FLOW RATING ANALYSIS FOR PUMP STATION S3

By

Sheng Yue

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DEFINITIONS

Acronyms

ADCP	Acoustic Doppler Current Profiler
CI	Confidence interval
NLIN	Nonlinear regression procedure in SAS software
TDH	Total dynamic head
TSH	Total static head
SFWMD	South Florida Water Management District

EXECUTIVE SUMMARY

We conducted a rating analysis for Pump Station S3 based on the conventional Case 8 model and developed a new rating equation based on the factory pump performance curve. The new rating shows better agreement with the measured flows than the existing rating, and hence we recommend that the new rating equation be implemented to compute flows through Pump Station S3 in DBHYDRO.

We performed an impact analysis to evaluate the need to recompute the historical flows through Pump Station S3 for the period from January 1, 2005 through May 31, 2011. A comparison between the daily flows computed using the existing and new rating equation indicates that the percentage of the data with absolute relative difference larger than 5% is 10. We recommend that the historical flows be recomputed with the new rating equation, and be reloaded into DBHYDRO.

1.0 INTRODUCTION

1.1 Background

The Pump Station S3 is located in the alignment of Lake Okeechobee South Shore Levee, at the intersection of the Miami Canal with Lake Okeechobee, in the western section of Palm Beach County just north of the town of Lake Harbor, Florida, as shown in **Figure 1**.

Figure 1. Location Map for Pump Station S3

The purpose of the pump station is to pump surplus water into Lake Okeechobee via the Miami Canal from the agricultural area southerly of the pumping station at the rate of 3/4 inches per day from the 129 sq. mile tributary drainage area.

1.2 Objectives and Scope

The purpose of the rating analysis in this study is to update and improve the rating for Pump Station S3 from the existing Case 2 rating to the Case 8 rating since Case 8 rating is a conventional rating equation that represents all possible cases. We will develop the new rating equation based on factory pump testing performance curve. We will compare the new rating equation to the existing rating equation along with the measured flows. We will also conduct impact analysis to evaluate the need to recalculate the historical flow records in DBHYDRO.

2.0 STATION DESIGN

The station is constructed of reinforced concrete and concrete block masonry superstructure with three Fairbanks Morse Company 144 inch diameter vertical pumps, each has the design capacity of 860 cfs at static head of 6.4 ft. **Table 1** provides the description of the station. The head water is in Miami Canal side and tail water in Lake Okeechobee side. **Figure 2** shows the plan view of Pump Station S3, and **Figure 3** cross-section view of Pump Station 3.

Table 1. Description of Structure S3

ITEM	Description
Number of pumps	3
Size and type of pumps	144 inch vertical propeller
Pump design capacity	860 cfs
Pump impeller speed	71.9 rpm
Pump manufacturer	Fairbanks Morse
Engine make & type	Fairbanks Morse, Model 38D8-1/8, 6 cylinder, opposed piston diesel
Engine horsepower	1600 hp
Design engine speed	720 rpm
Design headwater elevation:	13 ft
Design low water shut off elevation	10 ft
Design tailwater elevation (estimate)	19.4 ft
Normal “on elevation”	12.5 ft
Normal “off elevation”	10.0 ft

