FLOW RATING ANALYSIS FOR PUMP STATION G700

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ACKNOWLEDGEMENT

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DEFINITIONS

Acronyms

AARD	Average absolute relative difference
ARE	Absolute relative error
SFWMD	South Florida Water Management District
STA	Stormwater treatment area
TDH	Total dynamic head
TSH	Total static head

EXECUTIVE SUMMARY

Pump Station G700 houses two identical pump units with flow capacity of 40 cfs. This report summarizes a flow rating analysis for Pump Station G700 based on the corresponding pump performance curve. The developed rating equation will be used to compute flow through the pump station.

1.0 INTRODUCTION

1.1 Background

Pump Station G700 has two identical electric 24-inch pumps with a 75 Hp electric motor engine with flow capacity of 40 cfs. The purpose of the pump station is to prevent flooding in the residential area during heavy storm by pumping excess surface water to Packingham Slough. The pump station is located near the intersection between SR 60 and River Reanch, as shown in **Figure 1**.

Figure 1. Location Map of Pump Station G700

1.2 Objectives and Scope

We will conduct a rating analysis to develop a flow rating equation for Pump Station G700 to compute flow through the station.

2.0 STATION DESIGN

Table 1 presents more detailed description for the station. **Figure 2** shows the profile of the pump station.

Table 1. Description for Pump Station G700

Item	Description
Number of pumps	2
Pump design capacity (cfs)	40
Engine motor horsepower (HP)	75
Design motor speed (rpm)	705
Design head (ft))	5.53
Outlet discharging pipe diameter (ft)	24
Outlet discharging pipe invert elevation (ft, NGVD)	53.25
Shut off head water elevation/Minimun upstream water elevation (ft, NGVD)	48.83
Pump operation flow elevation (ft, NGVD)	55

