resistant terraces. This portion of the reach has not been significantly altered by human activity, and it contains numerous rapids that make navigation challenging and hazardous even using modern whitewater craft. In at least one location, the available river guides recommend portaging. This part of the reach would not have been navigable under ordinary and natural conditions using the watercraft in customary use at and before Arizona's statehood.
2. The downstream approximately 18 miles of the reach flows through a wider valley where the river is bounded by modern, more erodible alluvium in most locations. Under present conditions, the reach has an island-braided character, with multiple channels in many locations that are stabilized by riparian vegetation that remains relatively stable due to the upstream flow regulation. Under natural conditions prior to significant upstream flow-regulation, this reach responded to periodic high flow events such as those that occurred in the late-19$^{th}$ and early 20$^{th}$ centuries by developing a wide, braided pattern with multiple, unstable low-flow channels that would have precluded reliable navigation using the watercraft that were in customary use at and prior to Arizona's statehood.
3. The segmentation proposed by the Arizona State Lands Department (ASLD) provides a convenient structure for describing the characteristics of the Verde River; however, it is my opinion that segmentation of the reach is not necessary because no significant portion of ASLD Segments 3, 4 and 5 was navigable in its ordinary and natural condition at the time of Arizona's statehood.
4. Although I did not study ASLD Segments 1 and 2 in detail, I also do not believe these segments would have been navigable under ordinary and natural conditions at the time of Arizona's statehood, based on my general knowledge of the characteristics of the river and information presented by others in this case.

# 2 Basis for Opinions

## 2.1 General Character of Canyon-Bound and Dryland Rivers

River channels take on a variety of configurations that range from relatively narrow, single-thread cross sectional shapes with meandering planform to wide, braided cross sections with a relatively straight, down-valley alignment (Schumm, 1981; **Figure 2**)[3]. These forms can significantly influence whether or not the river is susceptible to navigation under the definition relevant to this case (see Footnote 1). In general, the configuration of any particular reach of the river results from the interplay between stream power and the resistance of the boundary materials to erosion (Graf, 2002). When the boundary materials are composed of modern-day alluvium, the configuration is also affected by the magnitude of the upstream sediment supply in relation to the local sediment transport capacity. Meandering configurations are most common in rivers with low stream power and high bank resistance resulting from erosion-resistant (i.e., cohesive) bank material and thick riparian vegetation. Braided configurations are common in rivers with high stream power, low boundary resistance and a high sediment load, particularly when a significant percentage of the load is carried as bed load[4].

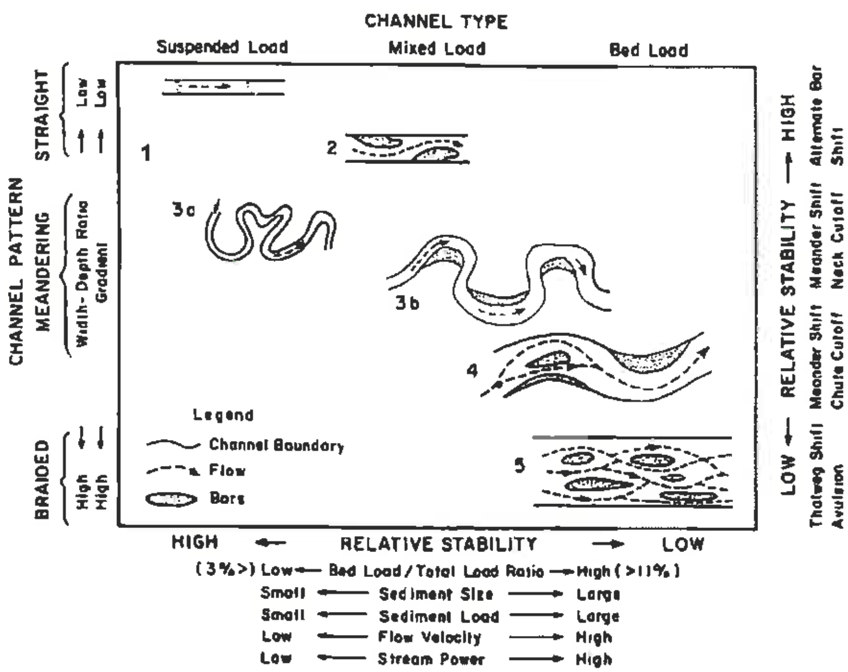


Figure 2. Channel classification based on pattern and type of sediment load, showing types of channels, their relative stability, and some associated variables (Schumm, 1981).

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[3]Meandering streams have a sinuous horizontal alignment consisting of a sequence of channel bends that are separated by relatively short, straight channel segments (often referred to as crossings). Meandering streams typically have only a single channel. Braided streams are streams that consist of an interlacing network of branching and reuniting shallow channels separated from each other by islands or channel bars.

[4]Bed load is that part of the total sediment load that moves by rolling, sliding or saltating along the streambed, in contrast to the suspended load that is carried in the water column above the channel bed.

The Verde River heads in the highlands and flows through the central mountain area of Arizona, where the physiography and geology is transitional between the high-elevation, relatively flat Colorado Plateau and the lower-elevation Basin and Range province. The central mountain area is characterized by the most rugged relief in Arizona, with large, high mountain ranges and deeply dissected alluvial basins. The reach of the Verde River that is of primary interest in this report *is entrenched into a relatively narrow, deep canyon, and it remains entrenched well below the surrounding countryside...downstream to its confluence with the Salt River* (Pearthree, 1996, p.1).

Canyon-bound rivers are strongly controlled by the characteristics of the bedrock and bounding terraces that provide both lateral and vertical control on the form of the river, and by coarse-grained sediment and debris that is delivered to the river by floods and debris flows from the side canyons and by colluvial processes (i.e., gravity) from the canyon walls (O'Connor et al., 2003; Howard and Dolan, 1981; Graf, 1979). In some locations along the Verde River, the bedrock can cause sharp breaks in the longitudinal profile that create waterfalls and rapids that can make navigation very challenging and dangerous, and in some cases, impossible (**Figure 3**). Coarse-grained sediment and debris delivered from the tributaries and side canyons often creates alluvial fans and bars that constrict the river, forming rapids that also severely limit navigability (Hereford et al., 1997; Graf, 1979) (**Figure 4**).

Figure 3. Verde River in the vicinity of Verde Falls and Pre-falls. Bedrock forms bed and banks of channel. Drop across the falls in the center of the photo is about 4 feet. (Photo by R. Mussetter, October 2013)

Figure 4. Black Hole Rapid. Cobble/boulder bar that forms the rapid upstream from bedrock constriction in canyon from material delivered from local side canyons. (Photo by R. Mussetter, October 2013)

Portions of the Verde River (e.g., much of the downstream approximately 18 miles of the reach) are bounded by modern alluvium; and thus, are not confined by bedrock or older, erosion-resistant terraces as discussed above. Graf (1983) argued that alluvial dryland river channels in this type of setting are not equilibrium forms. The morphology of the channel at any point in time is inherited from the last significant, flood-driven alteration, and this controls the channel form during the subsequent recovery period (Graf, 2002). Following the channel-altering flood event, the river channel returns to its pre-disturbance condition (i.e., it recovers) relatively slowly compared to the rate of adjustment during the flood through sedimentation in low energy areas and re-establishment of riparian vegetation on the surfaces that were disturbed by the flood. As a result, it is not possible to define a dominant discharge, because the larger, more infrequent flows are more geomorphically effective than the frequently occurring flows (Graf, 2002; Baker, 1977). During floods, the flows are so powerful that they can rapidly and significantly alter the channel and adjacent overbanks. The amount of alteration depends on many factors, including the magnitude and duration of the flows, the inflowing sediment load, the characteristics of the bed and bank material and riparian vegetation, and the degree to which the channel has recovered from the last major event. During the recovery periods of low- to moderate sustained flows, the channel form tends toward a single-thread, sinuous configuration within the overall wider cross section created by the disturbance flows.

The channel behavior described in the previous paragraph has been documented in a wide variety of settings. As noted in Dr. Schumm's (2004) expert report, for example, the Cimarron

River in southwestern Kansas was transformed from a narrow sinuous, 50-foot wide channel to a 1,200-foot wide, braided channel by a series of floods during the 1930s (Schumm and Lichty, 1963). Another notable example includes the Rio Salado, a tributary of the Rio Grande near San Acacia, New Mexico, where the channel width ranged from 12 feet to 49 feet in 1882, but widened to 330 to 550 feet by 1918 (Bryan, 1927). The Smoky Hill River originally *...had alternating sandy stretches and grassy stretches with series of pools* (sic). *Later the former were widened and the latter were sanded up.....* (Smith, 1940). The Republican River was greatly affected by the flood of 1935: *Formerly a narrow stream with a practically perennial flow of clear water and with well-wooded banks, the Republican now has a broad, shallow sandy channel with intermittent flow. The trees were practically all washed out and destroyed, much valuable farmland...was sanded over, and the channel has been filled up by several feet.* (Smith, 1940)

An additional example is the Red River floodplain near Burkburnett, Texas, that was the object of intensive study to resolve a boundary dispute between Oklahoma and Texas (Glenn, 1925; Sellards, 1923). The Red River was never a narrow, meandering stream in historic times; a survey in 1874 showed the river to be about 4,000 feet wide. The channel, however, has undergone some important changes. For example, comparison of a map prepared in 1920 (Sellards, 1923) with aerial photographs taken in 1953 showed enlargement of the floodplain; 5.5 $mi^2$ of floodplain were added over a 10-mile reach of the river. In 1937, the river averaged three-quarters of a mile wide, close to the average for the 1874 survey. In 1953, the average width had decreased to half a mile. In 1957, the river averaged two-thirds of one mile wide, indicating significant widening between 1953 and 1957, during which period three large floods occurred in the reach.

