How Deep is the River? The Shape of the Colorado River in Grand Canyon

Matt Kaplinski, Dan Buscombe, Joe Hazel: Northern Arizona University

Paul Grams, Keith Kohl, Bob Tusso, Tom Gushue: USGS-GCMRC

Between 2009 and 2017, a team of researchers from Northern Arizona University and GCMRC have surveyed and produced elevation maps of about 160 miles of the Colorado River below Glen Canyon Dam. The surveys cover from Glen Canyon Dam (river mile -15) to Phantom Ranch (river mile 88) and from National Canyon (river mile 166) to Diamond Creek (river mile 225). The river between Phantom Ranch and National Canyon has not been surveyed. The surveys combine total station and sonar surveys of the channel and channel margins.

The results of the surveys (figure 1) show that, at flows of 8,000 ft^3/s, the average depth of the river is 6.2m (20.3 ft), with a median depth of 5.4 m (17.8 ft). The maximum depth measured to date is 26.2 m (85.9 ft) in a pool just downstream of lower cremation camp, off the prominent Vishnu Schist buttress at the lower end of the eddy.

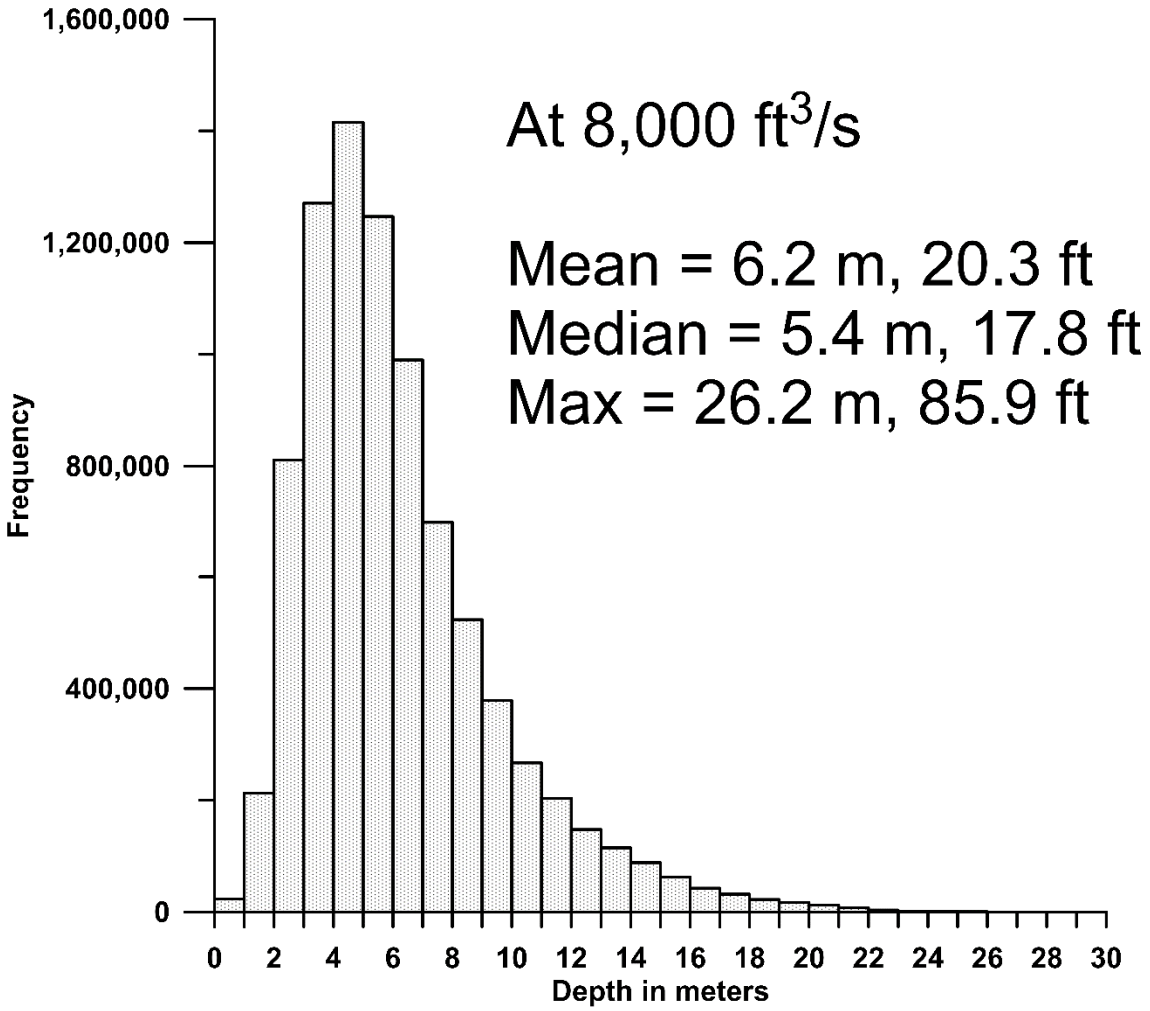

Figure 1. Histogram of river depths at a flow of 8,000 ft^3/s.

