DEPARTMENT OF THE INTERIOR
U.S. GEOLOGICAL SURVEY

PREPARED IN COOPERATION WITH THE
BUREAU OF RECLAMATION AND THE NATIONAL PARK SERVICE

HYDRAULIC MAPS OF MAJOR RAPIDS, GRAND CANYON, ARIZONA
24.5 MILE RAPIDS
MISCELLANEOUS INVESTIGATIONS SERIES
MAP I–1897–B

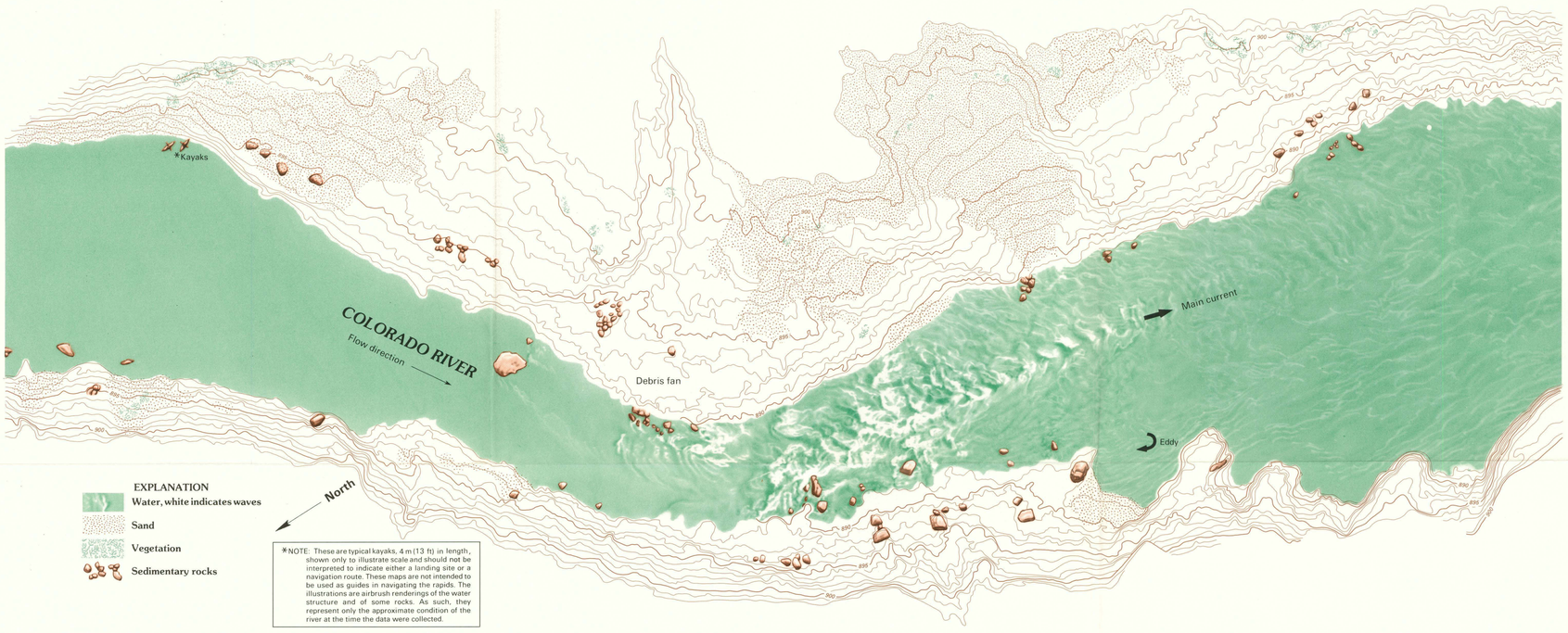


Figure 1—AT DISCHARGE OF 5,000 CUBIC FEET PER SECOND

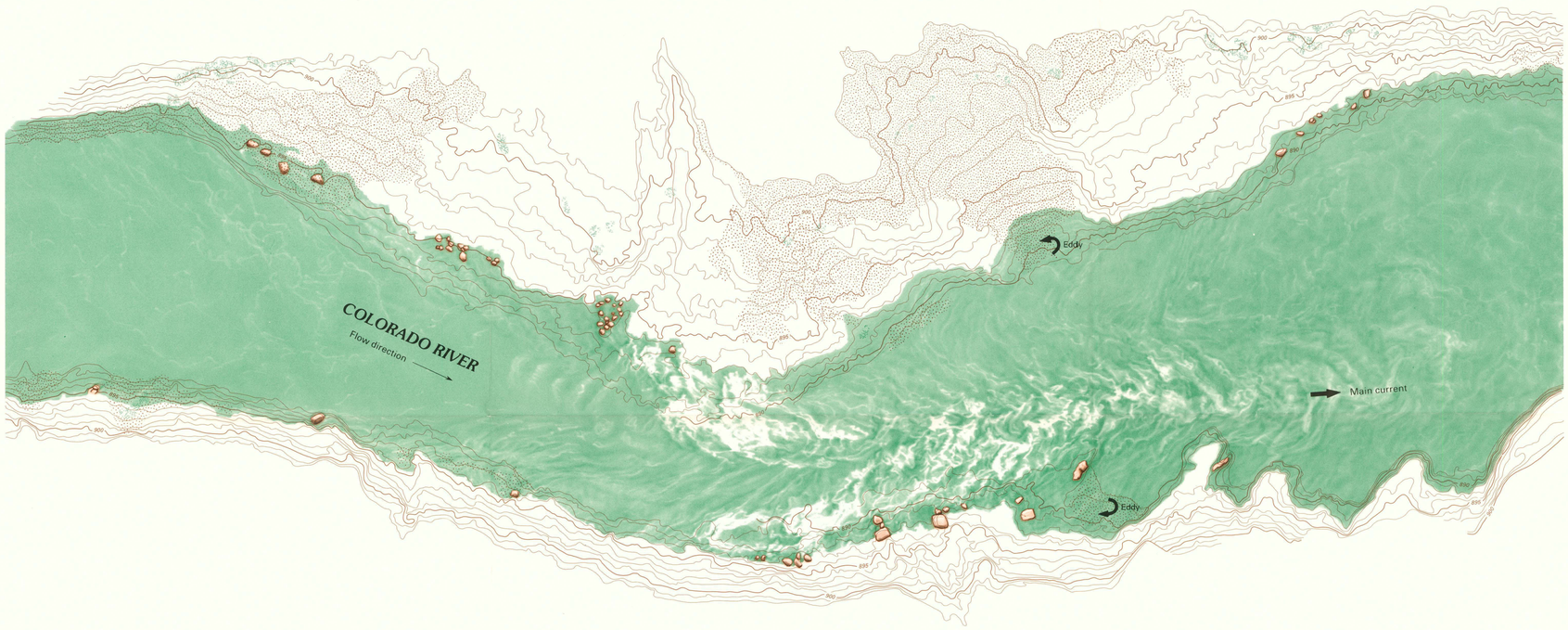


Figure 2—AT DISCHARGE OF 30,000 CUBIC FEET PER SECOND

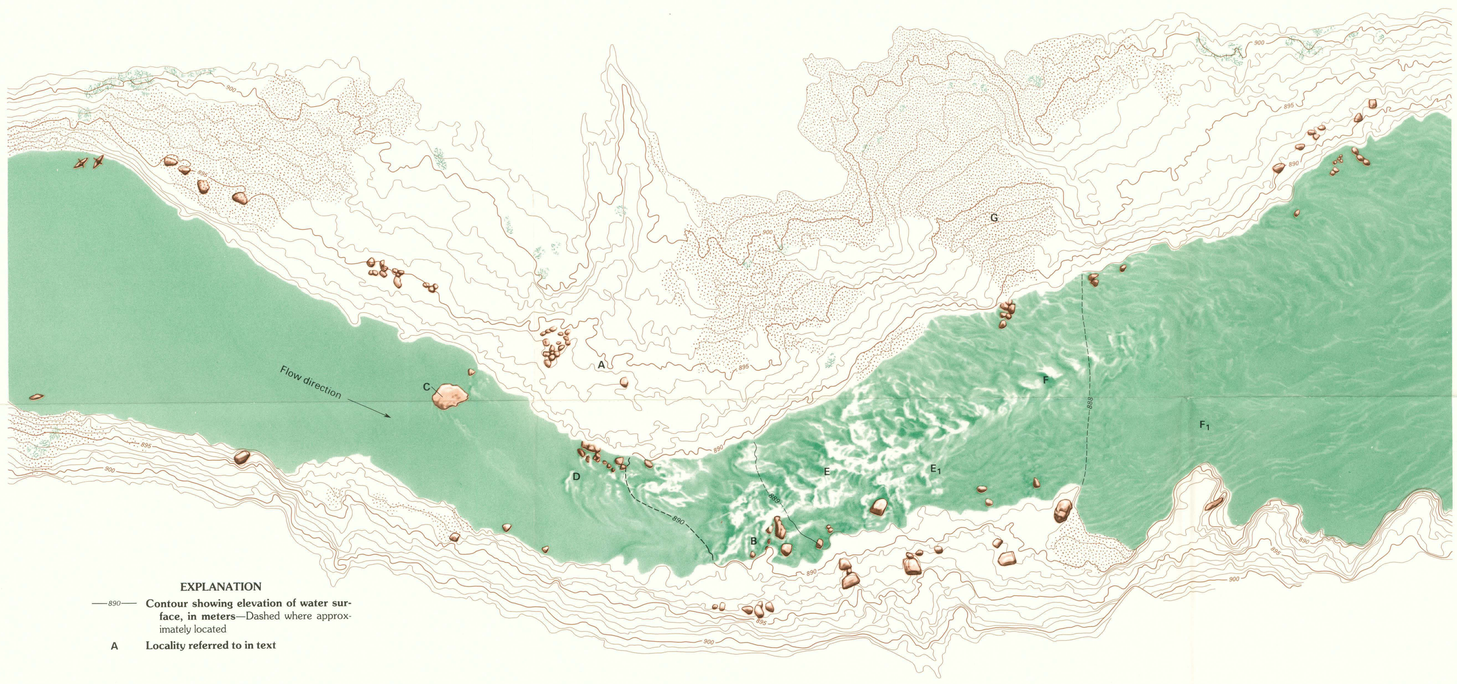


Figure 3—WATER-SURFACE CONTOURS AT DISCHARGE OF 5,000 CUBIC FEET PER SECOND

SCALE 1:1 000
100 0 100 200 300 FEET
10 0 10 20 30 40 50 60 70 80 90 METERS
CONTOUR INTERVAL 1 METER

Figure 4—24.5 Mile Rapids looking downstream with 25 Mile Rapids in the distance.

DISCUSSION

24.5 Mile Rapids (informally named, figs. 1–3) is one of approximately a dozen rapids of the Colorado River between river miles 20 and 30, known as "The Roaring Twenties" (fig. 4). The rapid is caused by