Appendix 5 – Evaluating Changes in Stage-Area Ratings

Three hypothetical examples of stage-area comparisons are presented to provide guidance on how to compare cross-section surveys and determine when a change to the stage-area rating may or may not be required. Figure 5-1 shows the results of the initial standard cross-section survey at an index velocity station and results of three re-surveys of the standard cross section during the same water year as the initial survey. The initial survey data was used to create the standard cross section when the station was established. The above-water portions of the original survey and re-surveys were obtained using levels and stadia. The below-water portions of the original survey and re-surveys were obtained by means of an ADCP and motorboat. The quality of each survey and re-survey was noted as "good." The channel survey data for each example were entered into the USGS AreaComp program to compute cross-sectional area and to create a stage-area rating for the range of stage measured during the water year.

For the first example, a flood event occurred at the station, and a re-survey was performed at the standard cross section after the flood waters receded. The results of the re-survey are shown in figure 5-1*B*. Using these data (from figure 5-1*B*), a new stage-area rating was created, and the computed areas from cross-section B were compared to the computed areas from the original stage-area rating (fig. 5-1*A*). The data for computed areas from the two stage-area ratings for the minimum, maximum, and mean stage for a water year are shown in table 5-1 (Example B). The data indicate that substantial change occurred in the cross section for the range of stages measured during the year (6.1–30 percent change from the original standard cross-section survey). Furthermore, the percentage of change exceeded (1) the uncertainty in the surveys, which had an uncertainty of 5 percent based on the stated quality of the surveys ("good") and (2), the discharge measurement quality ratings shown in table 5-2. According to Turnipseed and Sauer (2010), the qualitative discharge measurement quality ratings of good, fair, and poor correspond to accuracies of 5, 8, and greater than 8 percent respectively. Therefore, the changes that occurred in the cross section and the corresponding changes to the original stage-area rating require that a new stage-area rating be developed and used for the station. A new or revised stage-area rating also may necessitate the development of a new index rating. Validation discharge measurements can be used to determine if a new index rating will be required.

In the second example, a standard cross-section re-survey was performed 1 year after the original survey (fig. 5-1*C*). No droughts or floods occurred during the water year. The difference between computed areas from the two stage-area ratings for the minimum, maximum, and mean stage for a water year are shown in table 5-1 (Example C). Data indicate that (1) little change occurred in the computed areas based on the comparison of the original and the re-survey stage-area rating outputs for the range of stage measured at the station (less than 2 percent), and (2) the changes were within the uncertainties in the surveys (less than 5 percent) and the discharge measurement quality ratings (good to poor, 2 to 8 percent) shown in table 5-2. Therefore, no change in the stage-area rating is indicated.

In the third example, a standard cross-section re-survey was performed 1 year after the original survey (fig. 5-1*D*). No significant floods occurred during the water year. The differences between computed areas for the two stage-area ratings for the minimum, maximum, and mean stage for a water year are shown in table 5-1 (Example D). The comparison of this re-survey to the original rating indicates that changes occurred in the computed areas for the cross section; however, the changes may not be large enough to justify a change to the rating (–8.0 to –1.5 percent with a mean of –3.6 percent for the range of stage measured at the station). The re-survey had an estimated uncertainty of 5 percent (rated as "good"), and the discharge measurements made during the year were rated poor to fair at low stages and fair to good at higher stages (table 5-2). In order to determine whether or not a change in the stage-area rating should be made, the index rating for low stage measurements should be analyzed for any biases (divergence) between computed mean velocity and the mean velocity of the discharge measurements. If no bias or trend is evident, a change to the stage-area rating would most likely not be justified; however, if a trend or bias in the index rating at low stages is evident, then a change to the stage-area rating (and possibly the index rating) might be justified. In this example, it may be difficult to justify a change in the stage-area rating because of the high uncertainty associated with the discharge measurements at low stages when they are compared to the computed discharges. In other words, any bias or trend in the comparison of discharge measurements to the index rating may be smaller than the uncertainty associated with individual measurements. If the stage-area rating is revised, then the index rating also may need revision.

