CHAPTER 4 BASE-LINE ANALYSIS

4.1 INTRODUCTION

Base-line analysis involved building a HEC-RAS model that matched the flow depth in the physical model with **NO** bendway weirs. Specific options in HEC-RAS were used to build the model. The HEC-RAS options used to build the base-line model were:

1. Manning's *n*;
2. contraction coefficient; and
3. expansion coefficient.

By adjusting Manning's *n*, and the contraction, and expansion coefficients, the goal of matching the physical model flow depths with HEC-RAS could be achieved. Once the goal was achieved, the base-line model was used as the foundation model for bendway-weir analysis.

4.2 BASE-LINE MODEL – ORIGINAL TEST

The Original Test was the first attempt to build a model in HEC-RAS. The goal of the Original Test was to numerically model flow depths in the physical model with no bendway weirs.

4.2.1 Original Test Input Parameters

In order to build the HEC-RAS model, total station survey data were added to a HEC-RAS geometry file along with information about channel lengths, and left and right overbank lengths between cross sections. Once the survey data and information regarding the distance between cross sections was added to the geometry file, edits were made to Manning's *n*. Manning's *n* was set to a value of 0.015 at all cross sections in the concrete, rigid boundary model. Manning's *n*-values were found in the *River Analysis System Hydraulic Reference Manual* for HEC-RAS Version 3.0 (USACE, 2001a). No changes were made to the default values of the contraction and expansion coefficients. Default values of contraction and expansion coefficients were set to 0.1 and 0.3, respectively. Once survey data were entered into the HEC-RAS geometry file, discharge data were entered into the HEC-RAS steady flow file. Discharges of interest were 8 cfs, 12 cfs, and 16 cfs. Along with the discharge data, a downstream boundary condition was entered in the steady flow file since the flow regime was assumed to be subcritical. The project goal of creating a HEC-RAS model that matched flow depths in the physical model controlled the decision to use a known water-surface elevation as the downstream boundary condition. Known water-surface elevations were established to match the water-surface elevation at XS18. Table 4.1 presents known water-surface elevations used in HEC-RAS.

Table 4.1. Known Water-surface Elevations (*WSE*)

Q (cfs)	*WSE* (ft)
8	97.706
12	97.928
16	98.022

4.2.2 Original Test Results

Original Test results used HEC-RAS output for computed water-surface elevations at all cross sections marked along the physical model. The water-surface elevations were used to calculate the flow depth at each cross section. Equation 4.1 presents the equation used to estimate flow depths along the center of the channel:

$$y = WSE - z_D \qquad \textbf{Equation 4.1}$$

where:

WSE = water-surface elevation along the cross section (ft);

y = flow depth (ft); and

z_D = surveyed bed elevation at Piezometer D (ft).

Flow-depth estimates are calculated using Equation 4.1 even though HEC-RAS contains an output option of Maximum Channel Depth. Maximum Channel Depth would be a valid estimate of flow depth if the minimum cross-section elevation always occurred at Piezometer D. In the physical model, this was not always the case and, therefore, flow-depth estimates needed to be calculated using Equation 4.1. Table 4.2 presents the flow-depth results for the Original Test of the base-line model. Flow depths estimated by HEC-RAS in Table 4.2 were compared to the physical model flow-depth measurements along the Type I and Type III meander bends. Figure 4.1 compares flow-depth measurements from HEC-RAS computations to flow-depth measurements along the physical model. These values were further evaluated by observing the difference between average flow depths calculated in HEC-RAS to average flow-depth measurements in the physical model for the Type I and Type III bends. For each discharge, Table 4.3 displays the average flow depth in the Type I and Type III bends for

a discharge of 8 cfs, 12 cfs, and 16 cfs. As shown in Table 4.3 and Figure 4.1, flow depths computed in HEC-RAS at 8 cfs overestimated flow depths in the physical model by 0.0114 ft in the Type I bend and by 0.0127 ft in the Type III bend. Modifications needed to be made to HEC-RAS in order to better estimate flow-depth measurements in the physical model.