two debris fans from unnamed small tributary canyons on both banks—the larger debris fan (**A**, fig. 3) is on the east bank of the river, and the smaller one (**B**, fig. 3) is opposite in position on the west bank. The bedrock at 24.5 Mile Rapids is Redwall Limestone of Mississippian age, but the channel bank is nearly everywhere covered by a talus of sandstone and limestone boulders.

The head of 24.5 Mile Rapids is well marked by a large tabular sandstone rock at low discharges (**C** in fig. 3); this rock is covered by water and shows a distinct train of undular waves downstream when the discharge reaches 30,000 cfs (compare figs. 1 and 2). Downstream from the tabular rock is a smaller rock (**D**, fig. 3), which, at low flows, causes well-defined cavitation in the flow. At low water (figs. 1 and 3), the tongue of the rapid is complex because large rocks on the upper left side of the rapid (**C**, fig. 3) and slightly further downstream on the right side of the rapid (**B**, fig. 3), cause large waves and local eddies. At higher water levels (fig. 2), these rocks are more submerged and the rapid assumes a relatively simpler form with a well-defined tongue, a few crossing waves (near **E** at low water, but further toward the west near E_1 at higher water), and well-defined tailwaves (**F** at low water; F_1 at higher water). A fascinating feature of this rapid is the change in location and orientation of the tailwaves with discharge: as discharge increases, they move from the center of the river channel at low water (fig. 1) to the west side of the channel at higher discharges (fig. 2). The distribution of sand below the rapid on the east bank suggests that the waves in the rapid stay close to the west shore at higher discharges (for example, at the discharge of 92,000 cfs in 1983) and that a large eddy develops on the east side of the tailwaves, allowing sand to be deposited in the region around **G** (fig. 3).