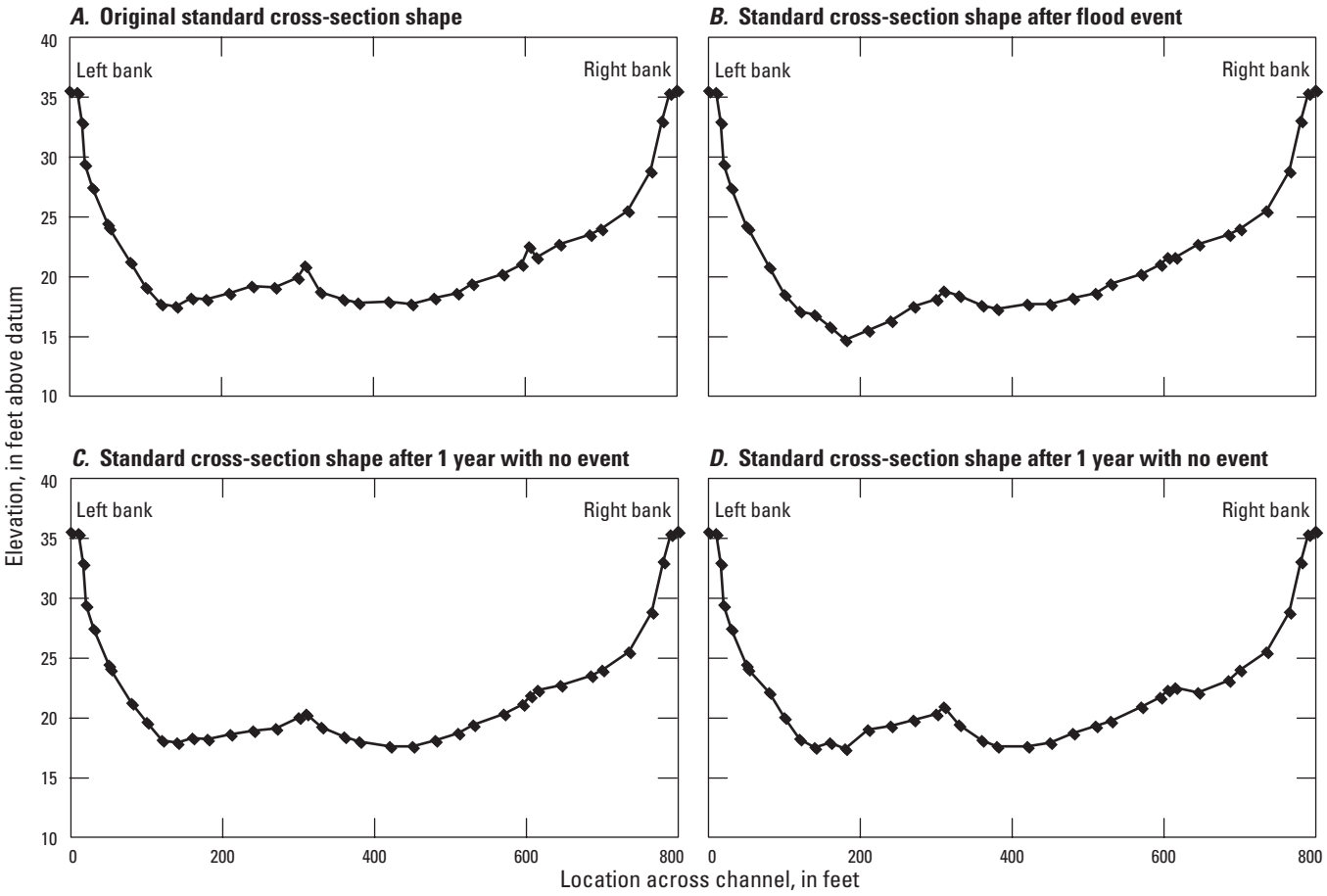

Figure 5-1. The initial standard cross-section shape and three re-surveys of the standard cross section.

Table 5-1. Differences in stage-area rating outputs between an original stage-area rating and stage-area ratings associated with three re-surveys.

[ft, foot; ft^2, square foot]

Statistic	Stage (ft)	Original stage-area rating A	Stage-area rating,[a] Example B		Stage-area rating,[b] Example C		Stage-area rating,[b] Example D	
		Rated area (ft^2)	Rated area (ft^2)	Percent difference from (A)	Rated area (ft^2)	Percent difference from (A)	Rated area (ft^2)	Percent difference from (A)
Minimum	22.15	1,760	2,290	30	1,730	–1.7	1,620	–8.0
Maximum	31.98	8,640	9,170	6.1	8,610	–0.4	8,510	–1.5
Mean	25.42	3,830	4,360	14	3,790	–1.0	3,690	–3.6

[a]After flood event

[b]After 1 year and no flood events

Table 5-2. Discharge measurements made during a water year for the station featured in table 5-1.

[ft^3/s, cubic foot per second; ft, foot; ft/s, foot per second]

Measurement no.	Discharge (ft^3/s)	Measurement quality rating	Gage height (ft above datum)	Index velocity (ft/s)
1	14,400	Good	25.10	3.90
2	8,790	Good	24.67	2.43
3	4,490	Fair	23.58	1.29
4	639	Poor	23.81	0.16
5	4,000	Fair	23.67	1.36
6	2,530	Poor	22.45	0.85
7	14,000	Good	25.67	3.34
8	30,000	Fair	31.66	3.56
9	3,540	Fair	24.56	1.00
10	586	Poor	24.98	0.13