PAP 916

Dog River Dam Hydraulic Model Study Results

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DOG RIVER DAM HYDRAULIC MODEL STUDY RESULTS

For

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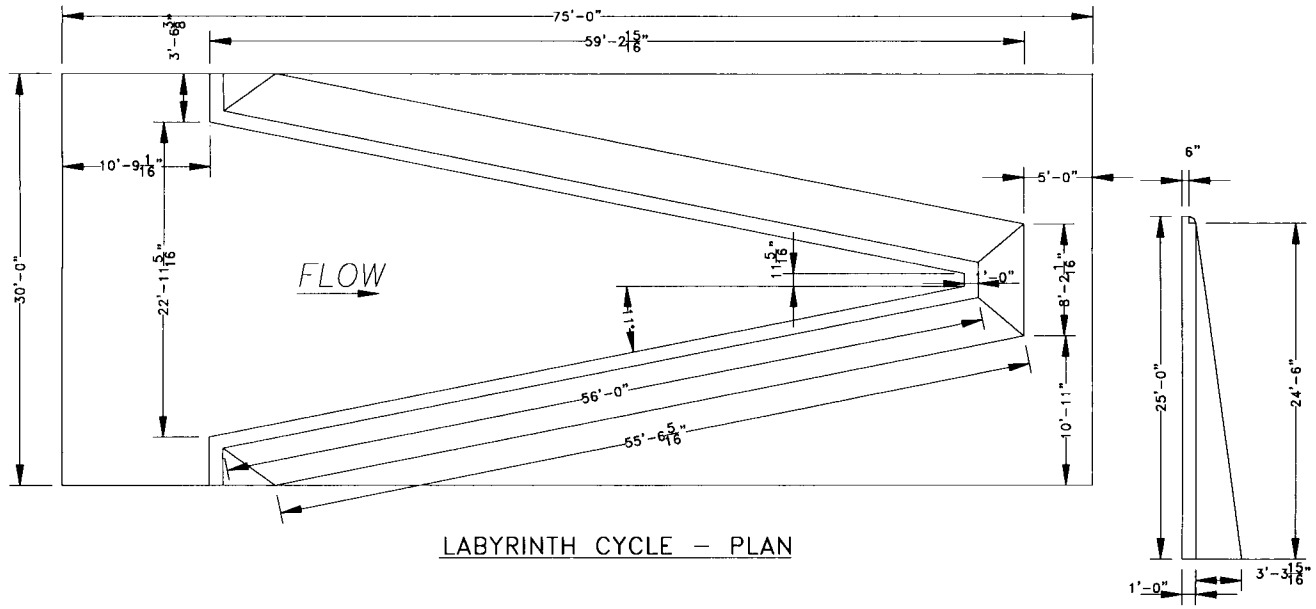

Figure 1. - Plan and sectional view of 1 cycle of the Dog River labyrinth weir.

Model Tests and Photographs

Test discharges and tailwater information were provided as shown in table 2. The three documented discharges of 16,100 ft^3/s, 35,300 ft^3/s, and 53,000 ft^3/s represent the 100 yr, 2/3 design storm, and design storm events, respectively.

Table 2. – Tailwater information provided.

	Discharge (ft^3/s)	Tailwater El. (ft)
Documented	16,100	731.1
	35,000	738
Documented	35,300	738.1
	40,000	739.4
	45,000	740.8
	50,000	742.0
Documented	53,000	742.7
	55,000	743.2
	60,000	744.4

The following photographs show the weir operating under the documented design values. The photographs, figures 2-11, show the weir on the embankment with the stilling basin flow conditions included.

Figure 2.- Flow of 16,100 ft^3/s over the 25-ft-high labyrinth weir located on the simulated embankment with 3:1 downstream slope leading to the USBR Type II stilling basin.

Figure 3. - Flow conditions in the stilling basin for a flow of 16,100 ft^3/s under tailwater El 731.1.

Figure 4. - View looking down on the 2 cycle labyrinth discharging 16,100 ft^3/s over the embankment. Flow is looking downstream from the weir to the stilling basin.