The surveys also reveal the geomorphic structure of the river corridor. The large scale (10's of kilometers) shape of the river is controlled by the geologic unit present at the river. The competence, or erodibility of the rock unit controls the overall depth and width of the river in the same way that it controls the profile of the canyon exposed in the cliffs. Cliff-forming rocks, like the Redwall Limestone and Vishnu metamorphic complex rocks are harder and more competent, which results in a narrower, deeper river channel. Conversely, more easily erodible rocks, like the Dox Sandstone, form a wider, shallower river channel.

The smaller scale (1's of kilometers) shape of the river is controlled by the presence and location of tributary debris fans. Schmidt and Rubin (1995) termed this basic, repeating channel unit the "fan-eddy complex", comprised by a channel-constricting debris fan, an upstream pool created by the backwater effect of the constriction, and a channel expansion with one or more eddies and plunge pool immediately downstream from the fan (figure 2). Further downstream from the scour hole created in the plunge pool by accelerated flow through the constriction, the channel typically narrows and shallows; a portion of the bed referred to as the exit slope. A mid-channel or bank-attached cobble bar often occurs in these areas of somewhat shallow flow. The coarse debris is the result of erosion of the upstream debris fan during pre-dam high flows. At lower discharges, flow typically passes around the margins of these cobble bars and creates a riffle.

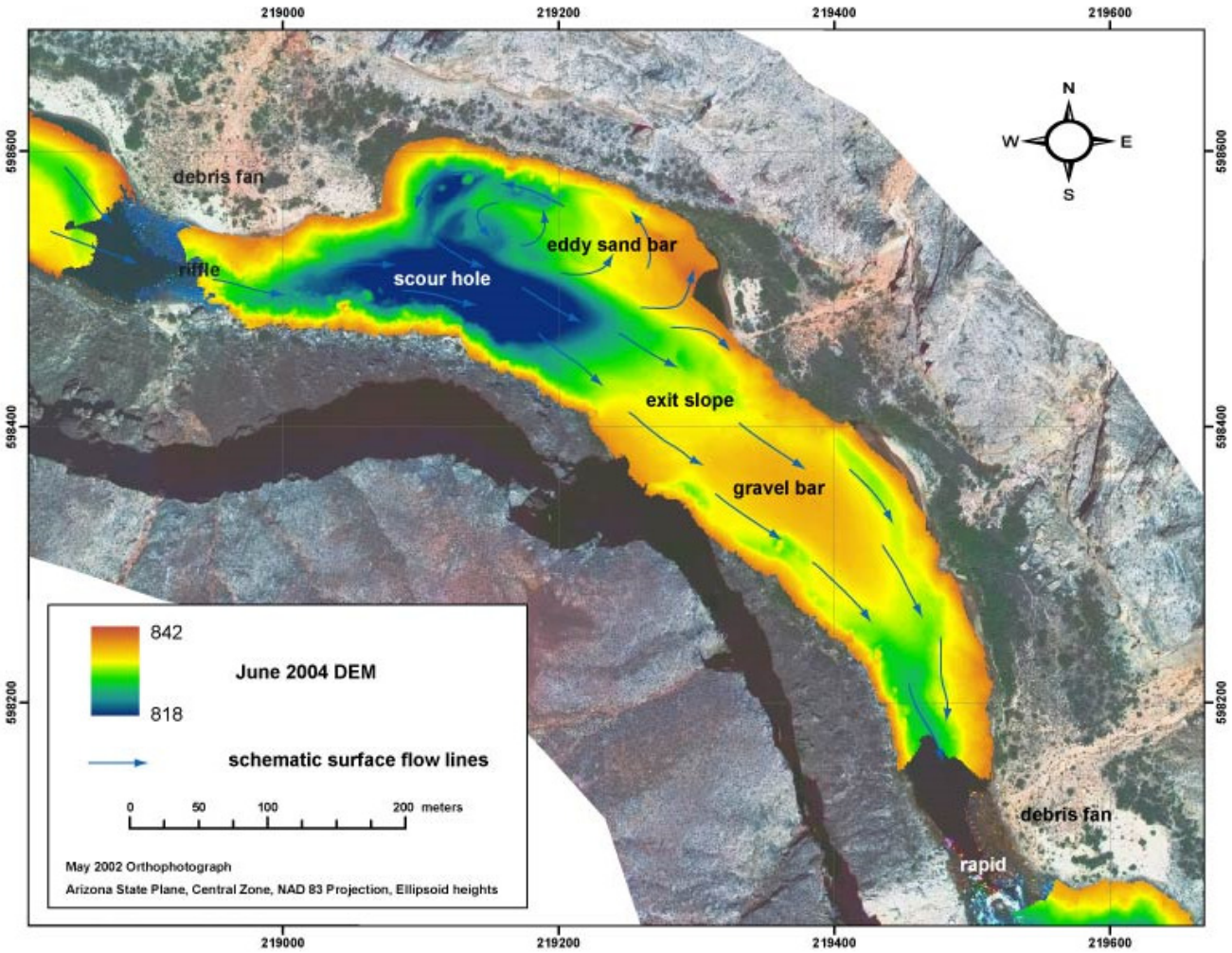

Figure 2. Map of a debris fan-eddy complex in lower Marble Canyon (river mile 43.5 to 44.0) showing the characteristic features of this fundamental channel unit.