FY2003 Inflow Study of Matagorda Bay

Background

In the fall of 2002, the U.S. Geological Survey (USGS) agreed to assist Texas Water Development Board (TWDB) in a study of flow dynamics of Matagorda Bay. Specifically, the USGS agreed to install and operate multiple gaging stations in and near the lower Colorado River, proximal to the intersection with the Gulf Intracoastal Waterway (GIWW). Figure 1 shows the entire Matagorda Bay study area, with a map inset showing the locations of gaging stations in the lower Colorado River. As part of an ongoing cooperative program with the U.S. Army Corps of Engineers, the USGS already operates velocity meters at two locations (sites 7A and 8C), as well as stage sensors at three locations (7A, 7C, and 8B). To determine tidal flux through this intersection (Colorado River, GIWW, and Colorado River Bypass Channel) three additional stations were to be established (sites 7C, 7B, and 8B). Data collected at each station would consist of water velocity and tidal stage. After installation of monitoring equipment, a 48-hour synoptic survey would be conducted on March 24-26, 2003, whereby several discharge measurements would be made at each location and velocity-index ratings would be developed. The gaging stations would then be operated until August 31, 2003, and the ratings could be used to determine discharge at each location for the 5-month study period.

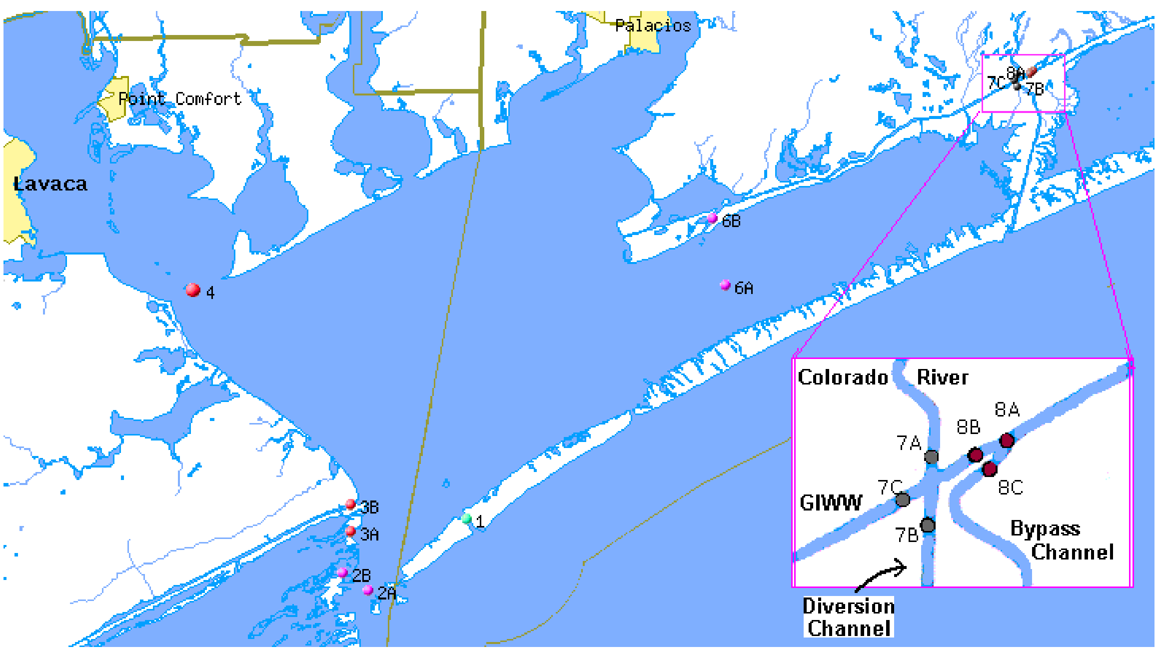

Figure 1. Matagorda Bay study area (Colorado River inset).