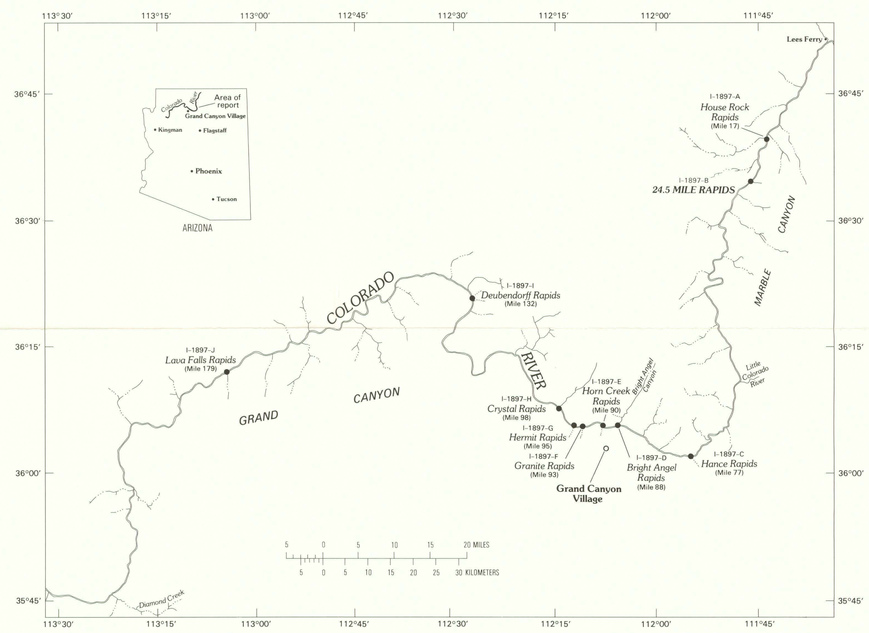
Streamlines (paths of floats) and velocities of floats that have been shown for eight of the rapids in this series of maps (I–1897–A, C, E–J) were not determined for 24.5 Mile Rapids because the continuous fast water between river miles 24 and 25 made launch and recovery of the floats difficult and dangerous (note the proximity of 24.5 and 25 Mile Rapids in figure 4; this is typical of the spacing between rapids in this stretch of the river). A fathometer traverse about 300 m upstream of the table rock **C** suggests that the channel is parabolic, with a maximum depth of about 6 m at 5,000 cfs. At 5,000-cfs discharge, the rapid drops about 2.5 m, from a water-surface elevation of 890.5 m to about 888 m. At higher discharges, the gradient through the rapids is less, as can be seen by comparing the shorelines above and below the rapids in figures 1 and 2. Because of the lack of data on channel configuration of this rapid, no discussion of typical features of flow in the Colorado River rapids is given with this map; for a general model of the rapids, and detailed information on many rapids, the reader should refer to Kieffer (1985, 1987).

To summarize, the most significant hydraulic features in 24.5 Mile Rapids are local standing waves and eddies caused by large rocks in the colluvium that lines the channel (for example, the waves associated with rocks near **D** and **B**), a complex tongue and wave structure at low discharges, and a dramatic change in position and orientation of waves below the tongue with changing discharge. The hydraulic features of 24.5 Mile Rapids reflect a dynamic equilibrium between the flow in the Colorado River channel and debris flows from small tributary canyons on both banks. The configuration of the channel bottom depends not only on the contribution from the tributary floods or debris flows, but also probably to some extent on the transient sediment load of the river. The channel configuration changes with time, both gradually and catastrophically.

REFERENCES

Kieffer, Susan Werner, 1985, The 1983 hydraulic jump in Crystal Rapid: Implications for river-running and geomorphic evolution in the Grand Canyon: Journal of Geology, v. 93, p. 385–406.

Kieffer, Susan Werner, 1987, The rapids and waves of the Colorado River, Grand Canyon, Arizona, U.S. Geological Survey Open-File Report 87–096.



LOCATIONS OF MAJOR RAPIDS IN THE COLORADO RIVER, GRAND CANYON, ARIZONA
I–1897–A indicates series number of map for each rapids.

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Hydraulic data collected in October–November 1985 by Susan Werner Kieffer, assisted by Margie Marley

Contour lines compiled on analytical stereoplotters at the U.S. Geological Survey, Flagstaff, Arizona, from aerial photographs flown in 1984 by the Bureau of Reclamation, Series GCES

Airbrush portrayal of hydraulic features by Patricia Hagerty Gray, U.S. Geological Survey

Prepared on behalf of the Bureau of Reclamation under Interagency Acquisition No. 6–AA–40–04190

HYDRAULIC MAP OF 24.5 MILE RAPIDS, GRAND CANYON, ARIZONA

By

Susan Werner Kieffer

1988

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