Figure 5. - Flow of 35,300 ft^3/s over the 25-ft-high labyrinth weir located on the simulated embankment with 3:1 downstream slope leading to the USBR Type II stilling basin.

Figure 6. - Flow conditions in the stilling basin for a flow of 35,300 ft^3/s under tailwater El. 738.1.

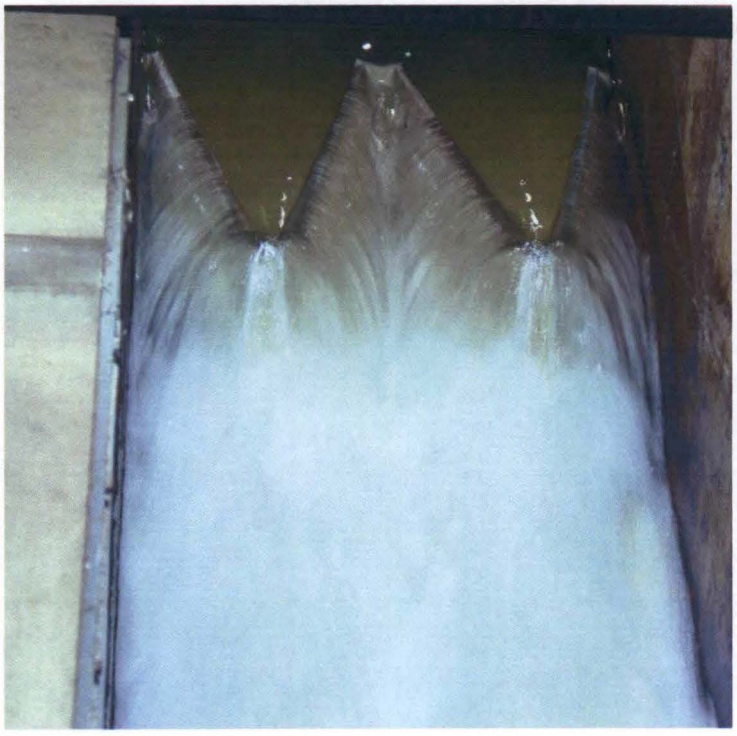

Figure 7. - View looking down on the 2 cycle labyrinth discharging 35,300 ft^3/s over the embankment.

