

FLOW RATING ANALYSIS FOR PUMP STATION S700



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PRELIMINARY FLOW RATING ANALYSIS FOR PUMP STATION S700

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DEFINITIONS

Acronyms

TDH	Total dynamic head
TSH	Total static head
SFWMD	South Florida Water Management District
STA	Stormwater treatment area



EXECUTIVE SUMMARY

Pump Station S700 consists of three electric pump: one with capacity of 50 cfs and the other two with capacity of 25 cfs. This report summarizes a preliminary flow rating analysis for each type of pump at Pump Station S700 based on their corresponding pump performance curves. The developed rating equations will be used to compute flow through the pump station.



2.0 STATION DESIGN

Figure 2 illustrates the plan view of Pump Station S700. Figure 3 and Figure 4 show the profile view of the pump of 50 cfs and 25 cfs, respectively.

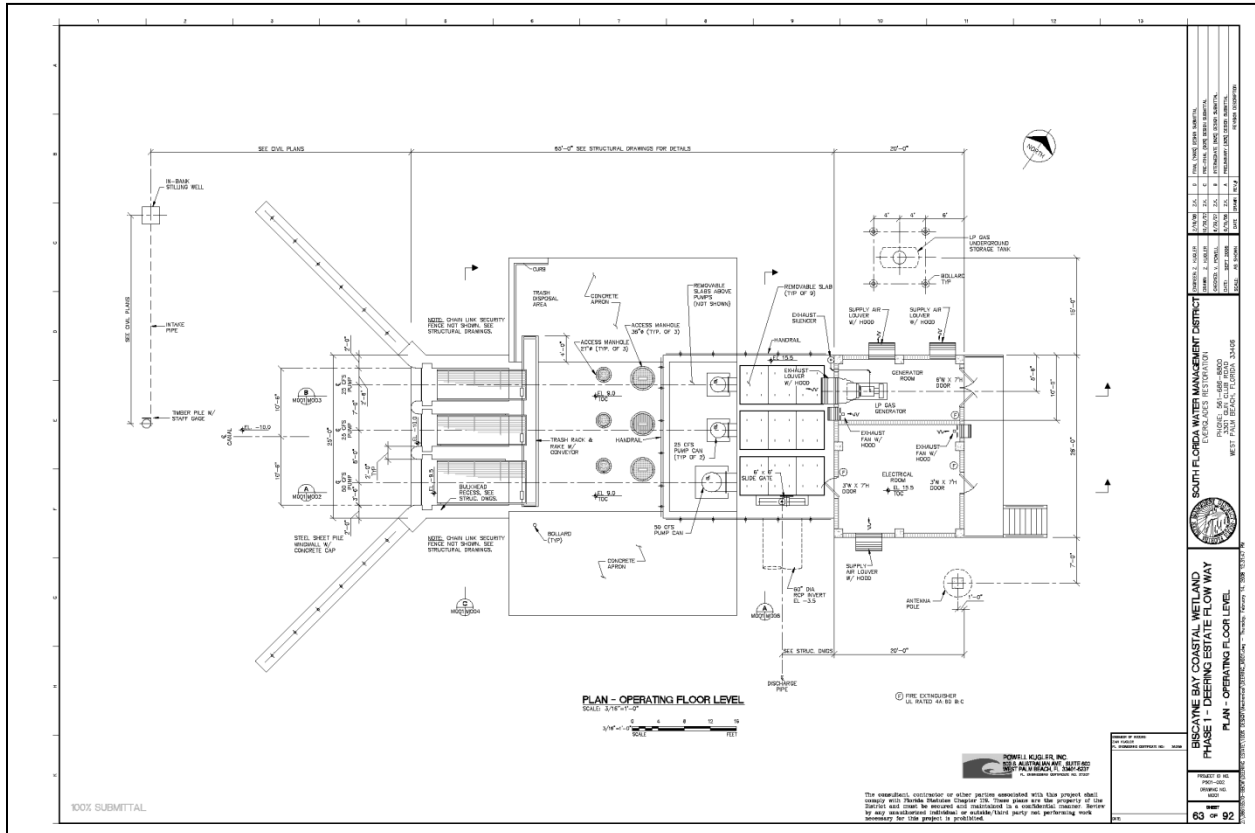


Figure 2. Plan view of Pump Station S700



2.1. Pump Performance Curves for S700

The manufacturer provides the pump performance curves for the pumps of 50 cfs and 25 cfs at Pump Station S700, as shown in **Figure 5** and **Figure 6**.