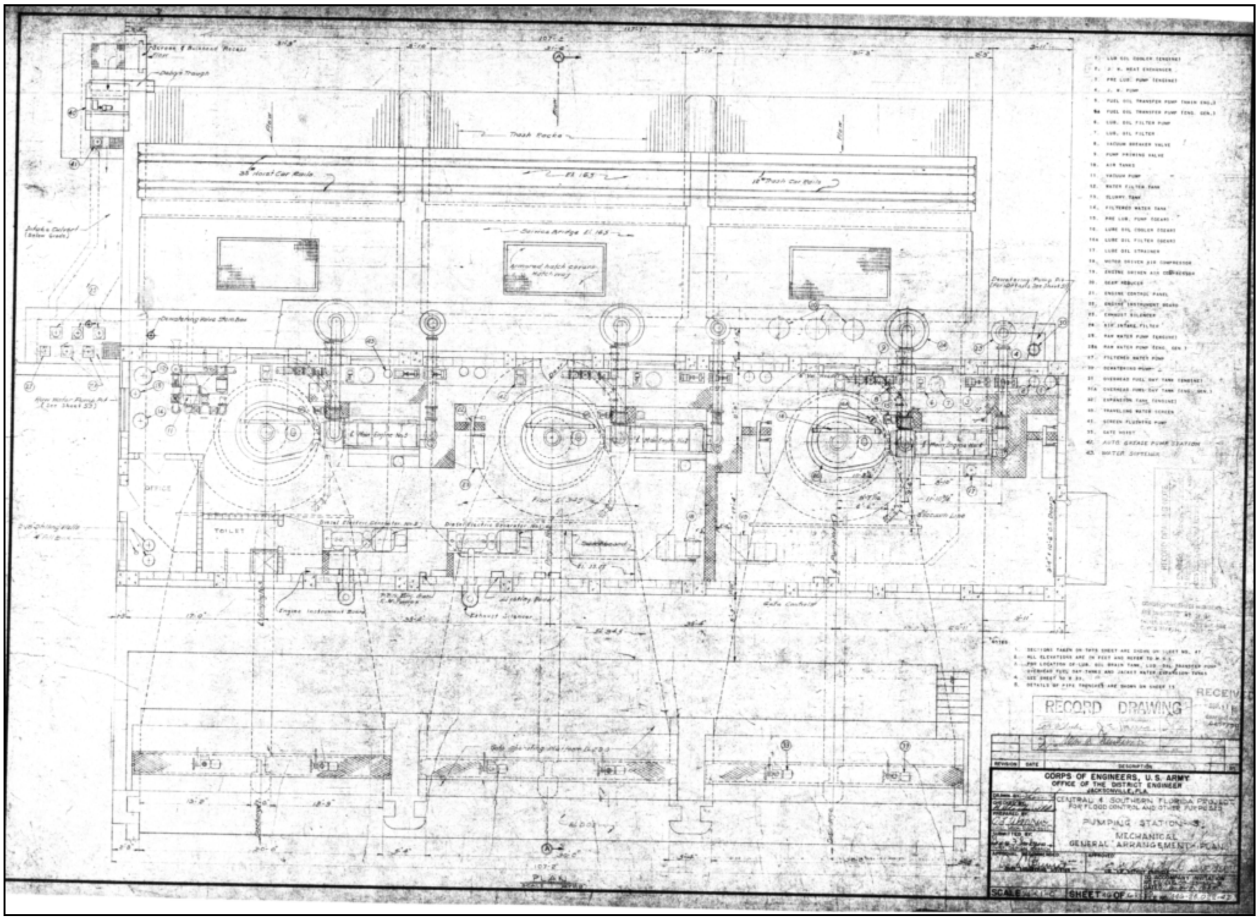

Figure 2. Plan View of Pump Station S3

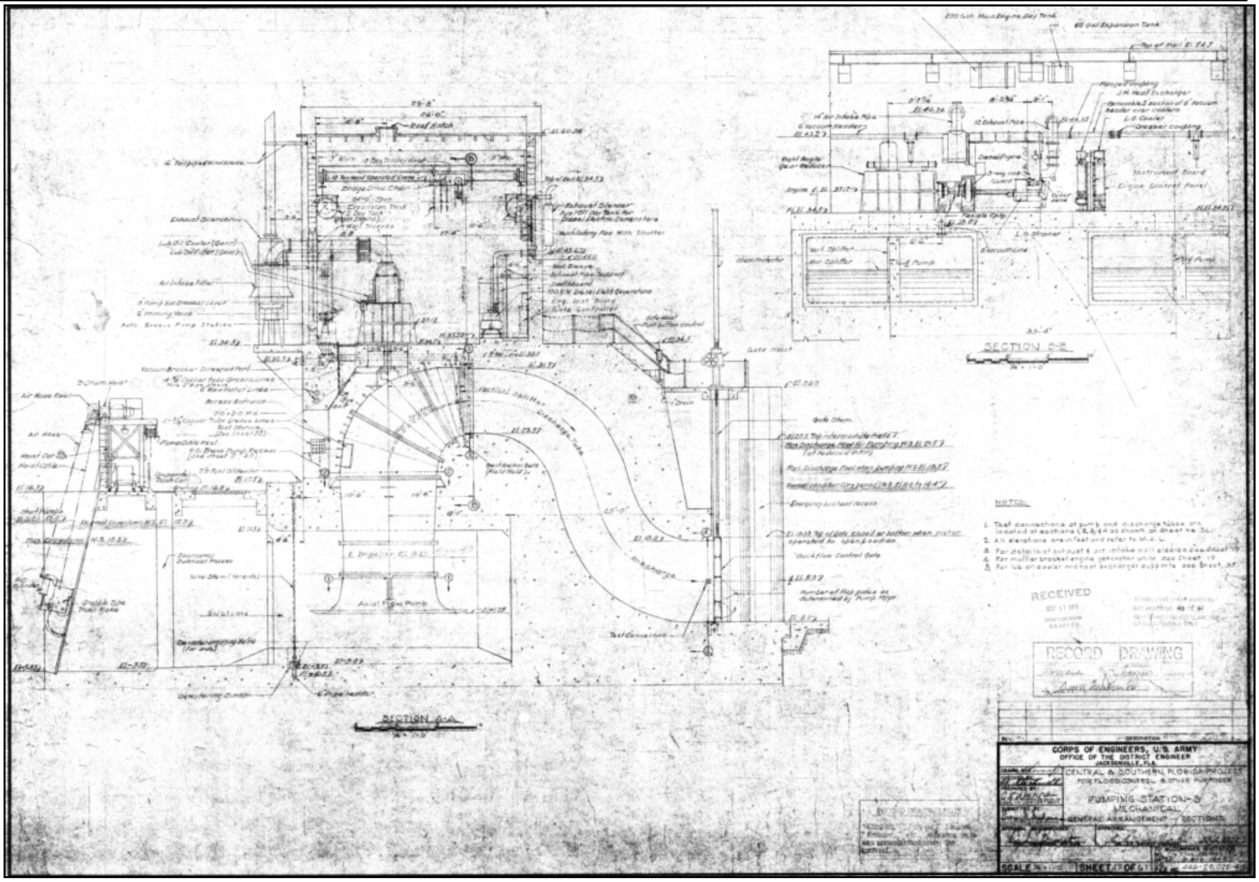

Figure 3. Cross-Sectional View of Pump Station S3

2.1. Pump Operation

The pump station is operated whenever the water level in the Miami canal within the agricultural area southerly of the pumping station exceeds 12.5 feet unless the water level in Lake Okeechobee is low enough to permit gravity discharge into the lake through S-354 at a desirable rate. The water surface should not be drawn below elevation 10.0 at the pumping station. Under design head, the capacity of Pumping Station 3 is 2,580 cfs. The pumps should be started and stopped slowly, one pump at a time, so that high velocities and surges will not occur in the Miami Canal. S-354 should be closed during pumping operations. Because of water quality concerns in Lake Okeechobee, at present, the station is operated according to the EAA Interim Action Plan. The Operation Chart defines the entire recommended range over which pumping can be accomplished. Inasmuch as the reduction ratio between engine and pump is fixed, all pump rotative speeds are expressed in terms of engine speeds which are indicated on the engine tachometer. At design speed each pump has a design capacity of 860 cfs or greater with pool to pool heads not in excess of 6.4 feet and intake pool gauge between El. 13.0 and 10.3. The pumps in this station are designed to pump drainage water containing a negligible amount of sediment or other material which might damage the surface of the pump or bearings. All pump bearings are designed for grease lubrication and to exclude dirt and grit. However, the quantity of water being pumped by the station should be reduced at any time the water in the suction bay becomes moderately silted or if it appears that the approach velocities are carrying a bottom load of sand into the sump chambers. The main pumping units installed at station are free from harmful criticals throughout the range of normal operating speeds from

580 to 715 rpm inclusive, However, there exists a severe critical at 260 rpm. The unit should, therefore, be brought up to 300 rpm immediately on starting. No operation should be attempted at speeds below 300 rpm.

2.2. Pump Performance Curve

Figure 4 shows the total static head and discharge relationship through the pumps at Pump Station S3 under laboratory conditions. Various pump speeds are represented by corresponding curves. The top curve represents 715 rpm, the bottom curve represents 580 rpm and the curves in between are for 600, 620, 640, 660, 680 and 700 rpm as shown.