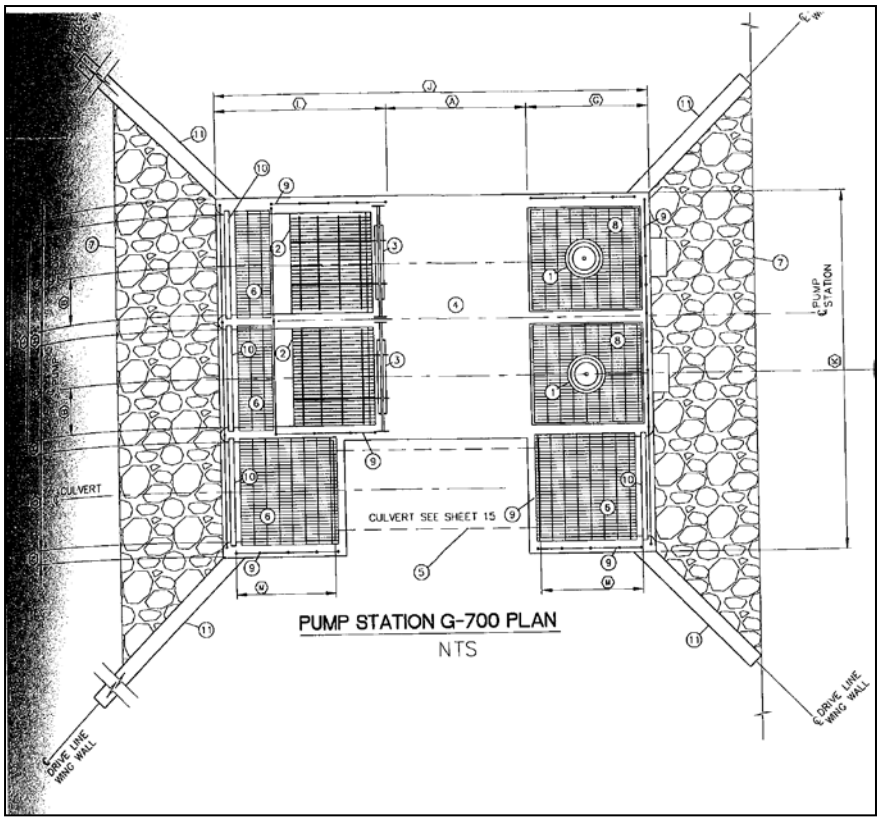

Figure 2. Plan view of Pump Station G700

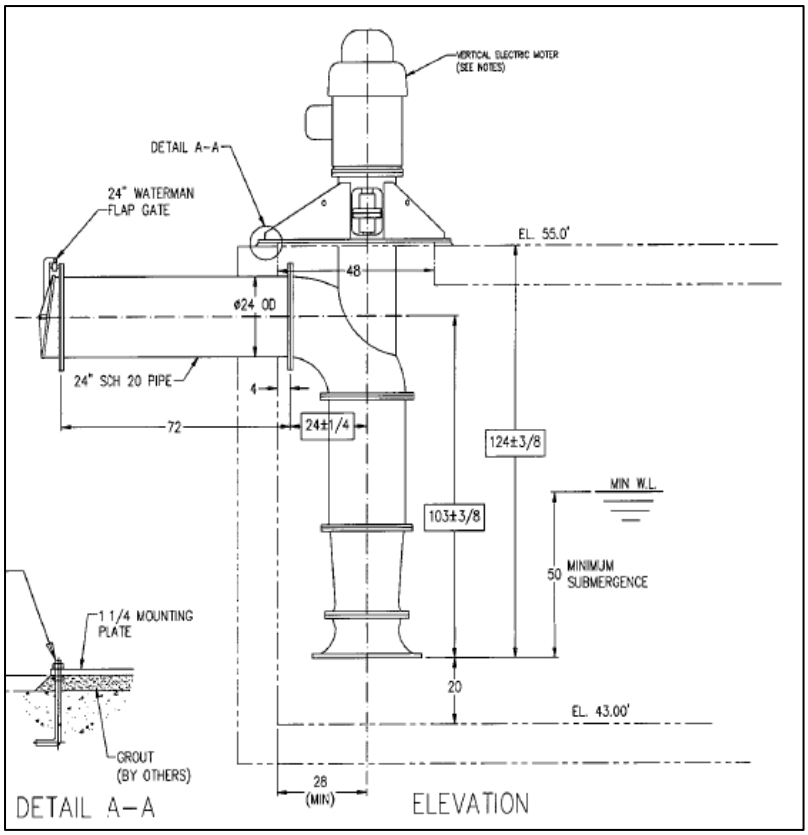

Figure 3. Profile view of Pump Station G700

2.1. Pump Performance Curve for G700

The manufacturer provides the pump performance curve for Pump Station G700, as shown in **Figure 4**.