Gaging stations were installed at sites 7C and 7B on March 19, 2003. Equipment at each site included Acoustic velocity meters with stage sensors, and internal data loggers. On this same date, efforts to find a suitable location to install equipment at site 8B were unsuccessful. This site is located in the Colorado River locks operated by the U.S. Army Corps of Engineers. Information provided by Corps employees indicated that there were no "safe" locations to install such equipment because barges passing through these locks routinely damage any fixed structures. A velocity meter was temporarily placed near the Corps of Engineers boat house, which is located outside of the lock chamber. However, due to inadequate depths, the acoustic signal could not reach out into the main channel and velocity data were not representative of flow conditions in the GIWW.

Synoptic Survey

On March 24-26, 2003, the USGS participated in an intensive synoptic survey of Matagorda Bay. Because of their familiarity with the lower Colorado River, the Lower Colorado River Authority (LCRA) was responsible for collecting data (discharge measurements and water-quality readings) at the USGS gaging sites 7A, 7C, 7B, 8A, 8B, and 8C. In turn, the USGS was responsible for collecting data at sites 6A and 6B. The survey began at approximately 0900 on March 24 and was scheduled to continue for 48 hours. However, during the evening of March 25, a storm encompassed the Bay and the survey was ended for safety considerations. Therefore, hourly discharge and water-quality measurements were made for approximately 38 hours.

Discharge measurements were made using a 1200 kHz RD Instruments acoustic Doppler current profiler (ADCP). Procedures used by the USGS when collecting data with ADCPs are documented in Simpson (2001). One measurement technique that was non-standard during the Matagorda Bay survey involved the number of transects (passes) that were used for a given discharge measurement. It is standard USGS policy to take the average of at least 4 transects for a discharge measurement. However, because of the extreme width of site 6A (over 3.8 miles wide) this was not practical. In particular, each transect took approximately 1 hour to make and flow conditions were constantly changing due to tidal influences. Therefore, only one transect was used for each discharge measurement at site 6A. Because of the time required to make measurements at site 6A, fewer measurements were made at site 6B.

Table 1 provides data collected by the USGS during the synoptic survey at sites 6A and 6B, while figure 2 shows discharge data collected at site 6A during the synoptic survey.

Table 1 – Discharge measurements made by the USGS during Matagorda Bay Synoptic Survey, March 24-25, 2003 (+ indicates ebb tide / - indicates flood tide)

Site #	Date	Start Time	End Time	Discharge (cfs)
6A	24-Mar-03	9:18	10:18	-95234
6A	24-Mar-03	10:41	11:31	-55550
6A	24-Mar-03	11:33	12:30	-33167
6A	24-Mar-03	12:31	13:21	-21249
6B	24-Mar-03	13:35	13:36	-4344
6B	24-Mar-03	13:39	13:41	-4027
6B	24-Mar-03	13:41	13:44	-4062
6A	24-Mar-03	14:00	15:03	-8720
6A	24-Mar-03	15:19	16:11	-10576
6B	24-Mar-03	17:52	17:53	-31
6A	24-Mar-03	18:14	19:09	26982
6A	24-Mar-03	19:11	20:02	24626
6A	24-Mar-03	20:26	21:25	17471
6A	24-Mar-03	21:40	22:30	44013
6A	25-Mar-03	1:11	n/a	n/a
6A	25-Mar-03	2:16	3:04	59380
6A	25-Mar-03	3:09	3:57	73245
6A	25-Mar-03	4:00	4:42	76800
6A	25-Mar-03	4:46	5:43	50916
6A	25-Mar-03	5:44	6:24	23928
6A	25-Mar-03	6:25	7:19	-31866
6A	25-Mar-03	8:49	9:55	-103980
6A	25-Mar-03	10:06	11:07	-79886
6A	25-Mar-03	11:08	n/a	n/a
6A	25-Mar-03	11:25	12:46	-59556
6A	25-Mar-03	12:47	13:39	-46431
6A	25-Mar-03	14:20	15:19	-43864
6A	25-Mar-03	16:52	17:47	-854
6A	25-Mar-03	17:48	18:38	11150
6A	25-Mar-03	18:39	19:38	31242
6A	25-Mar-03	19:41	20:30	44900
6A	25-Mar-03	20:33	21:25	37671
6A	25-Mar-03	21:29	22:20	43777
6A	25-Mar-03	22:22	23:11	47864