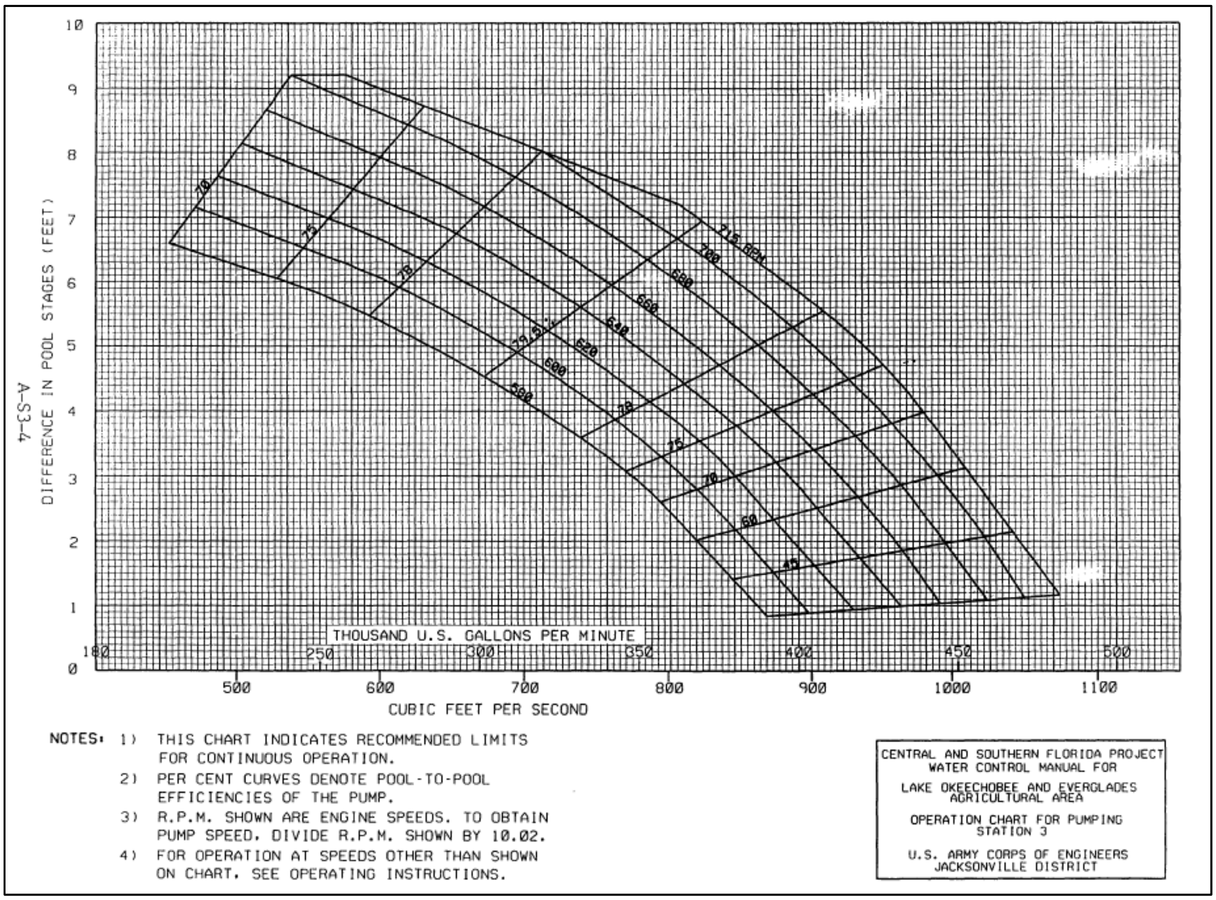

Figure 4. Pump Performance Curve at S3

3.0 STREAMGAUGING FLOW DATA

There are seventeen measured flow data for this station in the streamgauging database. Five of them are for siphon operation, i.e., flow through the pumps by gravity. The flow measurement was conducted using a Price AA (1996 observation) and Acoustic Doppler Current Profiler (ADCP) between 1996 and

2009. **Table 2** summarizes these flow measurements, including the static head, number of pumps in operation, average discharge, average engine speed, and measurement quality tag.

The total static head is calculated as the difference between the effective tailwater elevation and the monitored headwater elevation at pump Station S3 (S3-H). The effective tailwater elevation is the maximum of the discharge pipe centerline elevation, and the monitored tailwater elevation (S3-T). **Table 2** indicates that there are 8 flow measurements with tailwater elevation less than head water elevation.

The quality of each flow measurement has been evaluated and assigned quality tag or qualitative accuracy qualifier. There are six categories of qualifiers are used: “excellent (E)”, “good (G)”, “fair (F)”, “poor (P)”, “bad (B)”, and “Not processed (N). **Table 2** indicates that twelve of these measured flows are for pump and there is one with “N”, two with “P”, seven with “F”, and two with “E” quality tag. There are three measurements with “G” and two with “F” quality tag for siphon. Based on the District’s Standard Operation Procedure (SOP) (SFWMD, 2009), the flow data with “Poor” or “Bad” measurement quality tag should not be used for rating analysis.

Table 2. Summary of Flow Measurements

Measurement Date	Average Head Water El (ft, NGVD)	Average Tail Water El. (ft, NGVD)	Total Static Head (ft)	# Units in Operation	Avg. Engine Speed (rpm)	Average Discharge (cfs)	Quality Tag	Discharge Type
8/21/08	11.13	12.28	1.15	1	720.06	1037.758	E	Pump
10/9/96	12.58	15.05	2.47	1	720.05	983	E	Pump
10/5/00	11.8	12.4	0.60	2	718	2173	N	Pump
6/9/01	9.9	10.06	0.16	1	555	845.458	F	Pump
3/31/01	10.95	10.31	-0.64	1	649	989.148	F	Pump
3/30/01	11.86	10.24	-1.62	1	650.5	1028.725	F	Pump
6/5/01	11.28	10.06	-1.22	1	605.5	922.121	F	Pump
6/7/01	11.06	8.85	-2.21	1	600	905.948	***P***	Pump
6/8/01	11.3	10.07	-1.23	1	602	918.244	F	Pump
6/10/01	10.81	10.05	-0.76	1	606.58	885.851	F	Pump
6/12/01	10.89	10.03	-0.86	1	608.5	885.285	***P***	Pump
6/23/01	10.36	9.06	-1.30	1	604.5	849.982	F	Pump
3/6/09	11.28	12.75	1.47		0	-506.058	G	Siphon
2/25/09	11.4	12.99	1.59		0	-530.917	F	Siphon
3/3/09	11.21	12.95	1.74		0	-598.75	G	Siphon
5/12/09	10.52	10.92	0.40		0	-104.329	F	Siphon
3/6/09	11.23	12.75	1.52		0	-562.394	G	Siphon

4.0 RATING ANALYSIS

4.1 Existing Rating Equation

The existing flow rating equation at S3 is based on the Case 2 model. The Case 2 model is a third-order model with two independent variables (Ansar and Alexis, 2003) as below:

$$Q = C_o + C_1 X + C_2 Y + C_3 X^2 + C_4 XY + C_5 Y^5 + C_6 X^3 + C_7 YX^2 + C_8 XY^2 + C_9 Y^3 \quad (1)$$

$$X = H/H_{fact} \quad (2)$$

$$Y = (N - N_{min})/N_{fact} \quad (3)$$

where

Q: Discharge in cfs;
H: Total static head (TSH);
N: Engine speed in rpm;
C_0 through C_9: Model coefficients determined through regression analysis;
H_{fact}: Head factor = 10;
N_{min} Minimum engine speed = 300;
N_{max} Maximum engine speed = 720;
N_{fact} Engine speed factor = $N_{max} - N_{min}$ = 420.