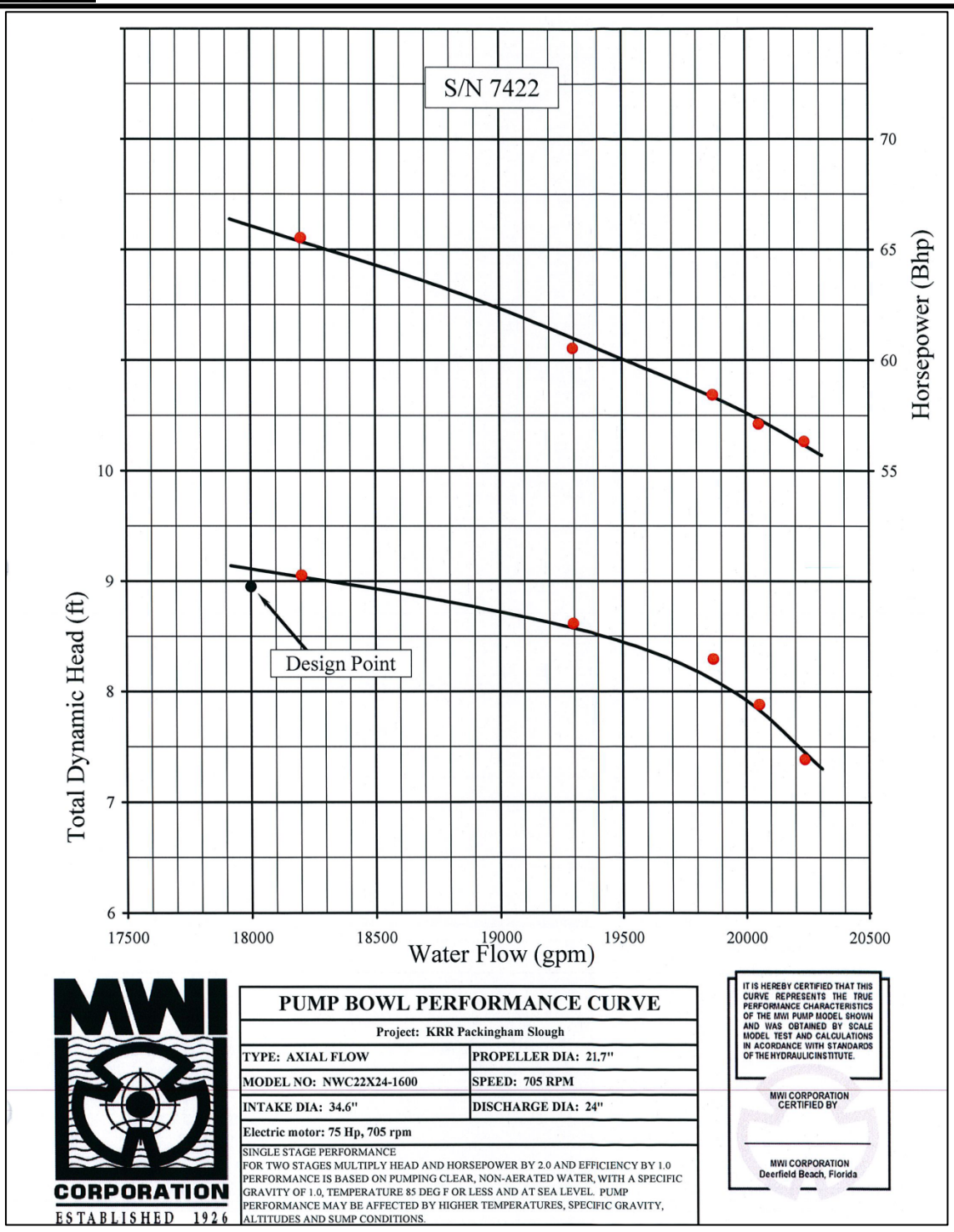

Figure 4. Pump Performance Curve for Pump Station G700

3.0 RATING ANALYSIS

We will develop a Case 8 flow rating equation for Pump Station G700 based on the factory pump performance curve. Case 8 rating equation is developed using dimensional analysis and the pump affinity laws. This conventional rating equation represents all the possible cases, as documented in Damisse (2001) and Imru and Wang (2003). Rating 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 (=1800 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.

For an electric pump with constant speed, $N = N_o$, and Equation (1) becomes

$$Q = A + BH^{C} \quad (3)$$

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 through a pump includes friction loss and minor losses. Friction head loss was ignored here since the discharge pipe is short. **Table 2** presents the minor loss coefficients for pump inlet, bend, and outlet. We take the head loss of flap gate 0.1 ft.

Table 2. Minor Loss Coefficients

Loss Coefficient		Value
Minor Loss Coefficient	Intake Bell	0.050
	Bend	0.236
	Pipe Exit - Projecting Exit	1.000
	Total	1.286

Table 3 presents TDH from the pump performance curve, total head loss, TSH, and pump speed vs. *Q* values for Pump Station G700. **Table 4** provides the flow rating equation coefficients of Eq. (3), which were estimated by conducting nonlinear regression analysis using SAS NLIN function.

Table 3. TDH, Head Loss, TSH, Pump Speed and Discharge Relations for the Pumps at Pump Station G700

Flow		TDH (ft)	Total head loss (ft)	TSH (ft)
GPM	CFS			
18000	40.105	9.105	3.358	5.747
18100	40.328	9.068	3.394	5.674
18200	40.551	9.041	3.430	5.610
18300	40.774	9.000	3.467	5.533
18400	40.997	8.959	3.504	5.455
18500	41.219	8.918	3.541	5.377
18600	41.442	8.886	3.578	5.308
18700	41.665	8.841	3.616	5.225
18800	41.888	8.805	3.654	5.151
18900	42.111	8.759	3.692	5.068
19000	42.334	8.718	3.730	4.989
19100	42.556	8.664	3.768	4.896
19200	42.779	8.623	3.806	4.816
19300	43.002	8.564	3.845	4.718
19400	43.225	8.509	3.884	4.625
19500	43.448	8.441	3.923	4.518
19600	43.670	8.364	3.963	4.401
19700	43.893	8.277	4.002	4.275
19800	44.116	8.182	4.042	4.140
19900	44.339	8.059	4.082	3.977
20000	44.562	7.909	4.122	3.787
20100	44.784	7.732	4.162	3.570
20200	45.007	7.523	4.203	3.320
20300	45.230	7.318	4.243	3.075

Table 4. Flow Rating Coefficients for the Pumps at G700

Rating Coefficient	Estimate	Approximate Lower 95% Confidence Limit	Approximate Upper 95% Confidence Limit
A	45.8721	45.7576	45.9866
B	-0.0112	-0.0143	-0.00803
C	3.5800	3.4276	3.7325

Figure 5 illustrates the developed rating curve for the pumps at Pump Station G700. The flows calculated from the developed rating equation well fits the discharges from the pump performance curve. **Table 5** presents the absolute relative errors between calculated flows and the flows from the pump performance curve, and the AARD between them is 0.081%. These results indicate that the developed rating well represents the relationship between total static head and discharge obtained from the manufactory pump performance curve.