Table 4.2. Base-line Original Test Flow-depth Measurements

XS	$y_{8\ cfs}$ (ft)	$y_{12\ cfs}$ (ft)	$y_{16\ cfs}$ (ft)
0 (U/S)	0.591	0.788	0.903
1	0.598	0.796	0.910
2	0.615	0.813	0.928
3	0.611	0.810	0.924
4	0.618	0.817	0.931
5	0.605	0.805	0.918
6	0.612	0.812	0.925
7	0.619	0.820	0.933
8	0.626	0.828	0.940
9	0.621	0.823	0.931
10	0.597	0.800	0.903
11	0.609	0.813	0.914
12	0.599	0.806	0.907
13	0.599	0.808	0.908
14	0.601	0.812	0.911
15	0.591	0.805	0.903
16	0.614	0.831	0.927
17	0.614	0.833	0.928
18 (D/S)	0.616	0.838	0.932

Table 4.3. Difference in Average Flow Depth Between HEC-RAS Output and Physical Model During the Original Test

Bend	$y_{8\ cfs}$ (ft)	$y_{12\ cfs}$ (ft)	$y_{16\ cfs}$ (ft)
Type I (U/S) Bend	0.0114	0.0017	0.0019
Type III (D/S) Bend	0.0127	0.0047	0.0039

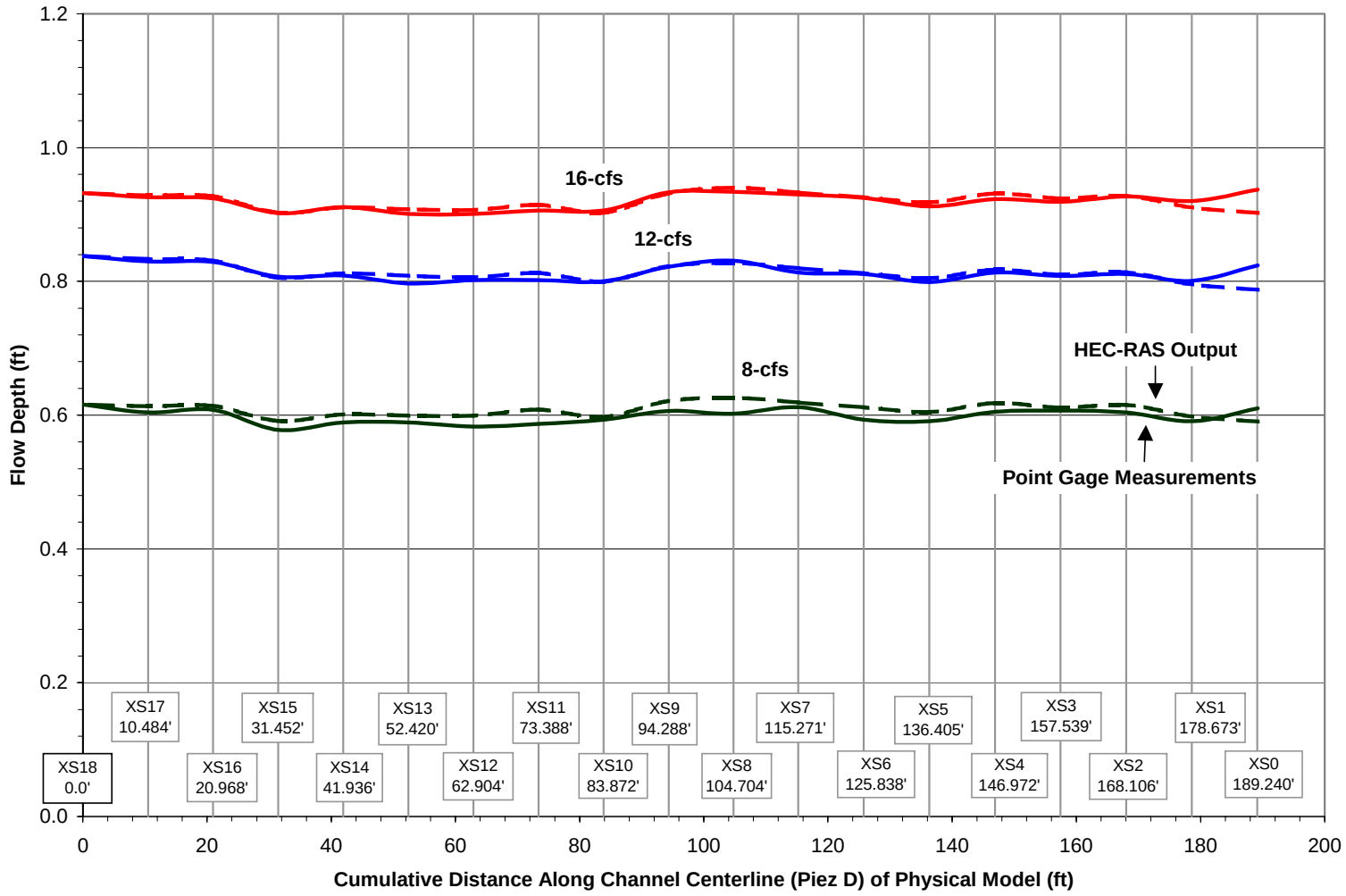

Figure 4.1. Comparison of Flow Depth Measured Along Physical Model and Flow Depth Estimated During the Original Test