The recorded history of the Gila River and many of its larger tributaries, including the Salt and Verde Rivers, documents cyclical changes that are very consistent with those described above. In a detailed study of the impacts of phreatophytes on the Gila River in the Safford Valley, Burkham (1972 and 1981) concluded that the historical character of the Gila River channel can be grouped into three time periods: 1846-1904, 1905-1917 and 1918-1970. From 1846-1904, the channel was relatively narrow, and it meandered through a floodplain covered with willow, cottonwood, and mesquite (**Figure 5**). Only moderate changes occurred in the channel width and sinuosity during this period. The maximum width was about 150 feet in 1875 and about 300 feet in 1903. In response to a series of large floods in the early-1900s that completely destroyed the meander pattern and floodplain vegetation, the average width of the river had increased to about 2,000 feet by 1917. The river then narrowed and developed a more sinuous planform with a densely vegetated floodplain between 1918 and 1970; by 1964, the maximum width had decreased to only about 200 feet.

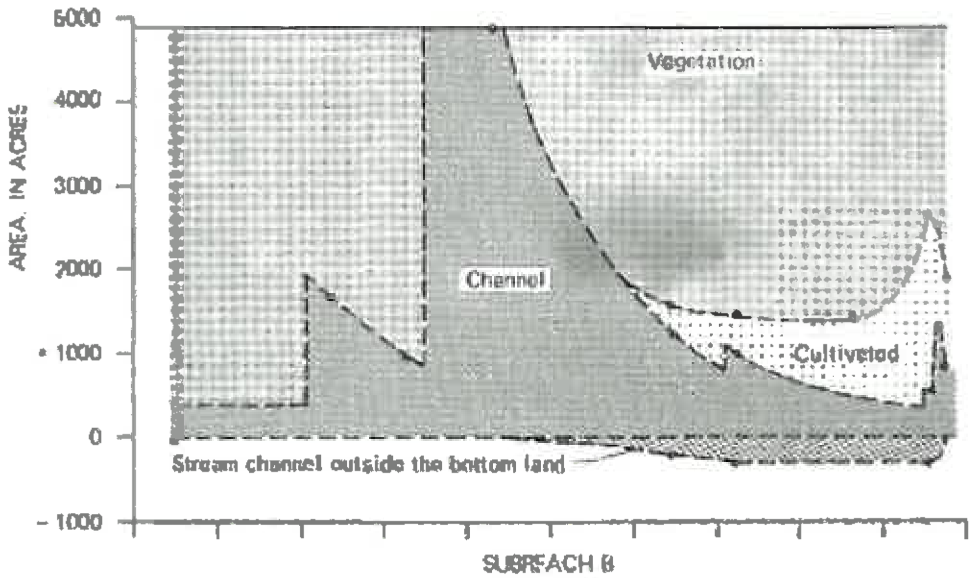


Figure 5. Historical changes in channel area of upper Gila River (San Simon to Pima) (from Burkham, 1972).

Huckleberry (1993) showed similar changes in the middle Gila River (**Figure 6**). In the late-1800s, the channel width averaged about 60 m (~200 feet), increasing to about 300 m (~1,000 feet) by about 1925 as a result of the large floods in the early-1900s, and then decreased back to about 40 m (~130 feet) by the 1940s. In response to large floods that occurred in the 1980s, the width increased to about 70 m (~230 feet) by the early-1990s.

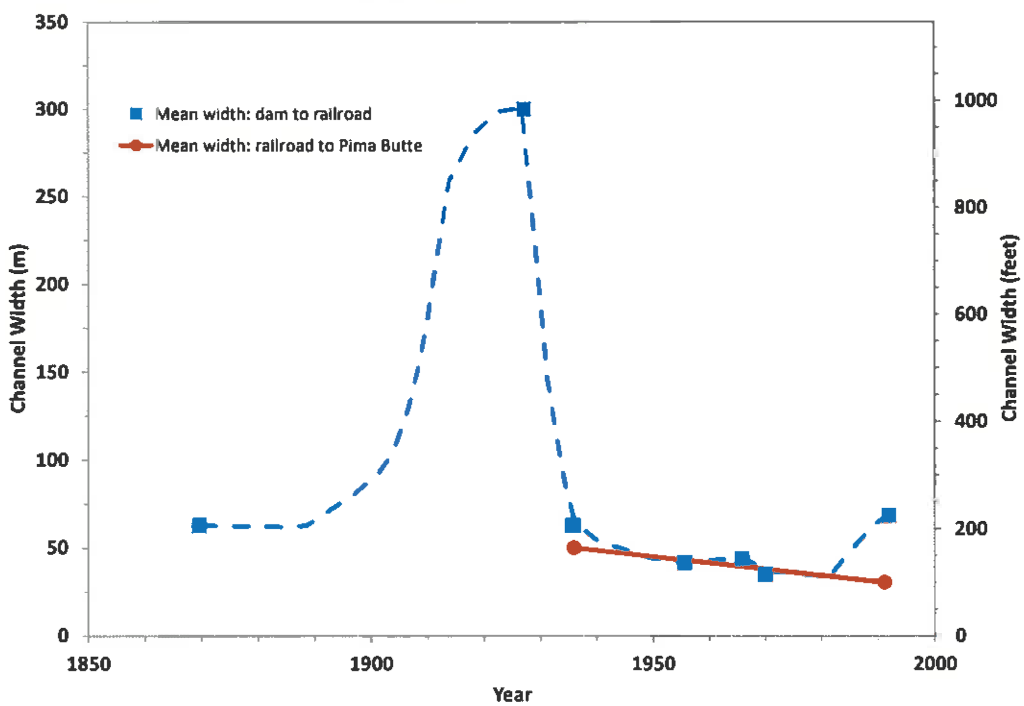


Figure 6. Changes in channel width for the Middle Gila River (modified from Huckleberry, 1993).

In summary, alluvial rivers in the arid southwestern U.S. experience cycles of low (or non-existent) to moderate flows punctuated by large, infrequent, monsoon-driven flood events. During the low to moderate flow periods, they tend toward a single-thread, meandering planform, and during the infrequent, large floods, they can rapidly transform into a wide, braided, multi-channel planform in which the flow depths are highly irregular, both spatially and temporally. Both conditions are *natural and ordinary* conditions of the river. Particularly during the floods and the subsequent recovery periods following the floods, the multiple, individual channels in the braided planform tend to be very shallow and unstable. Where the rivers are confined by bedrock, the planform and profile of the river is controlled by the bedrock and local deposits of coarse-grained material from debris flows emanating from the side canyons and from material falling directly into the river from the canyon walls. These features create rapids, shallow riffles, and in some cases, waterfalls that can make navigation extremely challenging or impossible, even for modern-day whitewater boats.

## 2.2 Historical (and Modern-day) Character of the Verde River

Following the U.S. Supreme Court guidance in the PPL Montana Case, the Arizona State Land Department (ASLD) has suggested that the Verde River can be divided into five segments, as follows:

1. Sullivan Lake and the mouth of Sycamore Creek (~37 miles),
2. Sycamore Creek to Beasley Flat boat ramp (~47 miles),
3. Beasley Flat to Verde Hot Spring (~17 miles),
4. Verde Hot Spring to head of Horseshoe Reservoir (~35-miles), and
5. Head of Horseshoe Reservoir to the confluence with the Salt River (~52 miles).

It is my opinion that the Verde River between Beasley Flat and the confluence with the Salt River[5] was not navigable or susceptible to navigation in its ordinary and natural condition at the date of Arizona's statehood; however, ASLD's proposed segmentation provides a convenient basis for discussing the range of characteristics of the river.

### 2.2.1 General Characteristics of the Verde River

As noted above, the Verde River heads in the highlands and flows through the central mountain area of Arizona, where the physiography and geology is transitional between the high-elevation, relatively flat Colorado Plateau and the lower-elevation Basin and Range province. The reach of the Verde River that is of primary interest in this report (i.e., ASLD Segments 3, 4 and 5) *is entrenched into a relatively narrow, deep canyon, and it remains entrenched well below the surrounding countryside…downstream to its confluence with the Salt River* (Pearthree, 1996, p1).