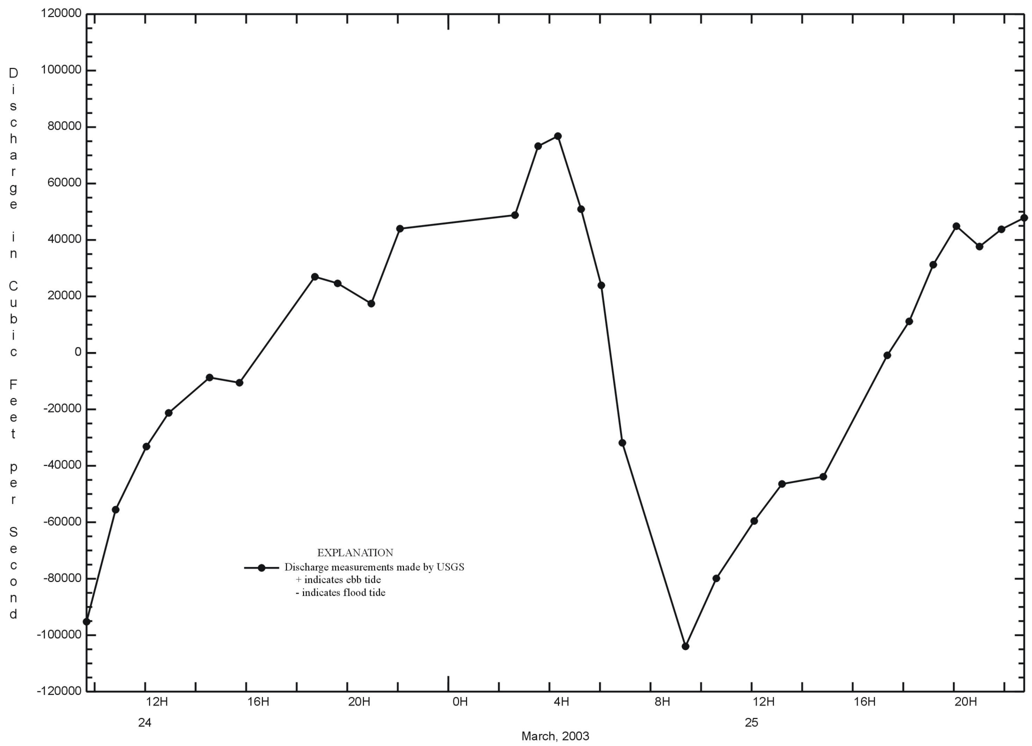

Figure 2 – Discharge measurements made by the USGS at site 6A during the Matagorda Bay synoptic survey of March 24-25, 2003

Rating Development

Velocity-index ratings for the four USGS sites (7A, 7C, 7B, 8C) were developed using discharge measurements made by the LCRA during the March 24-25 synoptic survey and concurrent velocity and stage data recorded by USGS equipment. The ratings were developed for each site by relating measured stream discharge to individual measurements of velocity (and possibly stage) through regression analysis. This method is discussed by Dunn and others (1997) and East and others (1998). The regression equation of the following form is used;

$$Q = B_1 + B_2V + B_3S$$

where Q is the estimated discharge in cubic feet per second, B_1, B_2, and B_3 are the regression coefficients, V is the measured velocity in feet per second, and S is the measured stage in feet. This equation allows for the computation of discharge from a single velocity (and possibly stage) measurement. Table 3 provides the regression coefficients and coefficients of determination for both sites 1 and 2 using this method.

Table 3 – Regression coefficients and coefficients of determination for discharge ratings at four lower Colorado River sites

Site Location	B_1	B_2	B_3	R^2
7A	-127	-2988	614	0.24
7C	2105	-1197	-742	0.75
7B	857	-2578	683	0.25
8C	-4598	2882	2225	0.97

Regressions for sites 7C and 8C appear reasonable and indicate that the data collected by the velocity meters index discharge in the entire stream cross-section adequately. However, regressions for sites 7A and 7B are poor and indicate that the meters do not index stream discharge very well. In particular, velocity data at these two sites does not appear to be as strongly influenced by tidal fluctuations. This is probably due, in part, to the fact that the range in velocity magnitude at these sites is fairly small, in comparison to other sites. Therefore, the ratings are less "sensitive" to changes in stream discharge.