4.3 MODIFIED TEST OF THE BASE-LINE MODEL

The Modified Test was the second attempt to build a HEC-RAS model that matched flow depths similar to the physical model. The Modified Test used the Original Test plan as a foundation for the HEC-RAS analysis.

4.3.1 Modified Test Input Parameters

Similar to the Original Test, the Modified Test geometry information such as cross-section data, channel length, and overbank length data remained the same. Unlike the Original Test, the Modified Test Manning's *n*-values were set to 0.013 and the contraction coefficients were set to 0.6 in the transition section of the model. The transition section was identified by XS9 and XS10. Table 4.4 presents the HEC-RAS expansion and contraction coefficient input table with the adjusted values.

Table 4.4. HEC-RAS Contraction and Expansion Coefficients Used During the Modified Test

XS	C_c	C_e
0 (U/S)	0.1	0.3
1	0.1	0.3
2	0.1	0.3
3	0.1	0.3
4	0.1	0.3
5	0.1	0.3
6	0.1	0.3
7	0.1	0.3
8	0.1	0.3
9	**0.6**	0.3
10	**0.6**	0.3
11	0.1	0.3
12	0.1	0.3
13	0.1	0.3
14	0.1	0.3
15	0.1	0.3
16	0.1	0.3
17	0.1	0.3
18 (D/S)	0.1	0.3

In the steady flow file, no adjustments were made. The simulated flow rates remained 8 cfs, 12 cfs, and 16 cfs and the downstream boundary condition was a known water-surface elevation. Known water-surface elevations were presented in Table 4.1.

4.3.2 Modified Test Results

Modified Test results used HEC-RAS output of computed water-surface elevations to calculate flow depths at all cross sections marked along the physical model. Water-surface elevations were evaluated with Equation 4.1; Table 4.5 presents the flow-depth results. Flow depths estimated in Table 4.5 were compared to physical model flow-depth measurements along the Type I and Type III meander bends. Figure 4.2 presents a comparison of flow depths calculated through HEC-RAS computation to flow-depth measurements along the physical model. These values were further evaluated by observing the difference between average flow depths estimated from HEC-RAS to average flow-depth measurements in the physical model for the Type I and Type III bends. Results are presented in Table 4.6. Based on calculations presented in Table 4.6, flow depths estimated by HEC-RAS during the Modified Test were more accurate than flow depths estimated during the Original Test. For example, at 16 cfs, the difference in average flow depth estimated from HEC-RAS and measured in the physical model during the Modified Test was 0.56% in the Type I bend and 0.43% in the Type III bend.

Table 4.5. Modified Test Flow-depth Measurements

XS	$y_{8\ cfs}$ (ft)	$y_{12\ cfs}$ (ft)	$y_{16\ cfs}$ (ft)
0 (U/S)	0.578	0.778	0.896
1	0.586	0.787	0.905
2	0.604	0.805	0.923
3	0.601	0.803	0.920
4	0.609	0.811	0.928
5	0.596	0.799	0.916
6	0.604	0.807	0.924
7	0.612	0.815	0.932
8	0.619	0.823	0.940
9	0.615	0.819	0.932
10	0.581	0.787	0.889
11	0.594	0.801	0.902
12	0.586	0.796	0.896
13	0.588	0.800	0.899
14	0.591	0.805	0.903
15	0.584	0.800	0.897
16	0.610	0.828	0.924
17	0.611	0.832	0.927
18 (D/S)	0.616	0.838	0.932