Entrenchment of the Verde River is believed to have started 2 million (M) to 2.5M years ago, for reasons that are not certain but likely include downcutting through previously-blocked basin outlets and broad regional uplift of the central mountains. The downcutting has resulted in a narrow bedrock confined canyon in parts of the reach, and has also created a series of terraces that flank the river and tend to confine the valley width in locations where the river is not in direct

[5] Although my analysis did not focus on the reach between Sullivan Lake and the Beasley Flat boat ramp, I believe, based on evidence presented by others in this case (e.g., Burtell, 2014), that this part of the reach was also probably not navigable in its ordinary and natural condition at the date of Arizona's statehood.

contact with the bedrock valley wall. The terraces range in age from early-Pleistocene (i.e., ~0.8M to 2.6M years ago) to late-Holocene (i.e., within the past few thousand years), and they represent former positions of the Verde River bed and floodplain. Most of the terraces are made up of thin veneers of material deposited on erosional surfaces that were carved on top of the bedrock (**Figure 7**). Due to the thinness of the deposits, the underlying bedrock units are exposed in the bed and banks of the river in many locations, implying that the long-term downcutting trend is continuing at present. These exposures exert strong local control on the longitudinal profile of the river (Figure 3).

Figure 7. Verde River between Beasley Flat and Verde Falls. Note strath[6] terraces along both sides of the river. Also note the shallow, boulder-strewn riffle near the top of the photo. (Photo by R. Mussetter, October 2013)

Long-term downcutting and the relative erodibility of the pre-incision bedrock and basin-fill units effectively control the extent and character of the terrace deposits and modern floodplain along the Verde River. In general, the older terraces that flank the river are more erosion-resistant than the younger terraces (Pearthree, 1996). Where the lithologies are more erosion-resistant, the river valley is steep and narrow with relatively limited amounts of alluvial storage in the valley bottom. In contrast, where the bounding materials are more erodible, the valley width is greater, the slope is flatter, and there is considerably more alluvial storage in the valley bottom

[6] In this context, a strath terrace is a broad overbank area underlain by bedrock and covered by a thin veneer of alluvium.

(Pearthree, 1996). In common with most canyon-bound rivers, local constrictions and expansions in the valley cause localized accumulations of alluvial sediments (Graf, 1979; Webb et al., 1988; Lisle, 1986; O'Connor et al., 1986; Harvey et al., 1993) (Figure 4).

The relative widths of the valley floor determine the geomorphic effectiveness of the large infrequent floods that tend to control channel form in arid regions such as the Verde River valley (Baker, 1977; Wolman and Gerson, 1978). In confined reaches of the valley (e.g., ASLD Segments 3 and 4), there is little potential for lateral migration of the river, while the lateral migration potential increases markedly where the valley is wider (e.g., the downstream approximately 18 miles of Segment 5). In general, where the valleys are narrow and confined, the large infrequent flood events tend to disturb most of the valley floor sediments, eliminating, or significantly modifying, vegetation that has established during the interflood period. Wider, less-confined reaches tend to be depositional during infrequent flood events, resulting in braiding, shifting of the low-flow channels, and disturbance to riparian plant communities.

### 2.2.2 Segment 3 (Beasley Flat to Verde Hot Spring)

The approximately 17-mile segment of the Verde River between Beasley Flat and Verde Hot Spring *…is entrenched into a relatively narrow, deep canyon…* (Pearthree, 1966). The overall gradient is relatively steep (~19 feet/mile), and bedrock is present in the bed and banks of the river in many locations, providing strong lateral and vertical control on the position and profile of the river. In one location (Verde Falls), bedrock outcrop creates an approximately 4-foot high waterfall with numerous other boulder obstructions (Figure 3). Arizona State Parks (1989) recommends that even present-day whitewater boaters portage around this area. In other locations, large caliber sediment and debris from the adjacent side canyons constrict the river and/or create shallow riffles, rapids, and obstacles within the channel that represent significant navigation hazards (**Figure 8**). In still other locations, constrictions in the valley width and bends in the valley alignment create upstream backwater[7] conditions at high flows when coarse-grained sediment is being transported, causing the transported sediment to deposit and form large cobble bars. During subsequent lower flows, the river is constricted to a relatively narrow channel along the sides (or in some cases, across the middle) of the bars, forming rapids and shallow riffles (Figure 4).

This segment is characterized by challenging whitewater during a season that is limited to the relatively short period between late-February and mid-April during the most favorable (i.e., high-flow) boating years, but may provide no boating opportunities at all during low-flow years (Arizona State Parks, 1989). Modern data (1945 through 2013) for the *Verde River below Tangle Creek* gage (USGS Gage No. 09508500) that is located just upstream from Horseshoe Reservoir indicates that the discharge in the river was less than 240 cfs about half the time and less than 340 cfs about 75 percent of the time, on an annual basis (**Figure 9**). Flows at this location are specifically representative of the flows at the downstream end of ASLD Segment 4, and they are probably slightly higher than the flows in the remainder of ASLD Segments 3 and 4 since Tangle Creek and the East Verde River, that have a combined drainage area of about 610 $mi^2$ (or about 11 percent of the total drainage area at the gage), enter within Segment 4.

[7]Backwater is a term used in hydraulic engineering to describe the local increase in water-surface elevation and depth, and flattening of the water-surface slope, upstream from a flow constriction.

Figure 8. Verde River looking upstream from about 0.8 miles upstream from Verde Hot Spring. Note shallow, boulder-strewn riffle along the cobble/boulder bar in the foreground.

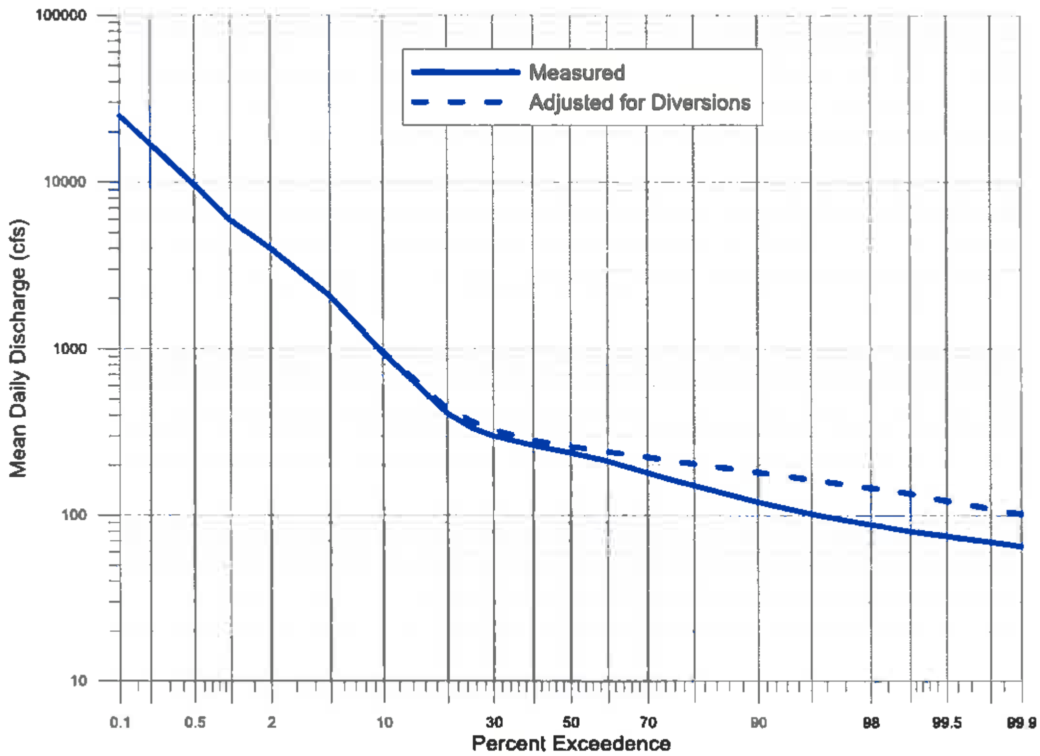


Figure 9. Mean daily flow duration curves based on the period of recorded flows (Calendar Year 1945 through 2013) at the Verde River below Tangle Creek above Horseshoe Reservoir gage (USGS Gage No. 09508500). Also shown is the curve adjusted for the effects of upstream irrigation diversions.

The overall hydrologic regime in the river (i.e., not considering the effects of upstream diversion) during the period of the gage measurements appears to be similar to long-term conditions that existed prior to significant human influences. Estimated annual flow volumes in the river from 1320 through 2005 using tree ring data (Meko and Hirschboeck, 2008) indicate that the mean flow and annual variance during the full period of the estimates are not statistically different from those during the 1945 through 2005 measurement period at the gage (**Figure 10**). The primary human modification to the flows during the measurement period is due to upstream irrigation diversions. Burtell (2014) estimated that these diversions totaled 183 cfs, and 57 percent of the diverted flow was lost to consumptive uses (i.e., about 43 percent returned to the river; thus, should be accounted for in the measured flows). Considering the uncertainty in these estimates, it seems reasonable to conservatively round the typical diversion quantity to 185 cfs and the flow loss to 60 percent; thus, flows under natural conditions during the irrigation season (typically April 15 through September 15) would have been 90 cfs to 95 cfs larger than the measured flows. A flow-duration curve developed by adjusting the irrigation season flows upward by the larger value of 95 cfs indicates that the discharge in Segments 3 and 4 would have been less than 265 cfs about 50 percent of the time and less than 375 cfs about 75 percent of the time, on an annual basis.