Flow Computations

Instantaneous velocity and stage data recorded at the four gaging stations were used to compute discharge using the regression equations shown above. Figures 3, 4, and 5 provide graphical representation of flow data computed at each site, for the period March 23 – August 31, 2003.

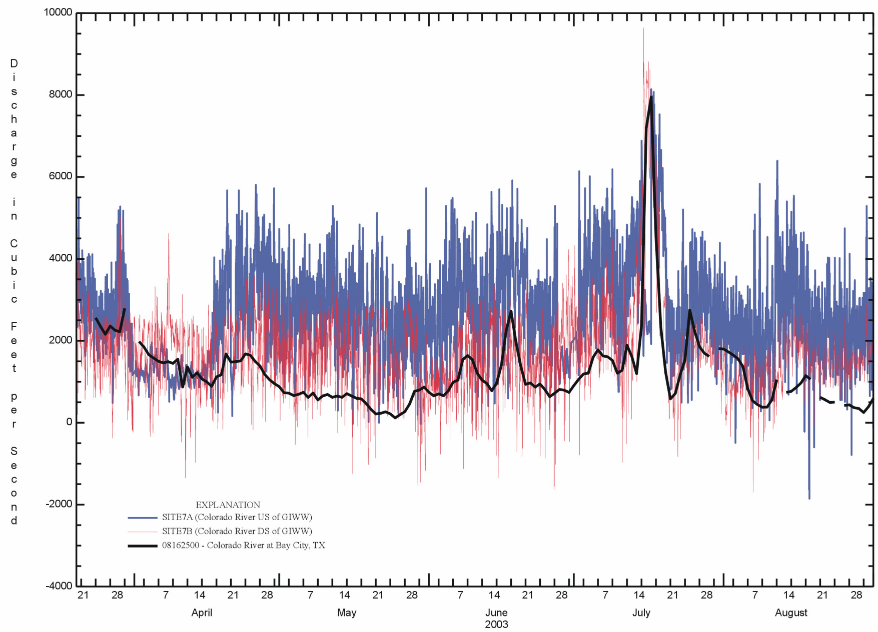

Figure 3. Computed discharge for the Colorado River above and below the Gulf Intracoastal Waterway, near Matagorda, Texas (Sites 7A and 7B) from March 23 – August 31, 2003

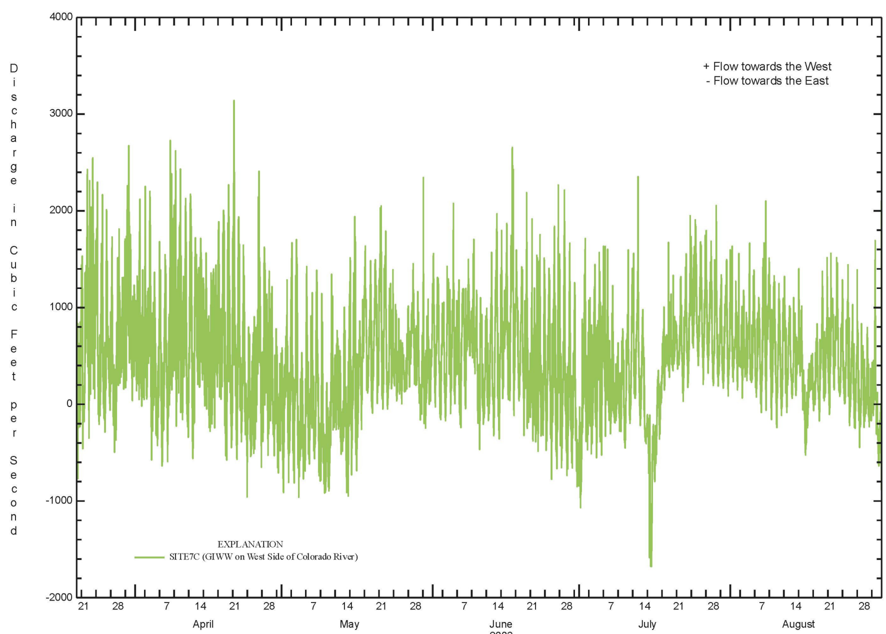

Figure 4. Computed discharge for the Gulf Intracoastal Waterway on the west side of the Colorado River, near Matagorda, Texas (Site 7C) from March 23-August 31, 2003