The coefficients for the S3 pumps are summarized in **Table 3**. The three pump units have the same coefficients.

Table 3. Model Coefficients for Existing Rating Equation

Pump Unit	Model Coefficients									
	C_0	C_1	C_2	C_3	C_4	C_5	C_6	C_7	C_8	C_9
#1	44.256011	-1992.8925	2683.1206	-1163.3879	4343.2822	-3118.5107	-422.74255	1438.8718	-2790.6811	1536
#2	44.256011	-1992.8925	2683.1206	-1163.3879	4343.2822	-3118.5107	-422.74255	1438.8718	-2790.6811	1536
#3	44.256011	-1992.8925	2683.1206	-1163.3879	4343.2822	-3118.5107	-422.74255	1438.8718	-2790.6811	1536

Based on the study of Akpoji et al, (2003), the rating is classified as "excellent" if 95% of the absolute relative errors <= 5%, "good" if 95% of the absolute relative errors <= 10%, "fair" if 95% of the absolute relative errors <= 15% and "poor" when the absolute relative errors are not within 15%.

The quality of the existing rating equation was evaluated by comparing the calculated discharges to the measured ones. **Table 4** presents the comparison between the computed and measured discharges. The average absolute relative error is 3.9%. The percentage of data with absolute average relative errors within 5% is 70, and with absolute errors between 5% and 10% is 30. The percentage of data with absolute average relative errors ≤ 10% is 100.

Table 4. Comparison between Measured and Computed Discharges for the Existing Rating Equation (Case 2)

No.	Measurement Date	Head Water Elevation (ft, NAVD)	Tail Water Elevation (ft, NAVD)	Q measured (cfs)	Q computed (cfs)	Relative Error (%)	Absolute Relative Error (%)
1	08/21/08	11.13	12.28	1037.76	1097.37	5.7	5.7
2	10/09/96	12.58	15.05	983.00	1046.65	6.5	6.5
3	10/05/00	11.80	12.40	1086.50	1114.69	2.6	2.6
4	06/09/01	9.90	10.06	845.46	861.28	1.9	1.9
5	03/31/01	10.95	10.31	989.15	981.95	-0.7	0.7
6	03/30/01	11.86	10.24	1028.73	952.93	-7.4	7.4
7	06/05/01	11.28	10.06	922.12	896.73	-2.8	2.8
8	06/08/01	11.30	10.07	918.24	891.02	-3.0	3.0
9	06/10/01	10.81	10.05	885.85	914.22	3.2	3.2
10	06/23/01	10.36	9.06	849.98	892.31	5.0	5.0
Average						1.1	3.9
Minimum						-7.4	0.7
Maximum						6.5	7.4
% of data with Absolute Relative Error <=5% (Rating is excellent)							70
% of data with 5% < Absolute Relative Error <=10% (Rating is good)							30
% of data with 10% < Absolute Relative Error <=15% (Rating is fair)							0
% of data with Absolute Relative Error >15% (Rating is poor)							0

4.2 New Rating Equation

Wang (2006) and Sangoyomi (2009) have developed a new rating based on Case 8 rating equation, but the rating has not been implemented yet. In this study, we will also conduct rating analysis using Case 8 rating equation. 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 (4) below shows the Case 8 rating equation.

$$Q = A\left(\frac{N}{No}\right) + BH^{C}\left(\frac{No}{N}\right)^{2C-1} \quad (4)$$

Where

Q:	Discharge in cfs;
N:	Pump engine speed in rpm;
No:	Design pump engine speed in rpm (720 rpm);
H:	Total static head (TSH);
A, B and C:	Regression coefficients determined through regression analysis (A > 0, B < 0, and C > 1.0).

The H versus Q relationship is usually determined by subtracting the head losses through the intake and discharge works from each point on the pump performance curve. This results in a station performance curve for each pump. The station performance curve can then be calibrated using available measured flow data.

4.2.1 TSH ≥ 0.0

For Pump Station S3, the total static head (H) (difference in pool stage) and discharge relationship is available for H ≥ 0.0, as shown in **Figure 4**. Hence, we do not need to estimate the system head losses. We obtained total static heads and the corresponding discharge values from the pump performance curve at pump engine speed of 680 rpm to develop new rating equation, as given in **Table 5**.

In the present rating analysis, we only need to estimate rating coefficients for one pump unit since all three pump units of S3 have the same design engine speed of 720 rpm and the same design discharge of 860 cfs. We conducted a nonlinear regression analysis using SAS NLIN function to determine the coefficients in equation (4) based on the H and Q data in **Table 5**. **Table 6** presents the resultant regression coefficients along with their approximate 95% confidence limits.

Figure 5 shows the pump curves for different pump engine speeds varying from 580 to 720 rpm by using the new rating equation. **Figure 5** indicates that the rating curve at N = 680 rpm well fits to the data points obtained from the pump performance curve (**Figure 4**).