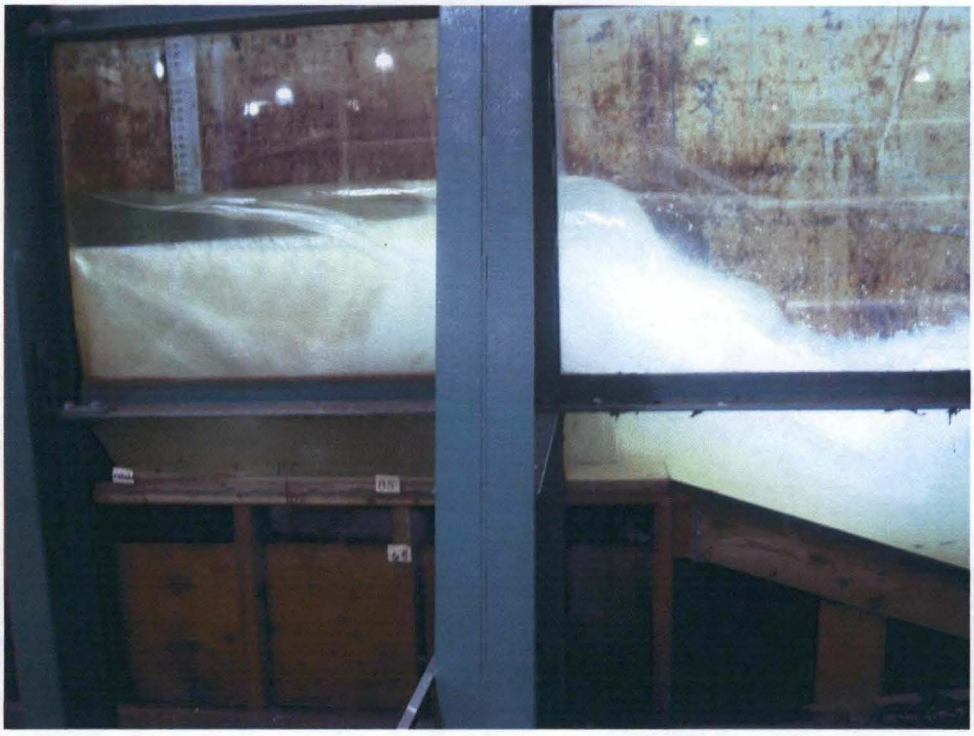

Figure 8. - Flow of 53,000 ft^3/s over the 25-ft-high labyrinth weir located on the simulated embankment with 3:1 downstream slope leading to the USBR Type II stilling basin.

Figure 9. - Flow of 53,000 ft^3/s over the 25-ft-high labyrinth weir located on the simulated embankment with 3:1 downstream slope leading to the USBR Type II stilling basin.

Figure 10. - Flow conditions in the stilling basin for a flow of 53,000 ft^3/s under tailwater El. 742.7.

Figure 11. - View looking down on the 2 cycle labyrinth discharging 53,000 ft^3/s over the embankment.

Results

The rating curve for the weir on the embankment is shown in figure 12. The velocity head was added to the head measured at 13 ft upstream from the weir. Adding the velocity head was necessary given the approach velocity in the flume section upstream from the weir installation. Velocity was calculated by continuity given the depth behind the weir and embankment and the total width. As may be seen the velocity head does influence the head values for the higher discharge range. The model data and calculations are given in table 3.

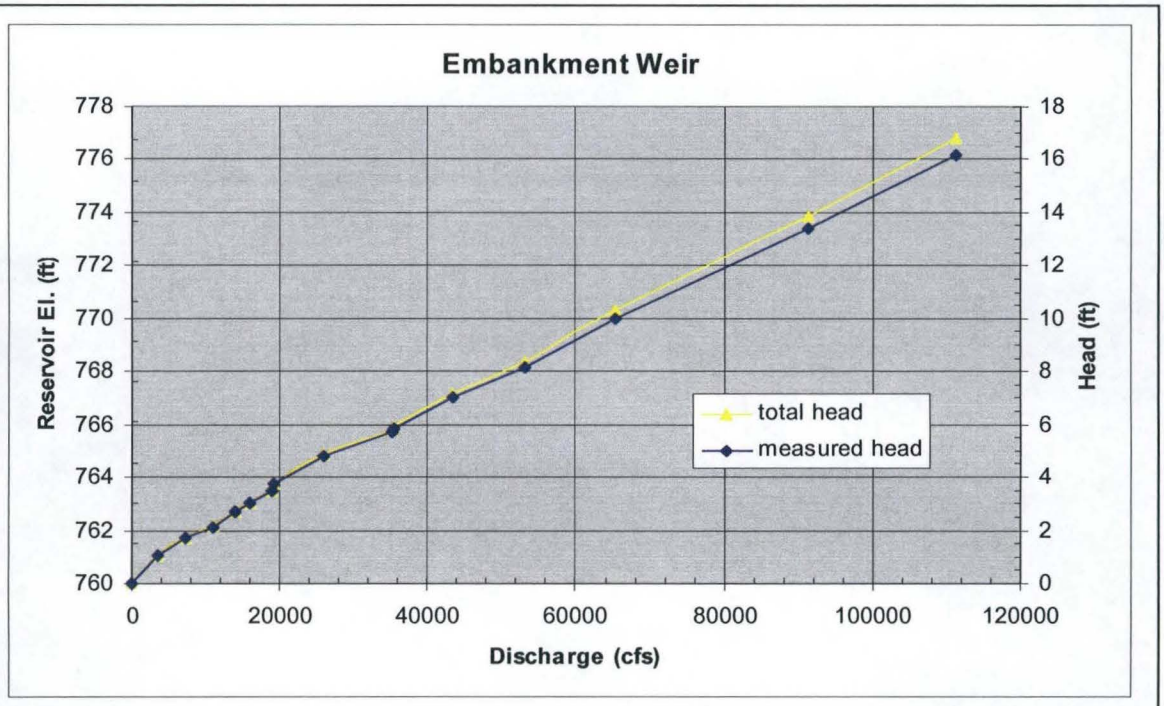

Figure 12. - Model data showing the difference between the measured head and total head for the weir on the embankment.