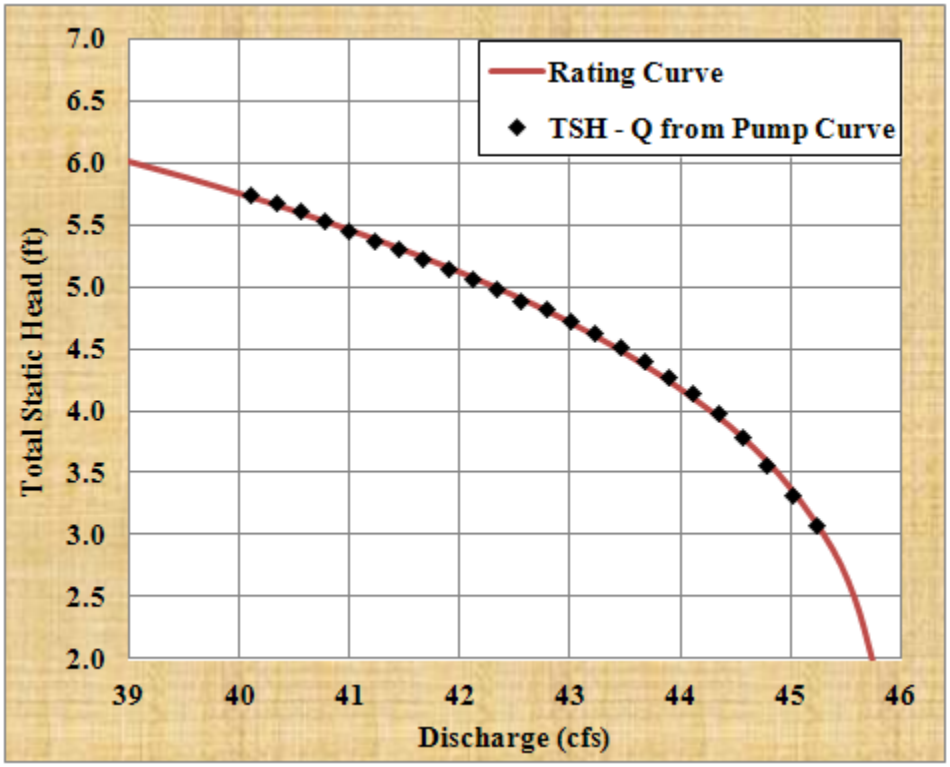

Figure 5. Flow Rating Curve for Pump Station G700

Table 5. Comparison between Computed Flows and Those from the Pump Curve

TSH (ft)	Discharge from Rating Equation (cfs)	Discharge from pump curve (cfs)	Absolute Relative Difference (%)
5.747	40.010	40.105	0.237
5.674	40.273	40.328	0.138
5.610	40.496	40.551	0.137
5.533	40.755	40.774	0.046
5.455	41.009	40.997	0.029
5.377	41.253	41.219	0.081
5.308	41.462	41.442	0.047
5.225	41.704	41.665	0.093
5.151	41.911	41.888	0.056
5.068	42.135	42.111	0.058
4.989	42.339	42.334	0.014
4.896	42.570	42.556	0.031
4.817	42.756	42.779	0.053
4.718	42.980	43.002	0.052
4.625	43.179	43.225	0.107
4.518	43.395	43.448	0.121
4.401	43.617	43.670	0.122
4.275	43.840	43.893	0.121
4.140	44.060	44.116	0.126
3.977	44.303	44.339	0.081
3.787	44.555	44.562	0.014
3.570	44.806	44.784	0.048
3.320	45.050	45.007	0.095
3.075	45.247	45.230	0.038
Average Absolute Relative Difference (AARD)			**0.081**

4.0 CONCLUDING REMARKS

We conducted rating analysis for Pump Station G700 based on the pump performance curve. **Table 4** presents the coefficients of the flow rating equation for Pump Station G700. The flow rating equation needs to be calibrated, and to be potentially improved based on future flow measurements.

REFERENCES

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.