Table 5. Discharges from Pump Performance Curve

TSH	Discharge (1000 GPM)	Discharge (cfs)	N (rpm)
1.1	459.0	1022.69	680
1.5	453.0	1009.32	680
2.0	446.0	993.72	680
2.5	438.0	975.90	680
3.0	430.0	958.07	680
3.5	420.6	937.13	680
4.0	410.0	913.51	680
4.5	399.4	889.89	680
5.0	388.0	864.49	680
5.5	376.0	837.76	680
6.0	362.0	806.56	680
6.5	349.0	777.60	680
7.0	333.0	741.95	680
7.5	316.0	704.07	680
8.0	297.0	661.74	680
8.5	275.0	612.72	680
9.0	250.0	557.02	680
9.2	241.0	536.97	680

Table 6. Case 8 Rating Coefficients for S3

Regression Coefficient	Estimate	Approximate Lower 95% Confidence Limit	Approximate Upper 95% Confidence Limit
A	1082.1	1071.9	1092.3
B	-6.666	-8.465	-4.867
C	1.854	1.742	1.967

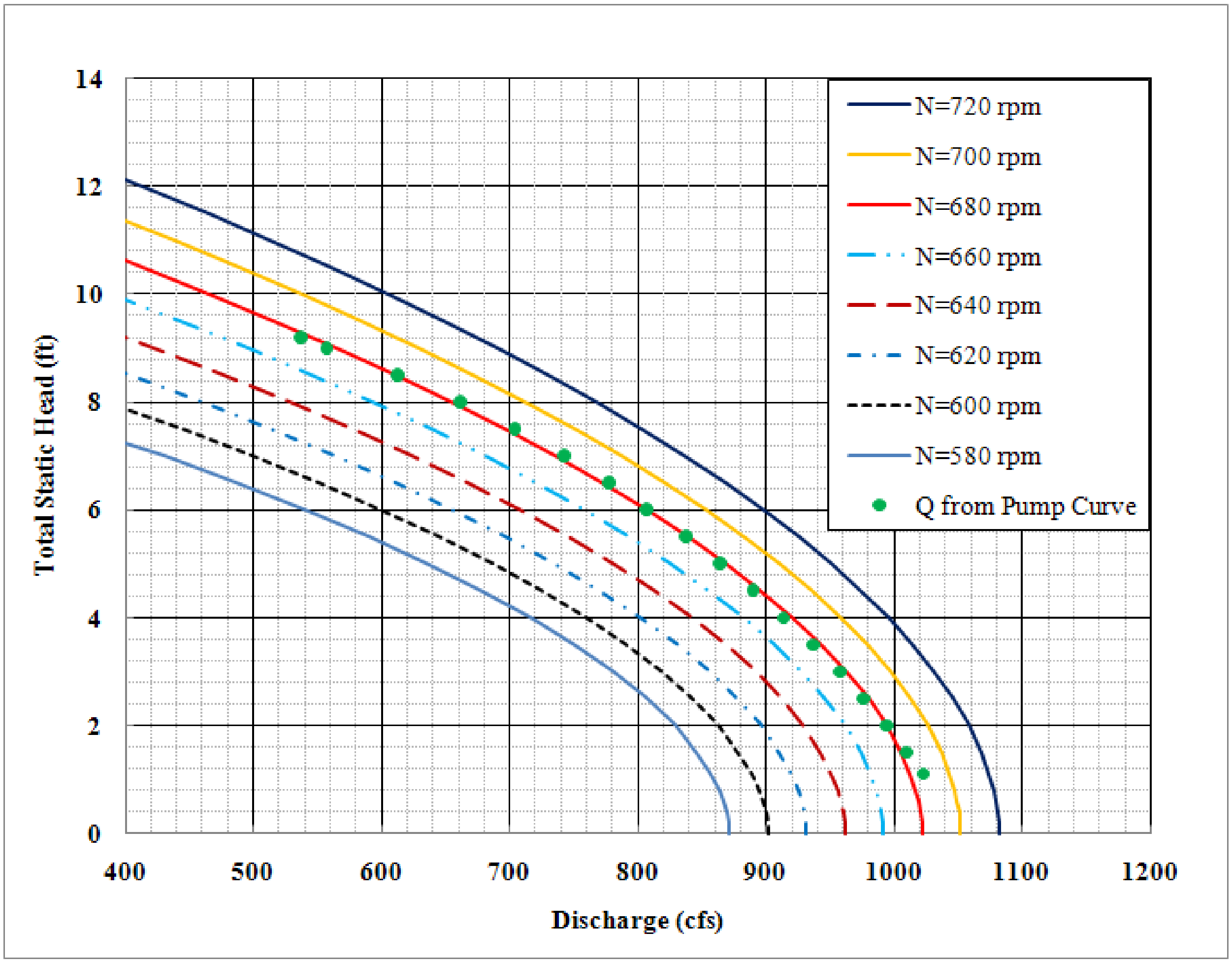

Figure 5. Pump Curves for Various Pump Engine Speeds based on New Rating Equation (Case 8)

4.2.2 TSH < 0

In the case that TSH < 0, i.e., HW < TW, a pump could theoretically convey more water through the pump than when TSH > 0 since in addition to the pumped flow, gravity will also make water flow through the pump.

We have conducted rating analysis using same procedure as in Section 4.2.2 to try to develop the rating equation coefficients when TSH < 0. We realized that it was almost impossible to obtain a good rating curve when TSH < 0 since equation (4) has to meet the following conditions: (i) coefficient *A* remains the same as in the case TSH > 0 in order to get the same discharge with the rating equation of TSH > 0 when TSH = 0.0; and (ii) parameter *C* must be an even number when TSH < 0 in order for the equation to be valid. We realized that it is reasonable to simply take the absolute values for both B and H in equation (4) to calculate flows through the pump when H < 0 as below (Imru and Wang, 2004):

$$Q = A\left(\frac{N}{No}\right) + |B| \cdot |H|^{C} \left(\frac{No}{N}\right)^{2C-1} \quad (5)$$

Equation (5) will compute more flows than when H > 0, which is expected.

We evaluated the quality of the new rating equation by comparing the calculated discharges to the measured ones. **Table 7** presents the comparison between the measured and computed discharges. The average absolute relative error is 2.9%, which is 1% less than that of the existing rating equation. The percentage of data with absolute average relative errors within 5% is 80, which is 10% higher than that of the existing rating equation. The percentage of data with absolute average relative errors ≤ 10% is 100.