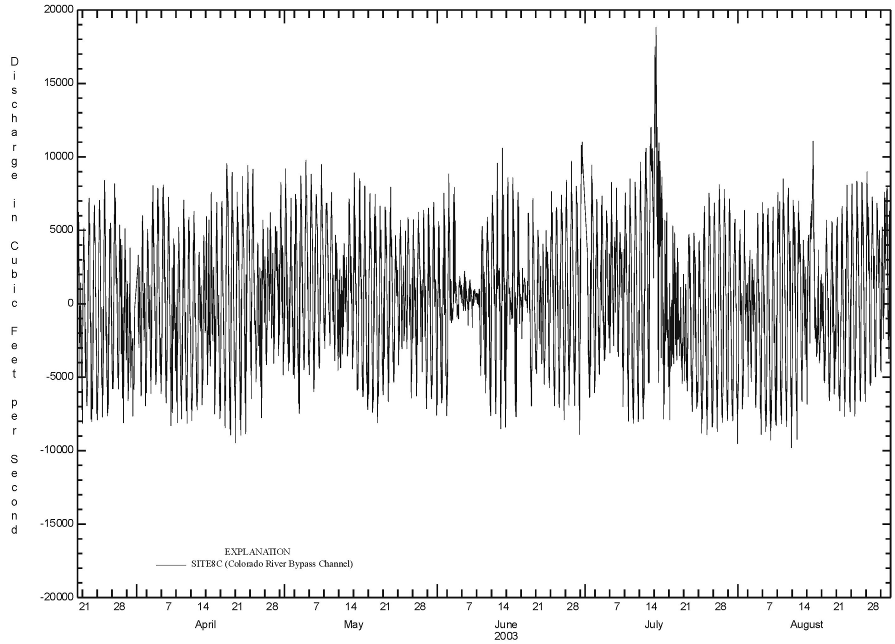

Figure 5. Computed discharge for the Colorado River Bypass Channel near Matagorda, Texas (Site 8C) from March 23-August 31, 2003

Figure 3 shows discharge for the Colorado River upstream and downstream of the GIWW. As mentioned in the ratings development section, the regression analysis were poor so these instantaneous values are somewhat questionable. However, examination of discharges at these two sites, as well as at the site on the GIWW west of the Colorado River (figure 4), does indicate that these data are reasonable. Positive discharge for the two river sites (figure 3) is downstream (towards the Bay), while positive discharge for the GIWW site (figure 4) is west, or from the river and into the GIWW. Generally, discharge at the upstream station is greater than discharge at the downstream station. Also, flow typically leaves the river and flows west into the GIWW. Therefore, it would be expected that discharge at the downstream station would be less than the upstream station. During the extreme event in mid-July, flow was from the GIWW into the river. During this same time period, discharge at the downstream river site was greater than discharge at the upstream site. A complete mass-balance cannot be achieved because discharge into and out of the GIWW on the east side of the Colorado River is unknown.

Examination of figure 5 shows that a significant amount of tidal interchange occurs in the Colorado River bypass channel. Daily fluctuations in excess of +-5,000 cubic feet per second are common during the study period. Index velocities measured at this site support this observation, in that velocity magnitudes in the bypass channel are significantly greater than those in the Colorado River sites.

References

Dunn, D.D., Solis R.S., and Ockerman, D.J., 1997, Discharge measurement in tidally affected channels during a hydrographic estuarine survey of Sabine Lake, Texas: U.S. Geological Survey Fact Sheet FS-157-97, 6 p.

East, J.W., Solis, R.S., and Ockerman, D.J., 1998, Computed discharges at five sites in lower Laguna Madre near Port Isabel, Texas, June 1997: U.S. Geological Survey Fact Sheet FS-167-98, 6 p.

Simpson, Michael, 2001, Discharge measurements using a broad-band acoustic Doppler current profiler, U.S. Geological Survey Open-File Report 01-01, 66 p.