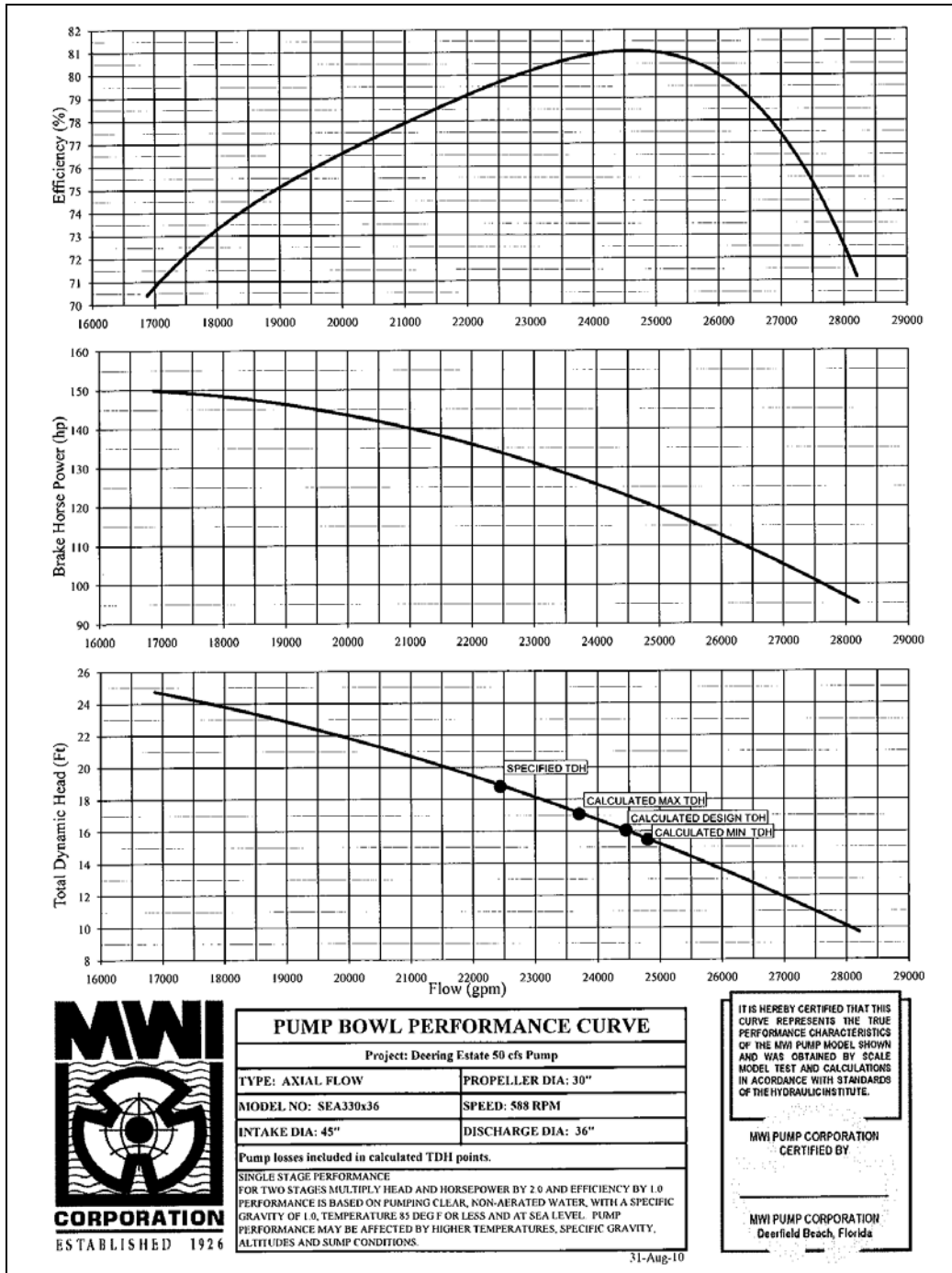


Figure 5. Pump performance curve for S700 electric pump of 50 cfs

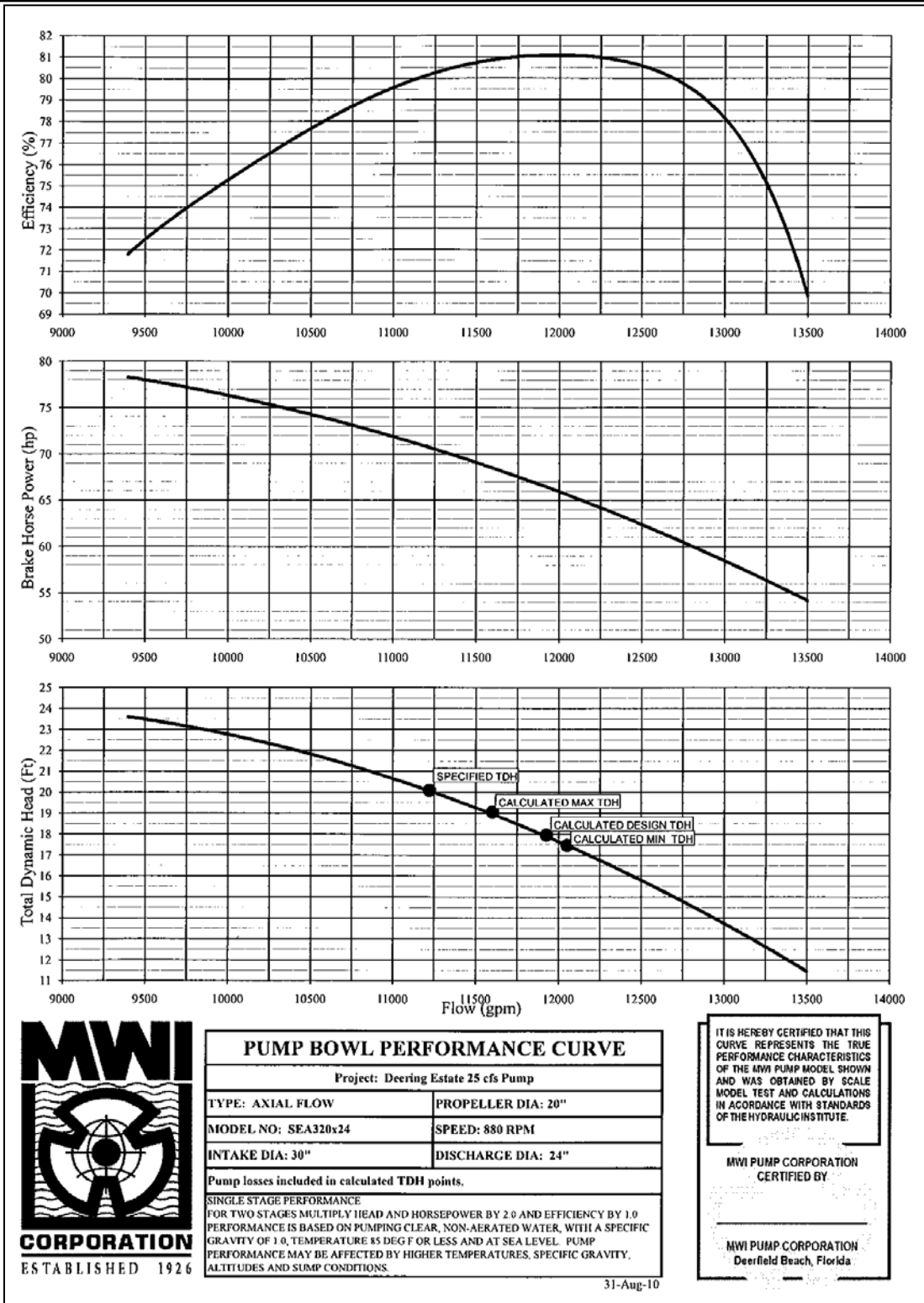


Figure 6. Pump performance curve for S700 electric pump of 25 cfs



3.0 RATING ANALYSIS

We will develop a Case 8 flow rating equation for each type of pump at Pump Station S700, based on the factory pump performance curve. Case 8 rating equation is developed by dimensional analysis and the pump affinity laws, which is the conventional rating equation representing all the possible cases, as documented in Damisse (2001) and Imru and Wang (2003). Equation below shows the Case 8 flow rating equation.

$$Q = A \left(\frac{N}{No} \right) + BH^c \left(\frac{No}{N} \right)^{2C-1} \quad (1)$$

$$H = \max\{CL, TW\} - HW \quad (2)$$

Where

- Q : Discharge in cfs;
 H : Total static head (TSH);
 N : Pump engine speed in rpm;
 No : Design pump engine speed in rpm;
 A, B and C : Regression coefficients determined through regression analysis ($A > 0$, $B < 0$, and $C > 1.0$).