Table 7. Comparison between Measured and Computed Discharges for the New Rating Equation (Case 8)

No.	Measurement Date	Head Water Elevation (ft, NAVD)	Tail Water Elevation (ft, NAVD)	Q measured (cfs)	Q computed (cfs)	Relative Error (%)	Absolute Relative Error (%)
1	08/21/08	11.13	12.28	1037.76	1073.55	3.4	3.4
2	10/09/96	12.58	15.05	983.00	1046.54	6.5	6.5
3	10/05/00	11.80	12.40	1086.50	1076.49	-0.9	0.9
4	06/09/01	9.90	10.06	845.46	833.67	-1.4	1.4
5	03/31/01	10.95	10.31	989.15	979.25	-1.0	1.0
6	03/30/01	11.86	10.24	1028.73	999.11	-2.9	2.9
7	06/05/01	11.28	10.06	922.12	925.42	0.4	0.4
8	06/08/01	11.30	10.07	918.24	920.64	0.3	0.3
9	06/10/01	10.81	10.05	885.85	918.01	3.6	3.6
10	06/23/01	10.36	9.06	849.98	925.92	8.9	8.9
Average						1.7	2.9
Minimum						-2.9	0.3
Maximum						8.9	8.9
% of data with Absolute Relative Error <=5% (Rating is excellent)							80

% of data with 5% < Absolute Relative Error <=10% (Rating is good)		20
% of data with 10% < Absolute Relative Error <=15% (Rating is fair)		0
% of data with Absolute Relative Error >15% (Rating is poor)		0

We also compared the measured discharges with the computed ones from both the existing rating (Case 2) and the new rating (Case 8), as shown in **Figure 6**. **Figure 6** visualizes that the discharges computed from the new rating equation show better agreement with the measured discharges than those from the existing equation. Overall, the new rating equation (Case 8) has less absolute relative errors and better agreement with the measured flow data than the existing rating equation (Case 2).

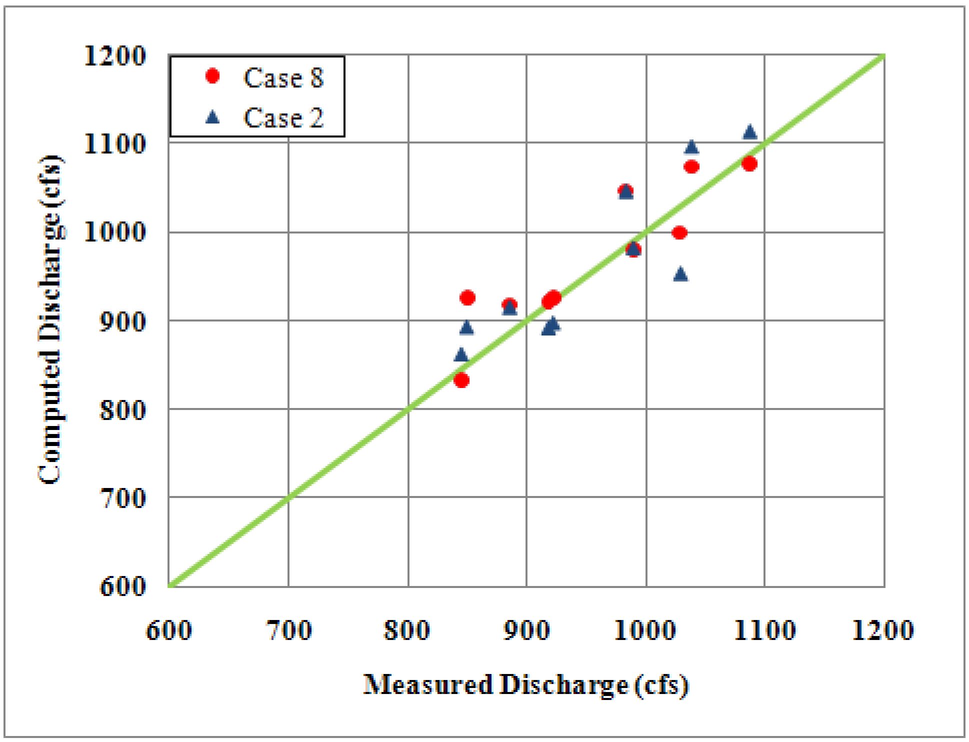

Figure 6. Comparison of Agreement between Measured and Computed Discharges

In order to further investigate the goodness-of-fit of the new rating to the measured flows, we divided the measured flow data into four groups based on their engine speed (=720, 650, 600 and 550 rpm), as given in **Table 8**. There are two measured flow data their 95% confidence interval has not been given, though QA/QC has been conducted on them. We plotted head-discharge relationships based on the new rating equations at given engine speed N = 720, 650, 600, and 550 rpm, and measured discharges and their 95 % confidence intervals, as shown in **Figure 7**. **Figure 7** indicates that the new rating curves with N = 720, 650, 600, and 550 rpm fall within the 95% confidence intervals of the corresponding measured flows except for the two points (2.47, 987) with 720 rpm and (-1.30, 850) with 600 rpm.

Table 8. Measured Flow data and their 95% Confidence Intervals

No.	Measurement Date	Average Head Water El (ft, NGVD)	Average Tail Water El. (ft, NGVD)	Total Static Head (ft)	Average Discharge (cfs)	95% CI	Average Engine Speed (rpm)	Plotting Group (rpm)
1	08/21/08	11.13	12.28	1.15	1038	± 23.23	720.06	**720**
2	10/09/96	12.58	15.05	2.47	983		720.05	
3	10/05/00	11.8	12.4	0.60	1087		718.00	
4	06/09/01	9.9	10.06	0.16	845	± 19.71	555.00	**550**
5	03/31/01	10.95	10.31	-0.64	989	± 28.49	649.00	**650**
6	03/30/01	11.86	10.24	-1.62	1029	± 41.55	650.50	
7	06/05/01	11.28	10.06	-1.22	922	± 25.24	605.50	**600**
8	06/08/01	11.3	10.07	-1.23	918	± 14.15	602.00	
9	06/10/01	10.81	10.05	-0.76	886	± 43.84	606.58	
10	06/23/01	10.36	9.06	-1.30	850	± 10.82	604.50	