The total head discharge rating is the correct rating to use and the total head was used in the curve fitting routine to develop the rating equation given in figure 13. Use of the total head rating or reservoir head matches the applications of other theories for discharge prediction.

The design discharge of 53,000 ft^3/s is passed with a head of 8.70 ft or a reservoir elevation of 768.7 as computed by the rating equation shown on figure 13.

Table 3. – Rating information for the embankment labyrinth weir.

Discharge (ft^3/s)	Measured head (ft)	Reservoir El. (ft)	Velocity head (ft)	Total head (ft)	Total head Reservoir El. (ft)	equation H=0.000596H^0.8808 Head (ft)	equation H=0.000596H^0.8808 Reservoir. El. (ft)
0.00	0.00	760.00	0.00	0.00	760.00	0.00	760.00
3516.10	1.08	761.08	0.00	1.08	761.08	0.79	760.79
7155.80	1.70	761.70	0.00	1.70	761.70	1.48	761.48
10924.01	2.13	762.13	0.01	2.14	762.14	2.15	762.15
13923.56	2.67	762.67	0.02	2.69	762.69	2.66	762.66
16086.44	3.03	763.03	0.02	3.05	763.05	3.02	763.02
18883.50	3.48	763.48	0.03	3.51	763.51	3.48	763.48
19181.73	3.72	763.72	0.03	3.75	763.75	3.53	763.53
25996.27	4.80	764.80	0.05	4.85	764.85	4.61	764.61
35056.61	5.72	765.72	0.09	5.81	765.81	6.00	766.00
35468.65	5.82	765.82	0.09	5.91	765.91	6.06	766.06
43406.49	7.02	767.02	0.13	7.15	767.15	7.24	767.24
53036.42	8.18	768.18	0.19	8.37	768.37	8.64	768.64
65297.26	10.01	770.01	0.28	10.28	770.28	10.38	770.38
91361.74	13.40	773.40	0.49	13.89	773.89	13.95	773.95
111244.84	16.14	776.14	0.67	16.81	776.81	16.60	776.60