 CL : Discharge pipe outlet centerline elevation;
 TW : Tailwater elevation;
 HW : Headwater elevation.

The H versus Q relationship can be estimated by subtracting the total head losses through the intake and discharge works from total dynamic head (TDH) on the pump performance curve. We will then conduct a non-linear regression analysis using SAS NLIN function to determine the coefficients in the above equation.

We computed TSH by subtracting total head loss from TDH. The total head loss includes friction loss and minor losses, which were computed based on the loss coefficients provided by the pump manufacturer. **Table 1** and **Table 2** present TDH, total head loss, and TSH vs. Q values for the pump of 50 cfs and the pump of 25 cfs, respectively. **Table 3** provides the flow rating equation coefficients of Eq. (1) corresponding to each type of the pump, which were estimated by nonlinear regression analysis. **Figure 7** illustrates the developed rating curve for S700 electric pump of 50 cfs, **Figure 8** for S700 electric pump of 25 cfs. These diagrams illustrate that the rating curves from the developed rating equation fits the TSH well.



Table 1. TDH, Head Loss, TSH and Discharge Relations for S700 Electric Pump -50 cfs

Flow Rate (gpm)	Flow Rate (cfs)	TDH (ft)	Head Loss (ft)	TSH (ft)
17000	37.877	24.67	1.965	22.701
17500	38.991	24.27	2.082	22.185
18000	40.105	23.77	2.202	21.564
18500	41.219	23.33	2.326	21.008
19000	42.334	22.87	2.453	20.414
19500	43.448	22.37	2.583	19.784
20000	44.562	21.77	2.717	19.050
20500	45.676	21.30	2.854	18.446
21000	46.790	20.67	2.994	17.673
21500	47.904	20.03	3.138	16.896
22000	49.018	19.43	3.285	16.149
22500	50.132	18.80	3.435	15.365
23000	51.246	18.13	3.589	14.544
23500	52.360	17.43	3.746	13.687
24000	53.474	16.73	3.907	12.827
24500	54.588	16.00	4.070	11.930
25000	55.702	15.17	4.238	10.929
25500	56.816	14.43	4.408	10.025
26000	57.930	13.57	4.582	8.985
26500	59.044	12.68	4.759	7.924
27000	60.158	11.83	4.940	6.893
27500	61.272	11.00	5.124	5.876
28000	62.386	10.00	5.311	4.689