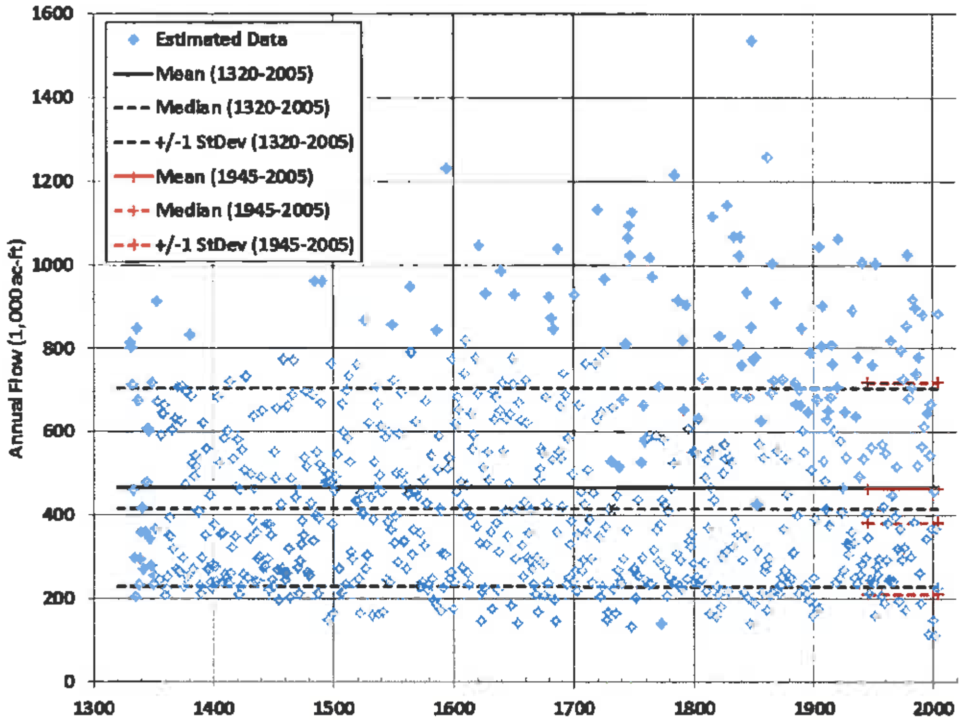


Figure 10. Estimated annual flow volumes from 1320 to 2005, based on tree ring analysis (Meko and Hirschboeck, 2008). Also shown are the mean, median and ±1 standard deviation for the full period and the period that overlaps with the available records at the *below Tangle Creek* gage.

For comparison, the measured mean daily discharge at the *below Tangle Creek* gage on October 29, 2013, when the field photographs that are presented throughout this report were taken, was 186 cfs. Hydraulic conditions at the obstacles to navigation shown in these photos would, therefore, have been similar to those at the median, natural flow, and not substantially different from the upper limit of flows that occur about 75 percent of the year. Although the depths would be somewhat greater at the higher flows (a few tenths of feet, based on the gage measurement data at the *below Tangle Creek* gage), the intensity of the hydraulic conditions at significant rapids, such as Verde Falls, would be greater, making the navigation hazard greater, as well.

ASLD Segment 3 contains 11 named rapids, including one Class IV and 7 Class III rapids[8] (**Table 1**). In all cases, the rapids and riffles represent significant impediments to navigation by the watercrafts that were in use at and prior to the time of Arizona's statehood. Although this

[8]The American Whitewater Association defines Class III and Class IV rapids as follows:

***Class IV:*** *Intense, powerful but predictable rapids requiring precise boat handling in turbulent water. Depending on the character of the river, it may feature large, unavoidable waves and holes or constricted passages demanding fast maneuvers under pressure. A fast, reliable eddy turn may be needed to initiate maneuvers, scout rapids, or rest. Rapids may require "must make" moves above dangerous hazards. Scouting may be necessary the first time down. Risk of injury to swimmers is moderate to high, and water conditions may make self-rescue difficult. Group assistance for rescue is often essential but requires practiced skills.*

***Class III:*** *Rapids with moderate, irregular waves which may be difficult to avoid and which can swamp an open canoe. Complex maneuvers in fast current and good boat control in tight passages or around ledges are often required; large waves or strainers may be present but are easily avoided. Strong eddies and powerful current effects can be found, particularly on large-volume rivers. Scouting is advisable for inexperienced parties. Injuries while swimming are rare; self-rescue is usually easy but group assistance may be required to avoid long swims.*

reach is now popular for whitewater boating, ...*evidence* [of present-day, primarily recreational use] *must be confined to that which shows the river could sustain the kinds of commercial use that, as a realistic matter, might have occurred at the time of statehood* (U.S. Supreme Court ruling in PPL Montana). The magnitude of human impacts to the physical characteristics that affect the navigability of this segment have been relatively minor. As a practical matter, the rapids and short, unreliable boating season (even for modern whitewater craft) strongly indicate that this segment was not navigable or susceptible to navigation under ordinary and natural conditions at the time of Arizona's statehood.

Table 1. Named rapids in Verde River, ASLD Segments 3 and 4 (USFS Boaters Guide to the Verde River).

| River Mile[1] | Name | Class | ASLD Segment |
|---|---|---|---|
| 1.7 | Off the Wall | II | 3 |
| 2.4 | Pre-Falls | III | 3 |
| 2.5 | Verde Falls | IV | 3 |
| 4.1 | Rock Garden | II | 3 |
| 4.8 | Palisades | III | 3 |
| 6.5 | Bull Run | III | 3 |
| 7.1 | Turkey Gobbler /Punk Rock | III | 3 |
| 8.4 | Bushman | III | 3 |
| 9.1 | Big Pink | III | 3 |
| 9.6 | Black Hole | III | 3 |
| 10.1 | White Flash | II | 3 |
| 17.3 | Childs Play | II | 4 |
| 18.2 | Baby Snaggle-Tooth | II | 4 |
| 18.4 | Little Drop | II | 4 |
| 21.2 | Nasty Little Dog Leg | III | 4 |
| 21.6 | Gnarly Little Rock Bar | II | 4 |
| 21.8 | Dog's Foot | III | 4 |
| 23.3 | Rockin Center | II | 4 |
| 26.9 | Shoots and Ladders | III | 4 |
| 27.7 | Red Wall | II | 4 |
| 40.6 | Red Creek | II | 4 |
| 44 | Dry Run | III | 4 |
| 46.3 | Junkyard | III | 4 |
| 48.3 | Honey Chute | II | 4 |

[1]Downstream from Beasley Flat Boat Ramp.

### 2.2.3 Segment 4 (Verde Hot Spring to Head of Horseshoe Reservoir)

Similar to Segment 3, the approximately 35-mile segment of the Verde River between Verde Hot Spring and the head of Horseshoe Reservoir is also entrenched into a deep, relatively narrow canyon. The overall gradient is slightly flatter than Segment 3, but still relatively steep at about 17 feet/mile. According to the USFS Boater's Guide, the reach contains 13 named rapids, 5 of which are rated as Class III and 8 of which are Class II[9]. A typical Class III rapid in this reach is named *Shoots and Ladders* (**Figure 11**), and typical Class II rapids include *Gnarly Little Rock Bar* (**Figure 12**). The reach also contains numerous shallow riffles and severely constricted areas in which the bed is strewn with boulder- and cobble-sized material, that would be very difficult to safely navigate at the low to moderate flows that occurred throughout most of the year with the watercraft that were in customary use at and before Arizona became a state (**Figures 13 and 14**).

In 2002, SRP retained Mussetter Engineering, Inc. (MEI) and ERO Resources to evaluate the effects of several potential dam operating scenarios on the frequency and duration of inundation of likely areas for the establishment and maintenance of riparian vegetation and mobilization of the sediment making up the channel bed and bars in the Verde River to assist them in preparation of an application for Incidental Take Permit (ITP) for continued operation of Horseshoe and Bartlett Dams. The MEI (2003) study involved detailed surveys of three sites that were located (1) between the head of Horseshoe Reservoir and the *below Tangle Creek gage* (referred to as Site 1), (2) 1.7 miles downstream from Horseshoe Dam and just downstream from the mouth of Davenport Wash (referred to as Site 2 or the KA Ranch Site), and (3) about 2.3 miles downstream from Bartlett Dam and about 0.6 miles upstream from Box Bar Ranch (referred to as Site 3) (**Figure 15**). Site 1 was located at the downstream end of ASLD Segment 4 and Sites 2 and 3 were located in ASLD Segment 5. Among other tasks, the study involved field surveys of the river-bed topography, gradation analysis of the bed and bar sediments and hydraulic modeling. To meet the study objectives, the sites were selected in relatively wide segments of the valley where the river is bounded by modern alluvium on at least one side, because the riparian zone in these areas is more likely to respond to changes in flow regime than in the more confined reaches. As a result, these sites are not in the areas that would have presented the greatest challenges to navigation at or before Arizona's statehood. Nevertheless, the surveys and hydraulic results illustrate that, even in these areas, navigation at the flows that persist during a significant part of the year would be challenging.