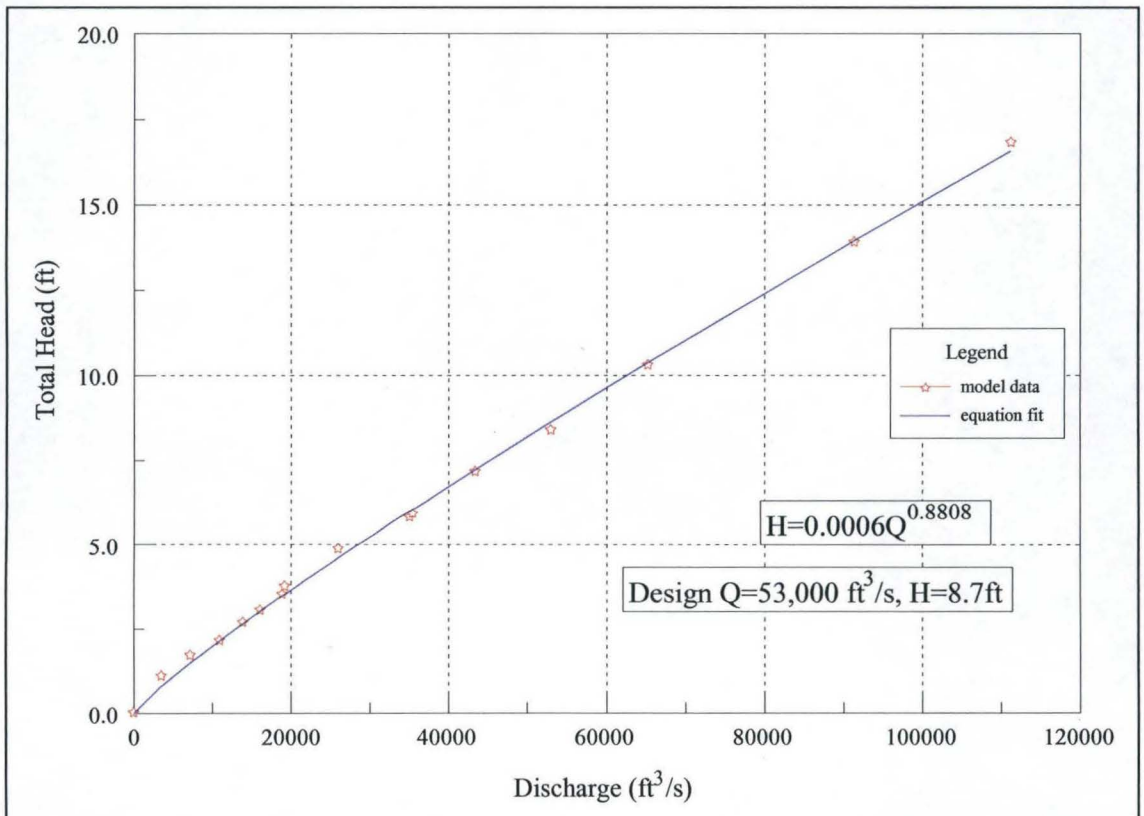

Figure 13. - Labyrinth weir discharge rating curves for the weir on the embankment or the design condition. The equation given is the best fit from a curve-fitting program.

An additional test was requested to investigate whether or not there would be a difference in the weir discharge rating when the 25-ft-high weir was mounted on the floor of the flume similar to all the research conducted to develop the design curves instead of on the sloping embankment. Figures 14 and 15 show the rating curves developed from the data in table 4. Again, the computed velocity head was added to the discharge rating.

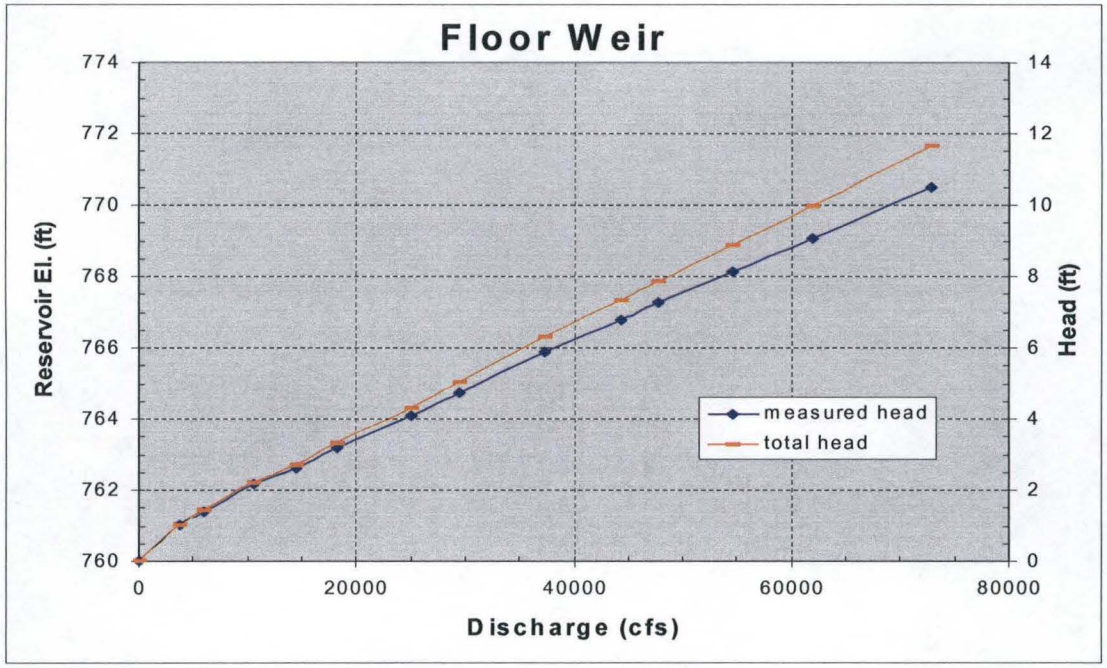

Figure 14. - Model data showing the difference between the measured head and total head for the weir on the floor. Reservoir El. 760 was assigned to the top of the floor weir to match the embankment weir elevation.