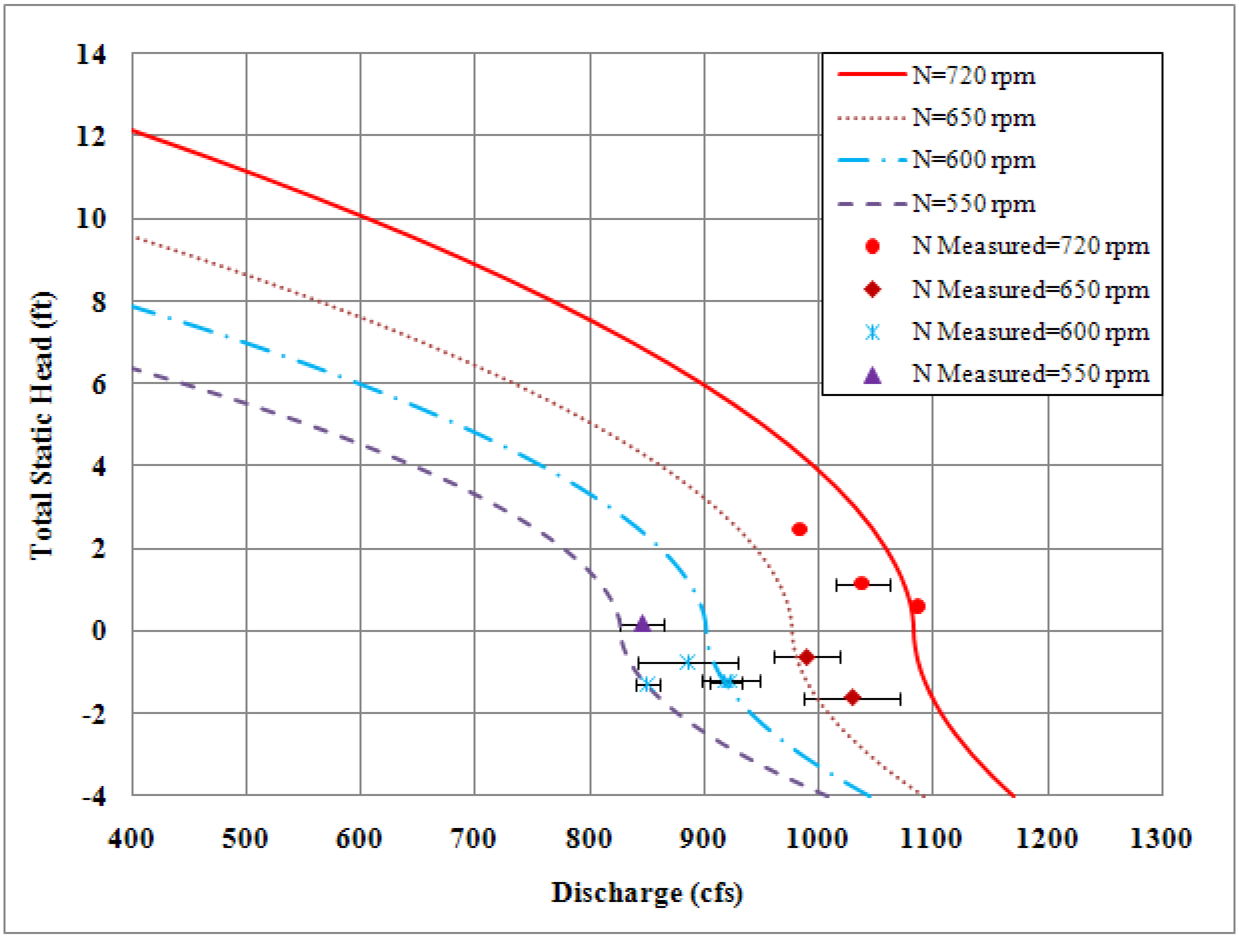

Figure 7. Head and Discharge Relationship for S3

5.0 RATING ANALYSES FOR SIPHON

5.1 Rating Equation

The relationship between siphoned discharge and static head can be expressed in the following formulas based on the conservation of energy principles and the functional relationship between flow rate and energy loss:

$$Q = a\,H^{\,b} \tag{6}$$

where

Q: Siphoned flow rate (cfs);
H: Static head across the pump station (head water – tail water) (feet);
a, *b*: Coefficient and exponent whose values are determined through regression analysis.

The existing rating equation with a = 148. 97 and b = 0.5 was developed by Sangoyomi (2009) based on the five measured flow data for siphon, as presented **in Table 9**. **Figure 8** illustrates the goodness-of-fit of the rating curve to the measured flows along their measured 95% confidence intervals. **Figure 8** shows that though we have five measured flow data, four of them clustered around the point (1.58 ft, 183.2 cfs).There are no measured flows in the static head range [0.5 ft, 1.45 ft]. We need more measured flow data that spread over wide static heads to verify and to update the existing rating.

Table 9. Siphon Flow Measurements

Measurement Date	Average Tailwater Stage (Lake Side) (ft, NGVD)	Average Headwater Stage (Canal Side) (ft, NGVD)	Head Difference (ft)	Average Discharge (cfs)	Discharge/ Pump (cfs)	95% Confidenc e Interval	Quality Tag
02/25/09	11.4	12.99	1.59	530.9	177.0	± 7.6	Fair
03/03/09	11.21	12.95	1.74	598.8	199.6	± 5.6	Good
03/06/09	11.28	12.75	1.47	506.1	168.7	± 13.1	Good
03/06/09	11.23	12.75	1.52	562.4	187.5	± 7.7	Good
05/12/09	10.52	10.92	0.40	104.0	34.7	± 2.9	Fair

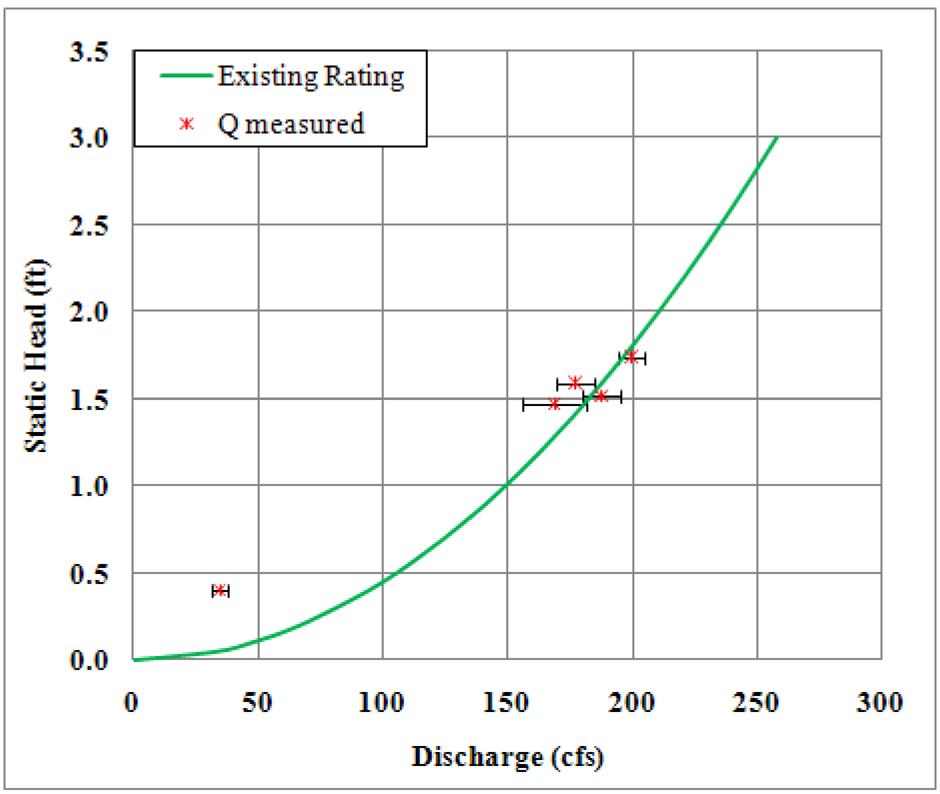

Figure 8. Comparison between the Existing Siphon Rating and Measured Flows

6.0 IMPACT ANALYSIS

In order to assess if the historical flow data need to be recomputed using the new rating equation, we conducted an impact analysis over the period of record spanning January 1, 2005 through May 31, 2011.