The total valley width at Site 1 is about 600 feet, and the site is bounded along the left side (downstream view) by a number of Holocene (modern) age terraces (**Figure 16**). Several older (late- to mid-Pleistocene-age) terraces are located father back from the river. The right side of the river in the upstream portion of the site is composed of pre-Quaternary basin-fill sediments, but the remainder of the right side is composed of coalesced late- to mid-Pleistocene age terraces and alluvial fans, and late-Holocene-age terraces (Pearthree, 1993). The active channel at this site is about 200 feet wide and flanked by narrow bands of riparian vegetation. In the lower two-thirds of the site, the active channel is flanked along the left bank by a very sparsely vegetated gravel-cobble bar that represents a high-flow chute-channel that is confined on its left margin by a Holocene-age terrace. In the upper third of the site, the chute channel is separated from the main channel by a relatively high-elevation vegetated bar. The downstream hydraulic control for the site is created by a constriction caused by the presence of erosion-

[9]The American Whitewater Association defines **Class II** rapids as follows:
Straightforward rapids with wide, clear channels which are evident without scouting. Occasional maneuvering may be required, but rocks and medium-sized waves are easily missed by trained paddlers.

resistant late- to mid-Pleistocene-age coalesced fans on the right bank, and a late-Holocene age terrace on the left bank.

The field surveys at this site were conducted in late-November 2012 when the discharges recorded at the *below Tangle Creek* gage ranged from 259 cfs to 296 cfs. The maximum depth at the locations within the site that would be most limiting to navigation was only about 2 feet (Figure 17), and the cross sectionally-averaged depth at Cross Section (XS) 5 (the shallowest cross section) is less than 2 feet for flows up to about 800 cfs (Figure 18), indicating that, even this area that is not the most limiting within Segment 4, would not have been navigable under ordinary and natural conditions at the time of Arizona's statehood.

Figure 11. View looking upstream of Shoots and Ladders Rapid (Class III) that is located about 2 miles downstream from the East Verde River confluence in ASLD Segment 4. (Photo by R. Mussetter, October 29, 2013)

Figure 12. Gnarly Little Rockbar Rapid (Class II) located about 0.7 miles downstream from the Fossil Creek confluence. (Photo by R. Mussetter, October 29, 2013)

Figure 13. Shallow, boulder-strewn riffle near the Tangle Creek confluence. (Photo by R. Mussetter, October 29, 2013)

Figure 14. Tree-choked cobble/boulder bar just upstream from the Fossil Creek confluence. (Photo by R. Mussetter, October 29, 2013)

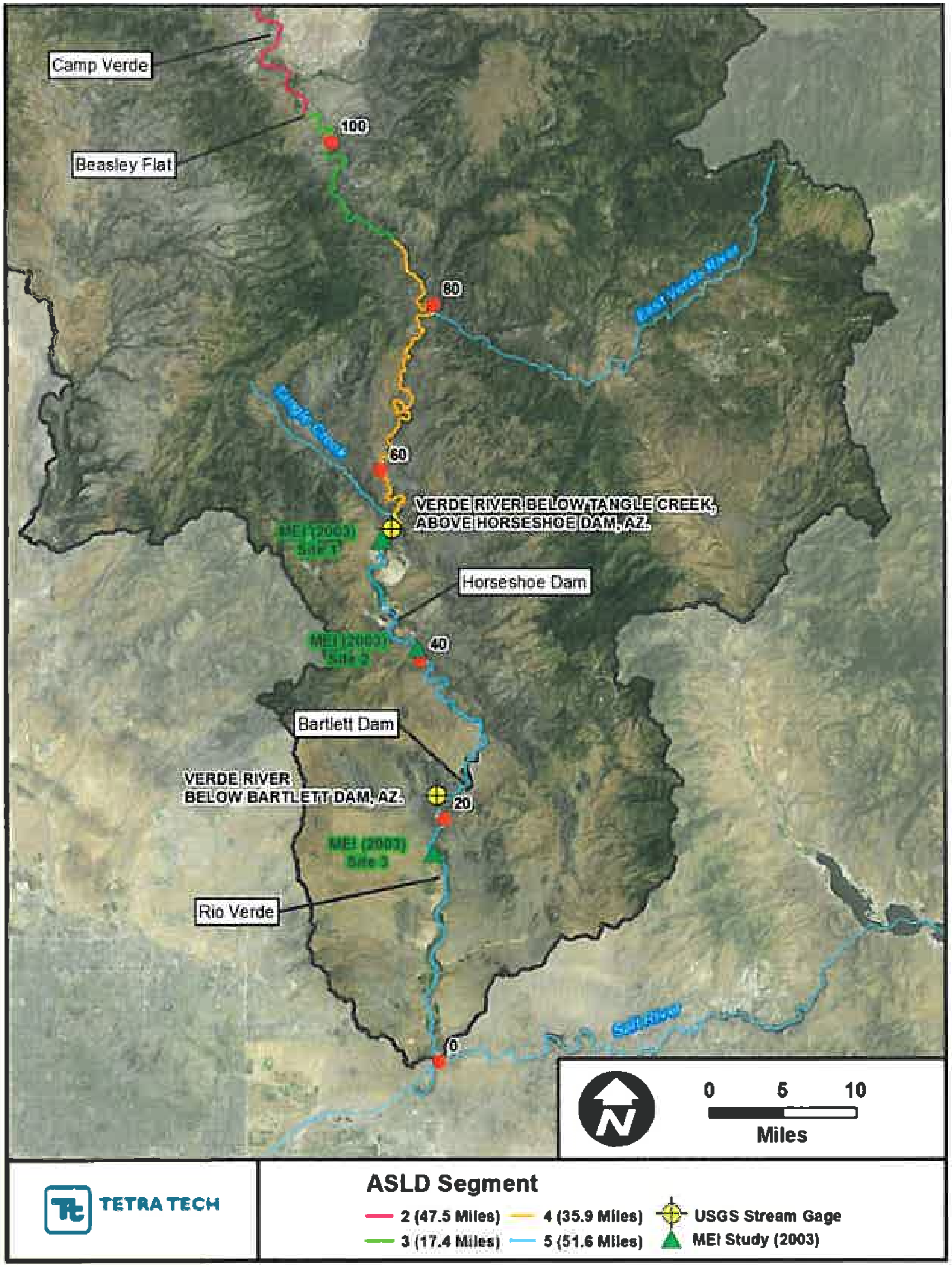


Figure 15. Vicinity map showing the locations of MEI (2003) study sites.

Figure 16. View looking upstream of MEI (2003) Study Site 1, below Tangle Creek. (Photo by R. Mussetter, November 2002)

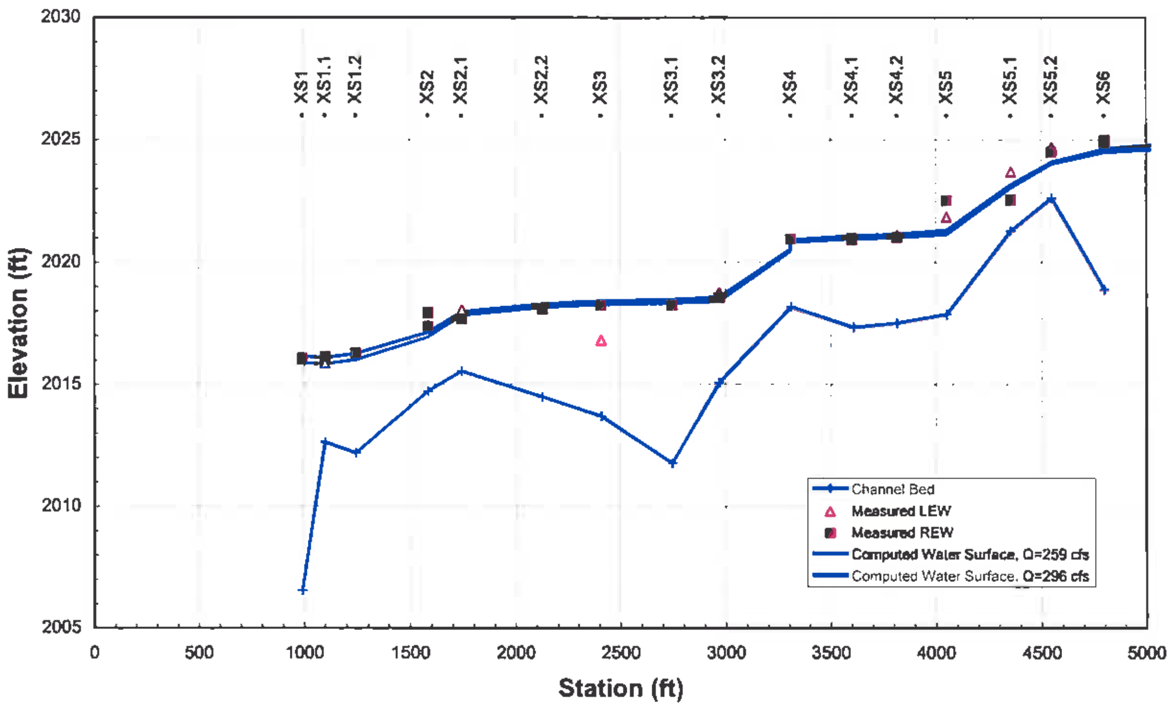


Figure 17. Thalweg and water-surface profiles at the MEI (2003) Study Site 1, below Tangle Creek.