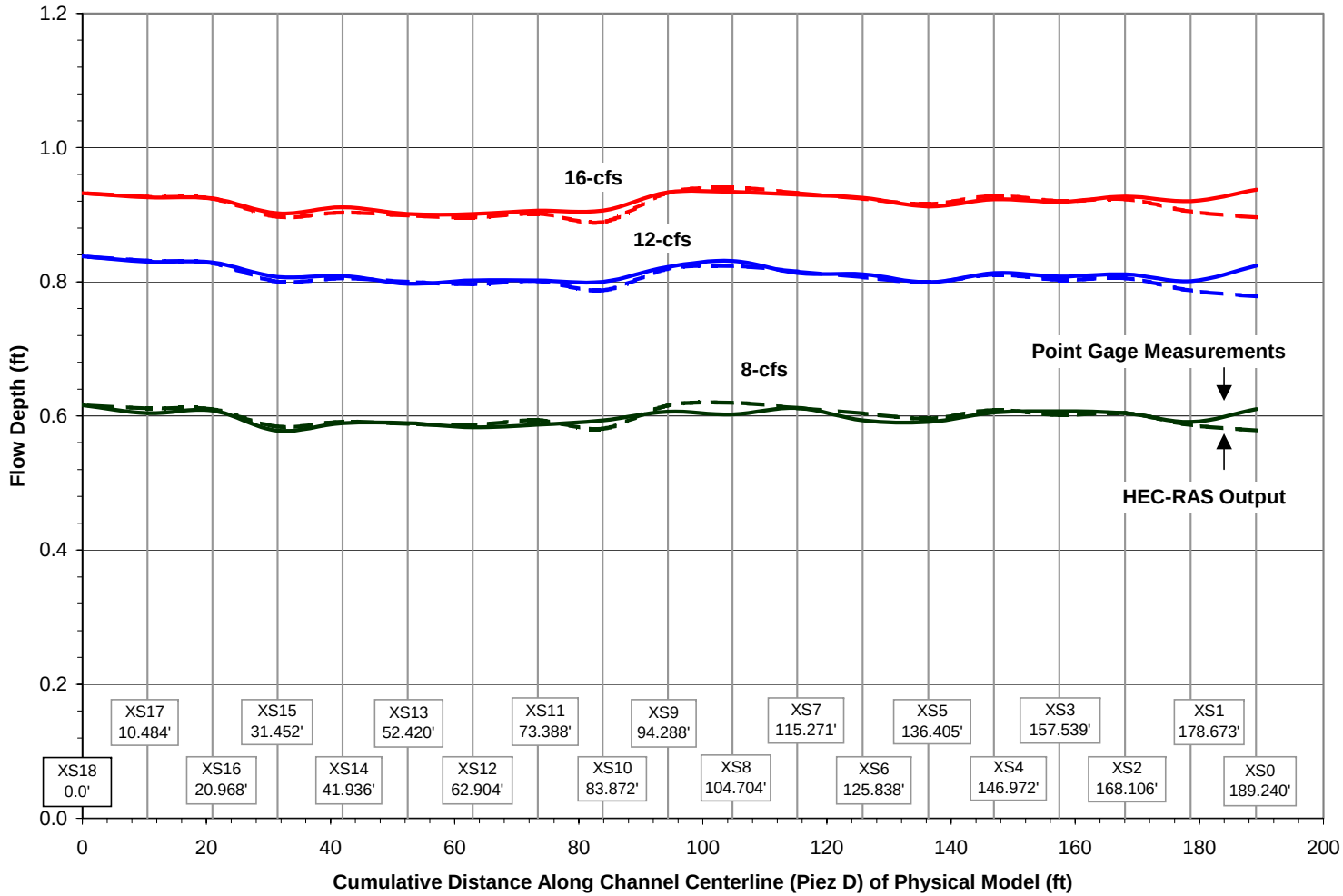

Figure 4.2. Comparison of Flow Depth Measured Along Physical Model and Flow Depth Estimated During the Modified Test

Table 4.6. Difference in Average Flow Depth Between HEC-RAS Output and Physical Model During the Modified Test

Bend	$y_{8\ cfs}$ (ft)	$y_{12\ cfs}$ (ft)	$y_{16\ cfs}$ (ft
Type I (U/S) Bend	0.0015	0.0053	0.0018
Type III (D/S) Bend	0.0038	0.0020	0.0034

4.4 BASE-LINE MODEL SELECTION

Selection of a base-line model focused on the project goal to determine a HEC-RAS model that matched flow depths in the physical model. Since flow depths estimated during the Modified Test resembled flow depths measured in the physical model, the Modified Test was selected. The Modified Test Base-line Model was considered the foundation model for bendway-weir analysis in HEC-RAS.