Table 2. TDH, Head Loss, TSH and Discharge Relations for S700 Electric Pump -25 cfs

Flow Rate (gpm)	Flow Rate (cfs)	TDH (ft)	Head Loss (ft)	TSH (ft)
Flow Rate (gpm)	Flow Rate (cfs)	TDH	Head Loss	TSH
9500	21.167	23.50	4.111	19.389
9750	21.724	23.20	4.329	18.871
10000	22.281	22.75	4.552	18.198
10250	22.838	22.30	4.782	17.518
10500	23.395	21.75	5.017	16.733
10750	23.952	21.25	5.257	15.993
11000	24.509	20.63	5.503	15.122
11250	25.066	20.00	5.755	14.245
11500	25.623	19.25	6.013	13.237
11750	26.180	18.50	6.276	12.224
12000	26.737	17.63	6.544	11.081
12250	27.294	16.75	6.818	9.932
12500	27.851	15.75	7.098	8.652
12750	28.408	14.75	7.384	7.366
13000	28.965	13.75	7.675	6.075
13250	29.522	12.58	7.971	4.604
13500	30.079	11.50	8.273	3.227

Table 3. Flow Rating Coefficients for the Pumps at S700

Pump Type	No (rpm)	Rating Coefficient	Estimate	Approximate Lower 95% Confidence Limit	Approximate Upper 95% Confidence Limit
Pump - 50 cfs	588	A	64.3302	63.8639	64.7965
		B	-0.2068	-0.2501	-0.1635
		C	1.5494	1.4862	1.6125
Pump - 25 cfs	880	A	30.3438	30.0758	30.6117
		B	-0.0662	-0.0917	-0.0407
		C	1.6556	1.5318	1.7794