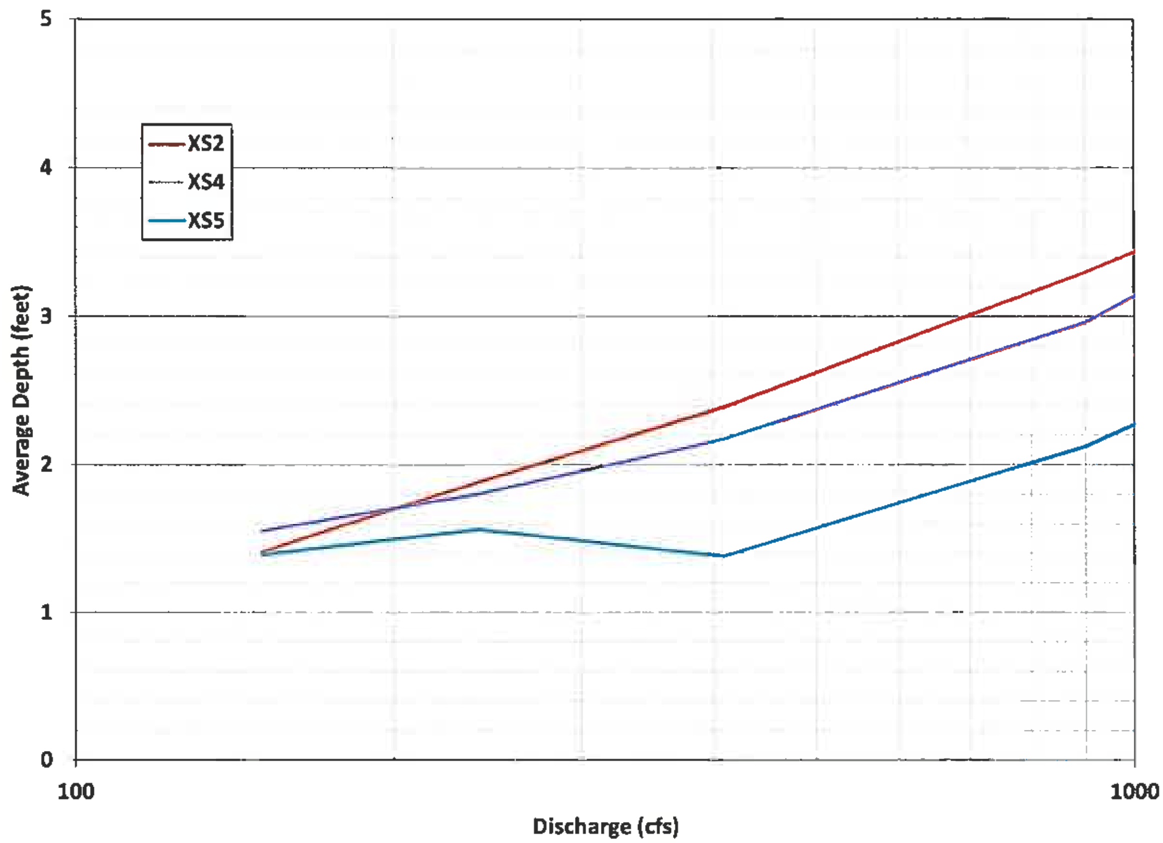


Figure 18. Average depth at MEI (2003) Site 1 XS2, XS4 and XS5.

### 2.2.4 Segment 5 (Head of Horseshoe Reservoir to Salt River Confluence)

The Verde River valley becomes less confined in ASLD Segment 5, providing more potential for lateral adjustment, and widening and braiding under un-regulated flow conditions. In portions of his 2004 report and testimony before this Commission, Dr. Schumm emphasized the braided character of the river in this portion of the reach. A series of high discharge years (1889, 1890, 1891) appears to have caused major channel erosion, and this was continued by the high discharge years of 1905, 1906, 1907, and 1909 (Schumm, 2004; **Figure 19**). The 1934 aerial photographs show that the active channel of the Verde River channel was wide, occupying the entire valley floor (**Figures 20 through 22**). Under present conditions, this portion of the reach is island-braided, a condition that developed during the mid-20th Century due to flow regulation and reduction in the peak flows by the upstream reservoirs (Graybill and Nials, 1989) (**Figures 23 through 25**).

MEI (2003) Study Site 2 is located about 3 miles downstream from Horseshoe Dam within an approximately 2,000 wide section of the Verde River valley (**Figure 26**). The active (i.e., unvegetated) channel through the site averages about 450 feet wide. The site is located in a depositional zone upstream from a valley constriction that is located about 1 mile downstream. The constriction is caused by an outcropping of erosion-resistant basin-fill on the right bank and older, alluvial terraces and tributary fan sediments on the left bank. Two large tributaries that episodically deliver significant quantities of sediment to the river further enhance the

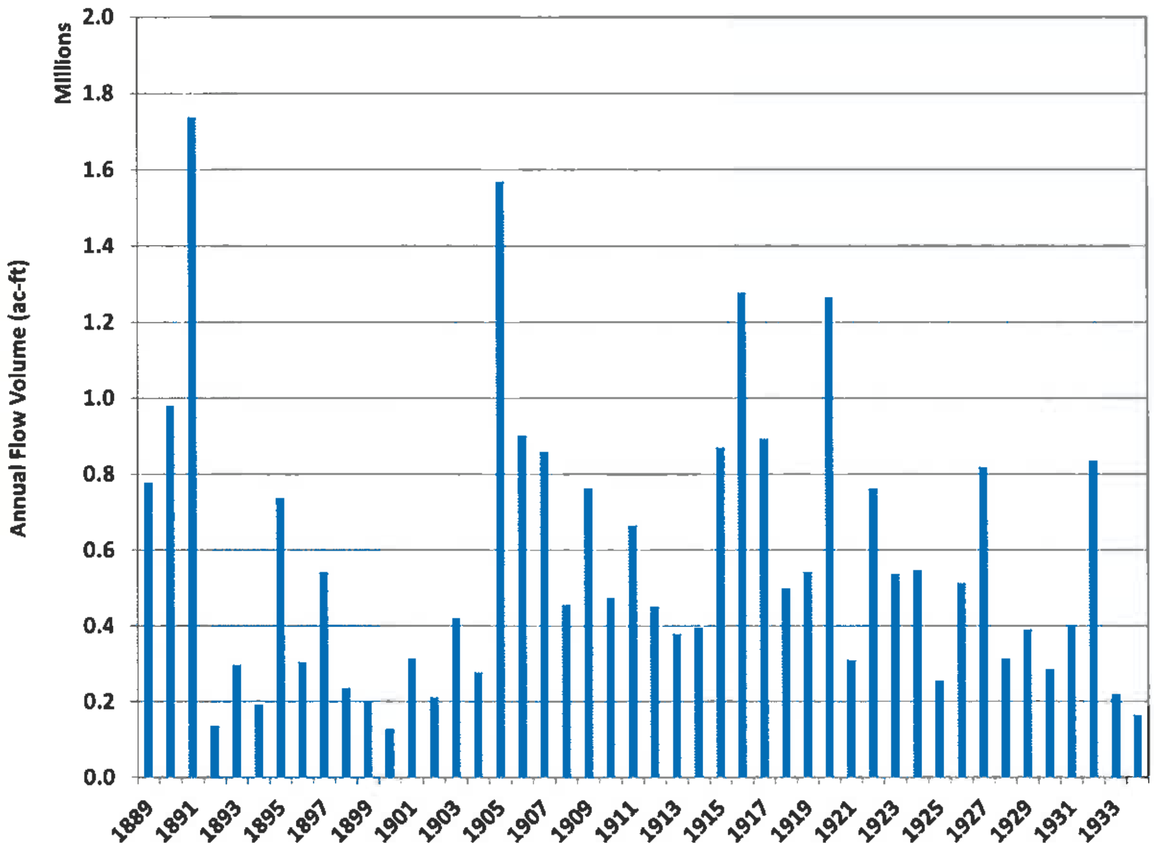


Figure 19. Annual flow volume below existing Bartlett Dam between 1889 and 1935 (from USGS, 1954).

Figure 20. Verde River at Horseshoe Dam site (T7N, R6E, Sec 2). 1934 aerial photograph showing braided channel pattern and constriction, as a result of geologic control. Note that channel occupies entire width of valley.