Table 4. – Rating information for the floor labyrinth weir.

Discharge (ft^3/s)	Measured head (ft)	Reservoir El. (ft)	Velocity head (ft)	Total Head (ft)	Total head Reservoir El. (ft)	equation H=0.0004968Q ^0.8976	
						Head (ft)	Reservoir. El. (ft)
0.00	0.00	760.00	0.00	0.00	760.00	0.00	760.00
3738.24	1.04	761.04	0.01	1.04	761.04	0.80	760.80
6000.71	1.40	761.40	0.01	1.41	761.41	1.22	761.22
10613.76	2.16	762.16	0.04	2.20	762.20	2.04	762.04
14505.97	2.63	762.63	0.07	2.70	762.70	2.70	762.70
18283.89	3.18	763.18	0.11	3.29	763.29	3.33	763.33
25148.45	4.10	764.10	0.20	4.30	764.30	4.43	764.43
29437.62	4.74	764.74	0.26	5.00	765.00	5.10	765.10
37440.76	5.88	765.88	0.40	6.28	766.28	6.33	766.33
44335.19	6.78	766.78	0.52	7.30	767.30	7.36	767.36
47771.09	7.26	767.26	0.59	7.85	767.85	7.87	767.87
54626.25	8.12	768.12	0.73	8.85	768.85	8.88	768.88
61895.54	9.08	769.08	0.89	9.96	769.96	9.94	769.94
72831.64	10.49	770.49	1.14	11.62	771.62	11.50	771.50

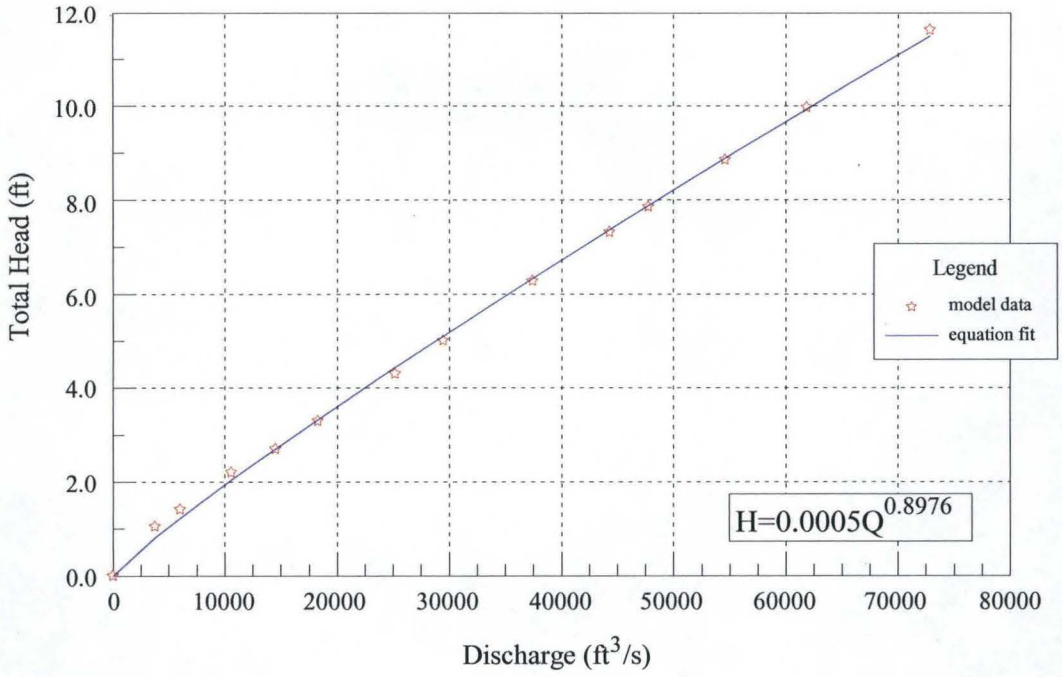

Figure 15. - Labyrinth weir discharge rating curve for the weir on the floor. Model data is shown with the best fit curve from a curve-fitting program.