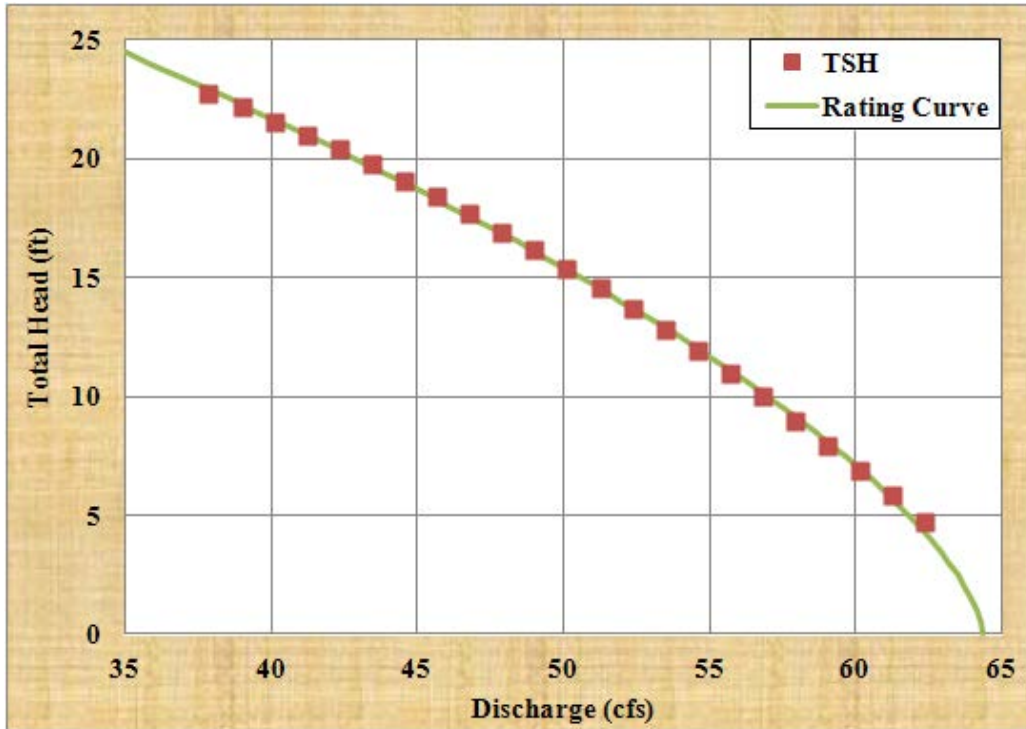


Figure 7. Flow rating curve for S700 electric pump of 50 cfs

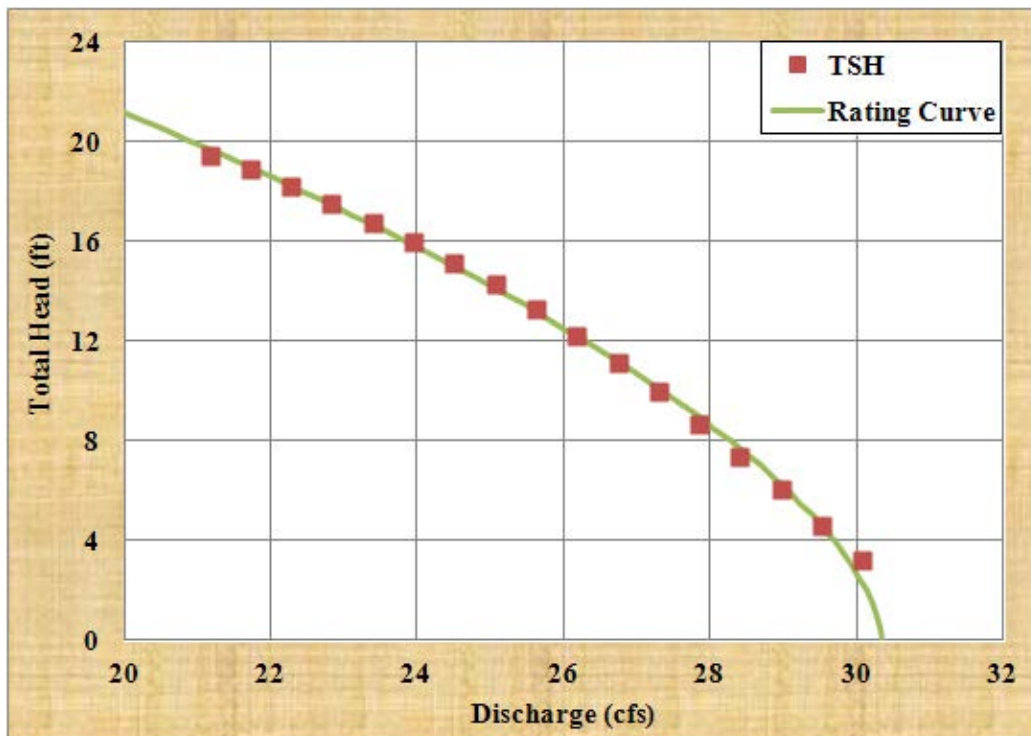


Figure 8. Flow rating curve for S700 electric pump of 25 cfs



4.0 CONCLUDING REMARKS

We conducted preliminary rating analysis for the each type of pump at Pump Station S700 based on the pump performance curve. **Table 3** presents the coefficients of the flow rating equation for Pump Station S700. The preliminary flow rating equation needs to be calibrated, and to be potentially improved based on future flow measurements after the pump stations are constructed and operated.



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Damisse, E. 2001. Flow rating development for G335 Pump Station in STA-2. Hydrologic Data Management Division, South Florida Water Management District, West Palm Beach, Florida.

Imru, M. and Y. Wang. 2003. Flow Rating Analysis Procedures for Pumps. Technical Publication EMA # 413, South Florida Water Management District, West Palm Beach, Florida.