Figure 21. **Verde River at "bottom of Fort McDowell Indian Reservation" (T3N, R7E, Sec 31). 1934 aerial photograph showing braided channel pattern and constriction, as a result of geologic control. Note that the channel occupies the entire width of the valley.**

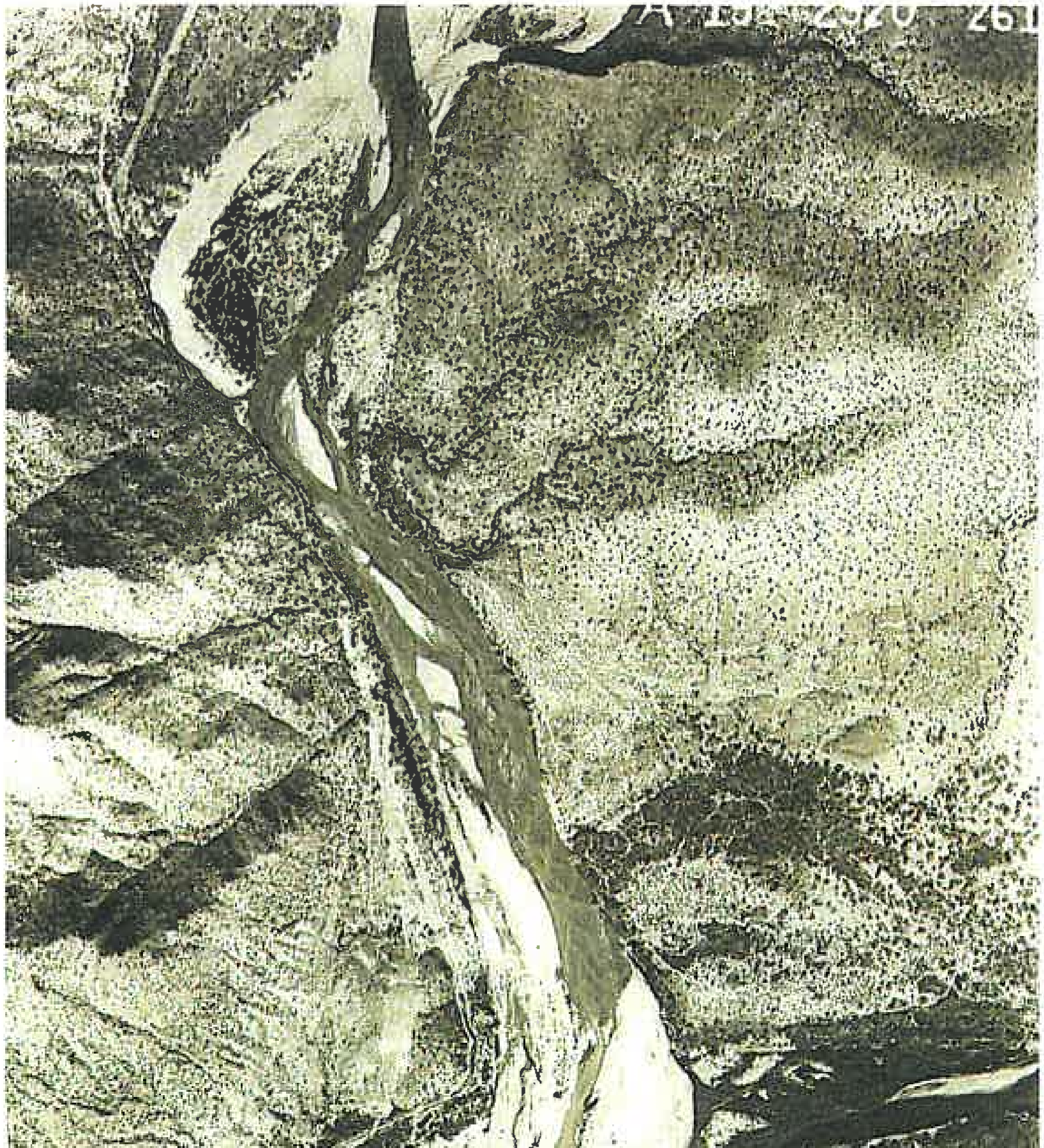

Figure 22. Verde and Salt River confluence (T2N, R7E, Sec 5). 1934 aerial photograph showing braided channel pattern and constriction. Note that large sediment delivery from Verde River forces Salt River channel to south side of valley.

Figure 23. Island-braided reach of the Verde River about 2.5 miles downstream from Horseshoe Dam. (Photo by R. Mussetter, October 29, 2013)

Figure 24. Island-braided and bedrock-controlled reach of the Verde River about 4.5 miles downstream from Bartlett Dam. (Photo by R. Mussetter, October 29, 2013)

Figure 25. View looking upstream of an island braided reach of the Verde River near the community of Rio Verde. (Photo by R. Mussetter, October 29, 2013)

Figure 26. MEI (2003) Study Site 2, approximately 3 miles downstream from Horseshoe Dam. (Photo by R. Mussetter, November 2002)

depositional nature of the site. Sediments delivered by the right bank arroyo at the site have formed a large alluvial fan that has prograded out onto the valley floor. The left valley wall throughout the site is composed of basin-fill sediments that also crop out on the right valley wall immediately downstream of the site. The right valley wall along most of the site is composed of old alluvial and fan sediments into which the present arroyo is inset. Morphologically, the site is characterized by an approximately 200-foot-wide low-flow channel that is fringed by riparian vegetation. A large, sparsely vegetated cobble-gravel bar separates the main channel from a chute channel that is located on the margin of the valley floor and runs along the base of the bounding alluvial fan and terraces for much of the length of the site. The active and chute channels are flanked by thin strands of riparian vegetation.

The survey data from this site indicate that maximum depths at XS2 and XS4 are less than 2 feet for flows up to 225 cfs to 250 cfs (**Figure 27**). The calibrated hydraulic modeling for this site also indicates that the cross sectionally-average depth is less than 2 feet at discharges up to about 600 cfs at XS2, and greater than 1,000 cfs at XS4 (**Figure 28**).

Site 3 is located about 6.5 miles downstream from Bartlett Dam in a section of the Verde River valley that is about 4,000 feet wide (**Figure 29**). The active channel at the site is about 600 feet wide, and it is flanked on the left side by the younger Lehi (Holocene) terrace that was overtopped by the large floods that occurred in the early part of the 20th century. The upper portion of the site is flanked by the older Lehi terrace, but the remainder of the site is flanked by both late- and early-Pleistocene age alluvial sediments that are dissected by a number of relatively small active arroyos. The older Lehi terrace does not appear to have been overtopped by the large floods of the early part of the 20th century. The site is located in a depositional zone upstream from a valley constriction located about one mile downstream that is caused by older, erosion-resistant alluvial deposits in the right bank and outcrop of the Needle Rock Formation on the left bank (Skotnicki, 1996). Morphologically, the site is characterized by an approximately 500-foot-wide active channel that is separated from a chute channel that runs along the left side of the site for most of its length by a sparsely vegetated gravel-cobble bar.

The MEI (2003) survey data indicate maximum depths are less than 2 feet at discharges in the range of 300 cfs to 500 cfs at XS1, XS4, XS6 and XS8 (**Figure 30**). The calibrated hydraulic model indicates average depth of less than 2 feet at discharges up to 2,000 cfs at XS1, up to 1,000 cfs at XS4 and up to about 1,500 cfs at XS8 (**Figure 31**).

Both of these sites likely had considerably less riparian vegetation after the large floods that occurred in the late-19$^{th}$ and early 20$^{th}$ Centuries leading up to the time of Arizona's statehood, and as a result, the low–flow channels were most likely wider, shallower and less stable than they are under modern conditions. The data from these sites further illustrate that ASLD Segment 5 was not navigable under ordinary and natural conditions at Arizona's statehood.

### 2.2.5 Conclusion

Based on the above information, it is my opinion that the Verde River would not have been navigable under *ordinary and natural conditions* at and prior to the date of Arizona's statehood. Specific aspects of this overall conclusion are described in more in Section 1.2 at the beginning of this declaration.