Figure 16 shows the comparison of the labyrinth weir performance whether on the embankment or on the flat floor of the flume. The actual data is plotted with the curves fit with an equation fitting program. The equations are slightly different but certainly there is little or no effect caused by the weir being placed on a raised sloping embankment. The difference in the predicted discharge, developed from weirs on flat floors, was not due to the different physical placement of the weir.

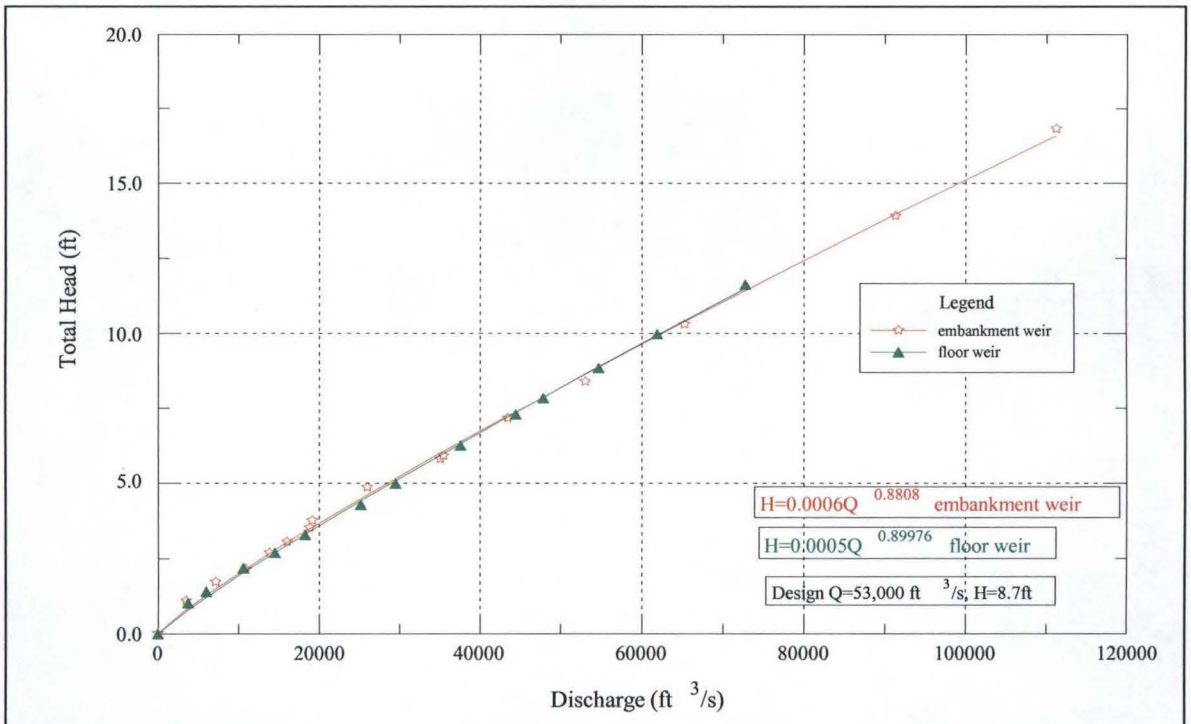

Figure 16. - Comparison of the embankment weir and the floor weir ratings. Model data is shown with the best fit curve for each. The ratings include the velocity head or would match a reservoir situation. The design discharge is passed under 8.70 ft of head. There is no significant difference between the labyrinth on the sloping embankment or directly on the floor.

Discussion

The weir passes the design flow under a head of 8.7 ft using the equation fit to the model data. This is true whether the weir is on the embankment or on the floor of the flume.

Of interest is the fact that the H/P value changed from 0.6 to 0.36 as the weir height changed in the design from 15 to 25 ft. Theory, whether Lux or Tullis or Falvey spreadsheet based upon Tullis's work, suggests that the weir should NOT pass the same flow under the same head as the weir height is increased.

Figure 17 shows plots developed by using Falvey's spreadsheet and changing only the height of the weir. As may be seen in figure 17, for the same discharge the H/P value quickly increases with a decrease in weir height. The figure also shows that for small discharges the head values are similar and not dependent upon the weir height. As the discharge increases, the head values then begin quickly increasing as the weir height decreases.

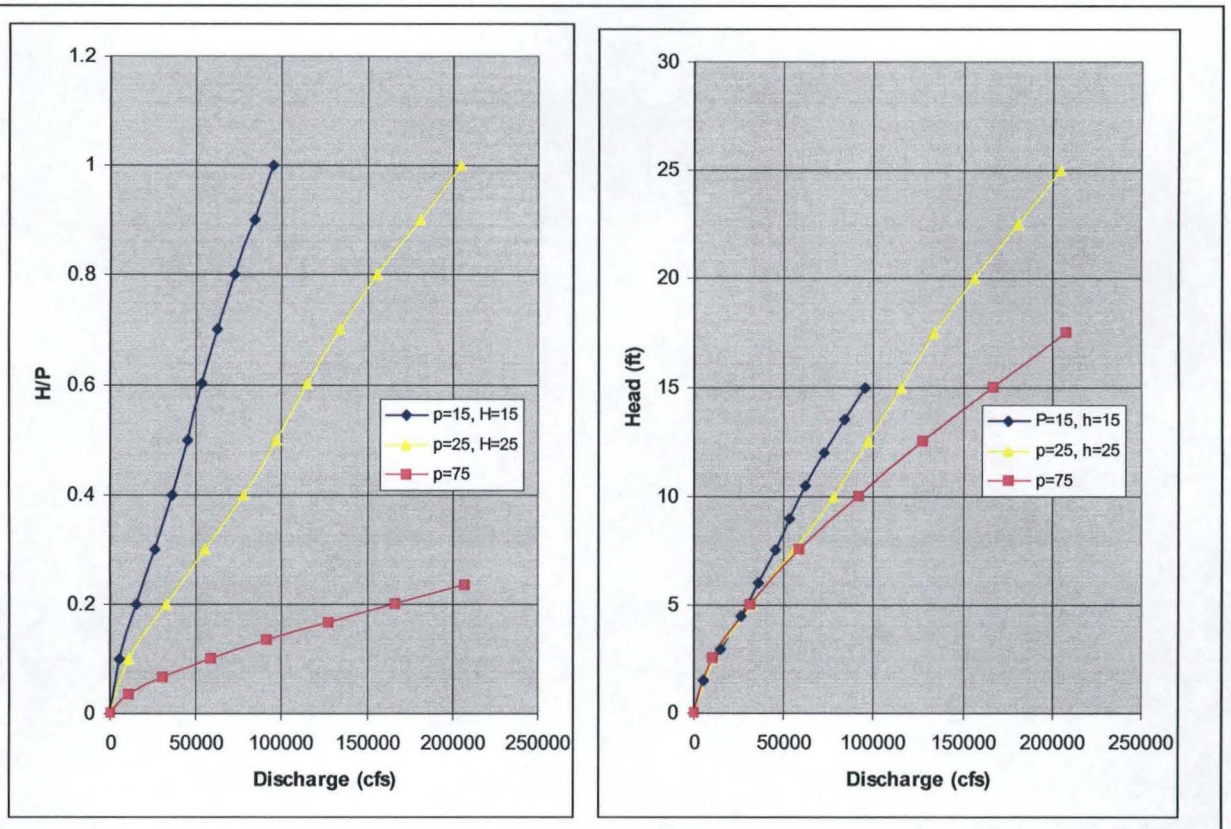

Figure 17. - Ratings developed from the Falvey spreadsheet and plotted discharge versus H/P and H for various weir heights. Notice that the H/P parameter for a given discharge quickly changes for any weir height, whereas the head remains fairly constant over a range of smaller discharges before showing an influence of weir height.

Because the Dog River design discharge is relatively low, when the weir height was increased, the theory and the model showed that the head would not be substantially different. A proposal for why the discharge is not well predicted by theory as the weir height is increased, as indicated in figure 17, might be that the testing used to develop the theory had some other phenomena occurring as the head increased over a constant height weir. Perhaps there was a downstream influence, other than nappe interference over the side walls, that would have reduce weir efficiency that was not observed.