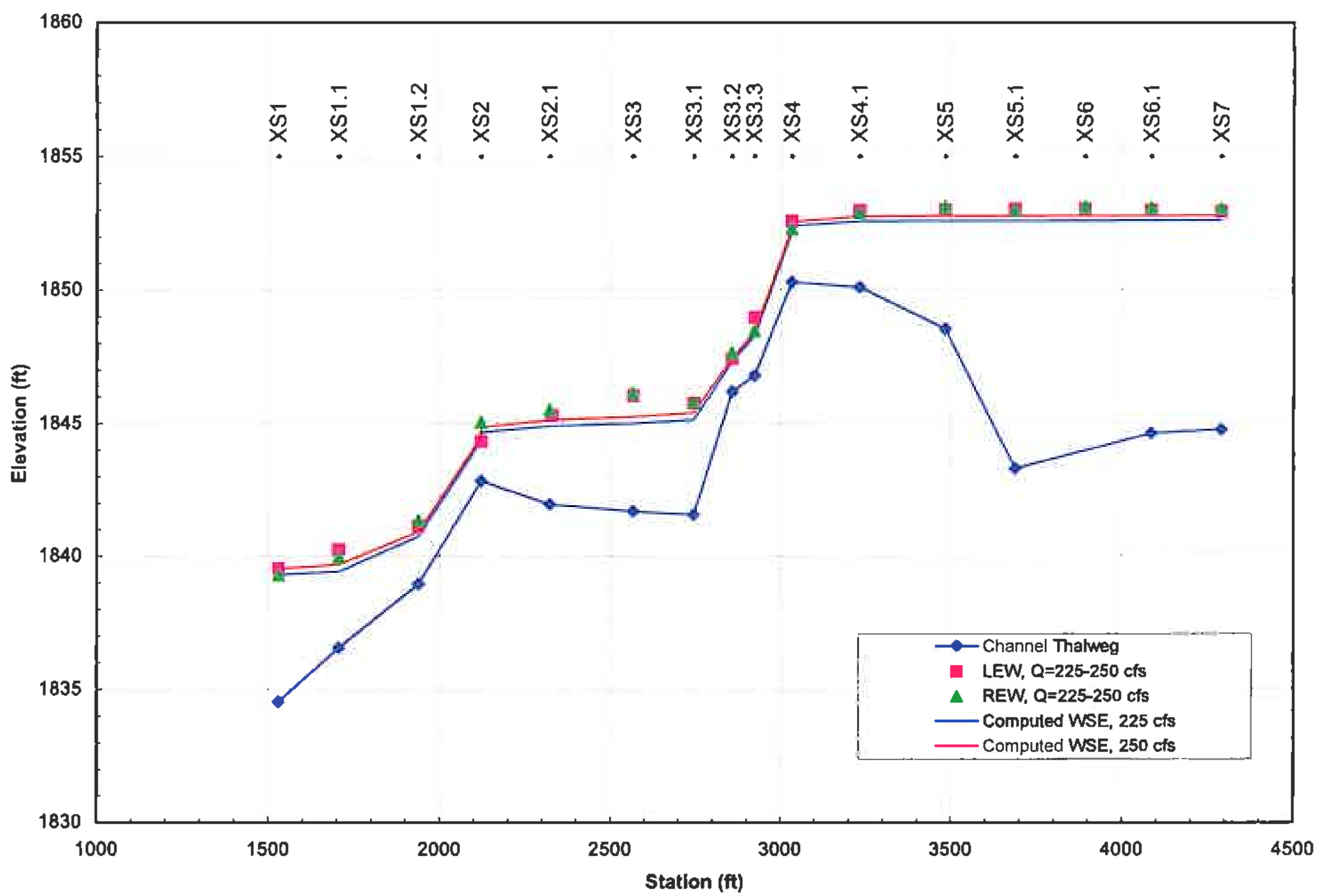


Figure 27. Thalweg and water-surface profiles at the MEI (2003) Study Site 2, about 3 miles downstream from Horseshoe Dam.

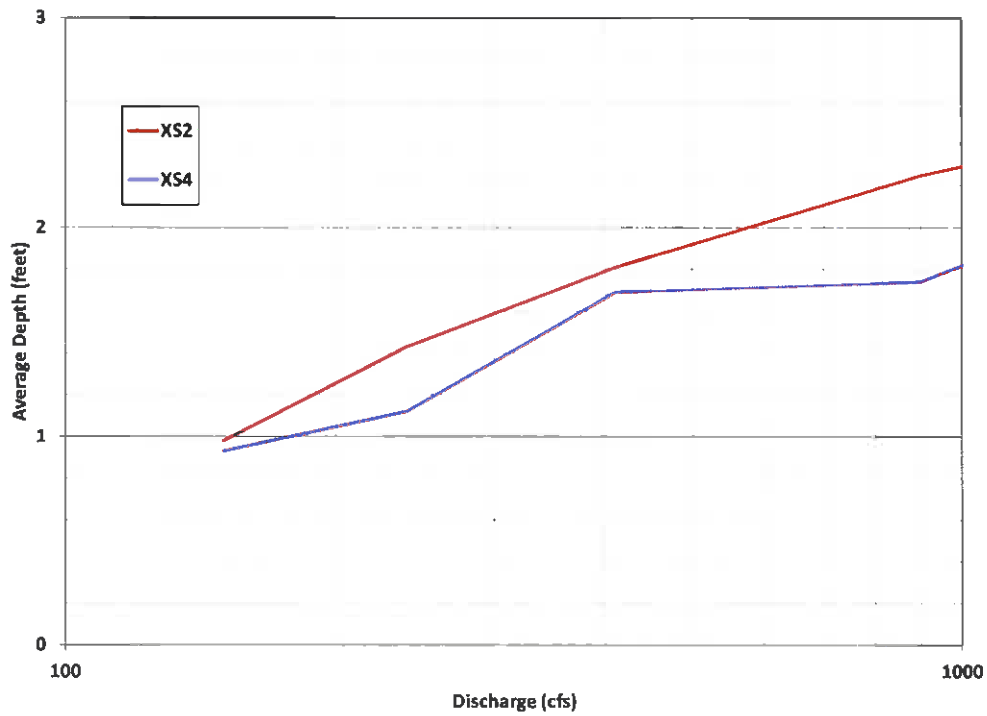


Figure 28. Average depth at MEI (2003) Site 2 XS2 and XS4.

Figure 29. MEI (2003) Study Site 3, approximately 7 miles downstream from Bartlett Dam. (Photo by R. Mussetter, November 2002)

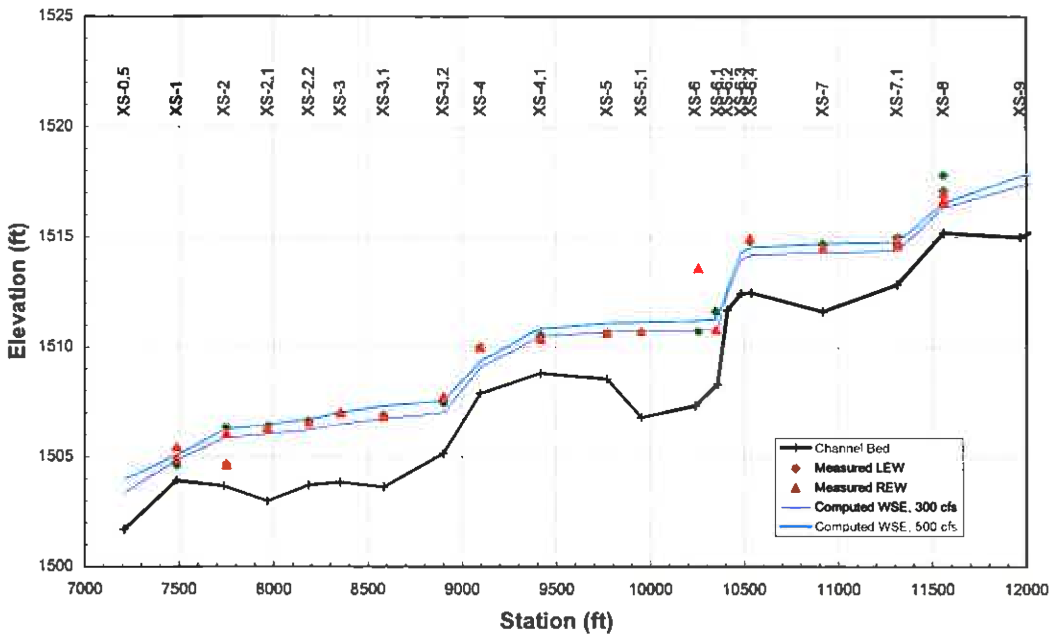


Figure 30. Site 3 surveyed water-surface elevations and computed water-surface profiles for the discharges at the time of the survey (300 to 500 cfs).

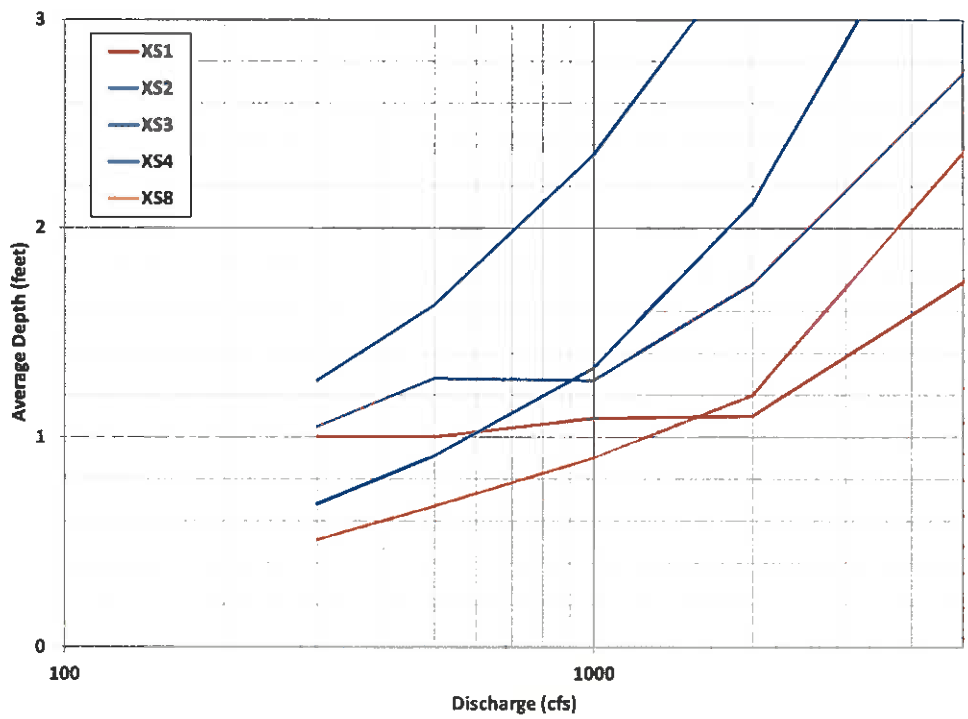


Figure 31. Average depth at MEI (2003) Site 3 XS1, XS2, XS3, XS4 and XS8.

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