The impact analysis involved the evaluation of the differences between the flows computed using the existing and new rating equation. **Table 10** presents a summary of the difference in daily flows per year. There are 48 days when flows occurred during the period of interest. The average absolute relative difference in computed daily flows between the existing and new rating equations is about 3.5%, with differences ranging from -6.4% to 75.3%. There are 5 days with absolute relative differences equal to or larger than 5%, which is about 10% of total number of days when flows occurred. **Figure 9** illustrates the absolute relative difference in average daily flows for the period of interest, in which the vertical axis is in log scale.

Table 10. Summary of Impact Analysis for S3

Year	Number of Days with Flow	Minimum Relative Difference (%)	Maximum Relative Difference (%)	Avg. Relative Difference (%)	Average Abs. Relative Difference (%)	Abs. Relative Differences >=5%	
						Number of Days	%
2005	5	0.1	2.6	0.9	0.9	0	0
2006	11	0.0	51.7	7.8	7.8	3	27
2007	4	-6.4	0.0	-2.2	2.2	1	25
2008	9	-3.5	2.9	-0.3	1.6	0	0
2009	9	-3.4	75.3	8.4	9.4	1	11
2010	9	0.6	4.8	2.0	2.0	0	0
2011	1	0.5	0.5	0.5	0.5	0	0
Entire Period	**48**	**-6.4**	**75.3**	**2.4**	**3.5**	**5**	**10**

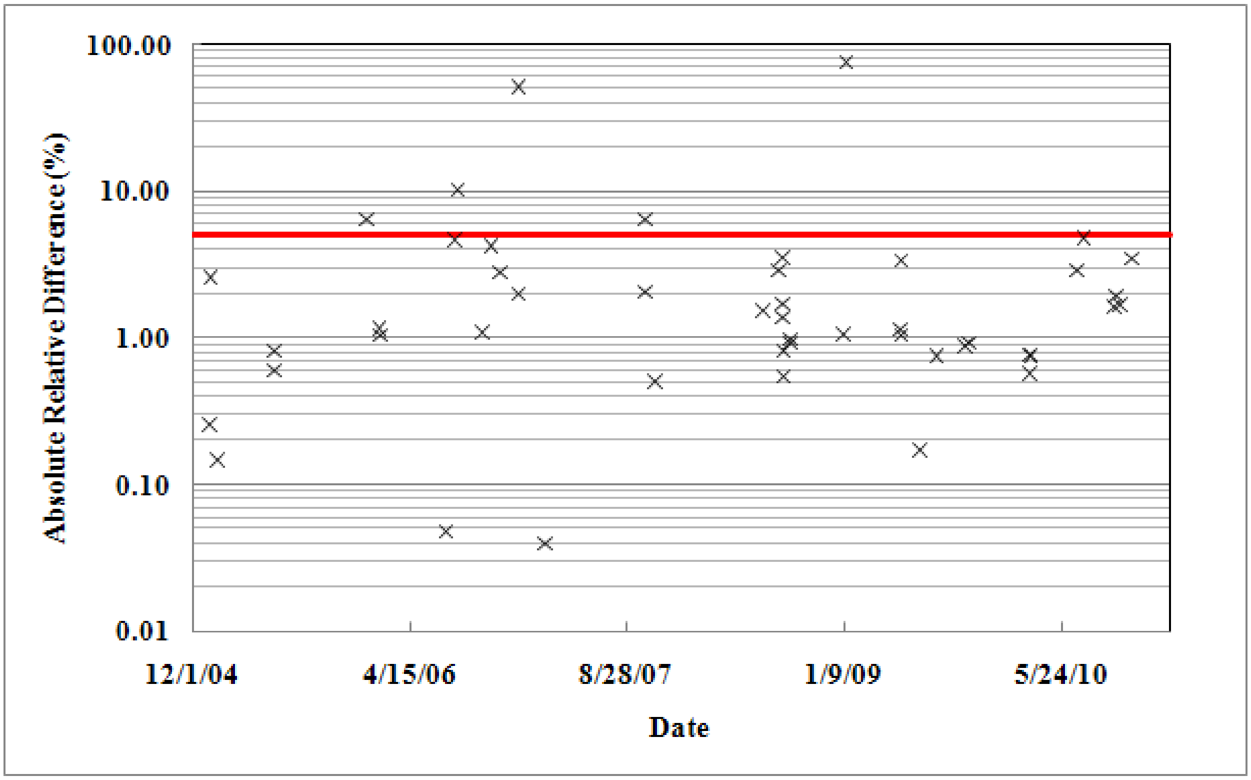

Figure 9. Absolute Relative Difference between Daily Flows Computed by Existing and New Rating Equations.

The Change Management Procedure for Hydrometeorological Data in the District's Hydrologic Database (SFWMD, 2009) indicates that the historical flows computed using the existing equation are subject to modification if one or more records in any flow time-series deviate at least 5% from the corresponding new flow records. Therefore, we recommend that the historical flows through Pump Station S3 be recomputed with the proposed rating equation and subsequently be reloaded into DBHYDRO.

7.0 STREAMGAUGING NEED

We developed the new rating equation for pumps based on the pump performance curve and verified the new rating using limited number of measured flows. In order to improve the new rating equation, more measured flow data are required for Pump Station S3. We also need more flow measurements to improve the existing Siphon rating equation. **Table 11** summarizes the desired number of flow measurements under each of the pump operating conditions.

Table 11. Stream Gauging Needs for Pump Station S3

Type	Total Static Head (ft)	Number of Measurements required
Pump	3-5	5
	5-7	5
Siphon	0-0.5	4
	0.5-1.5	5
	2-3	5

8.0 SUMMARY AND CONCLUSIONS

We developed the new rating equation for Pump Station S3 based on the pump performance curve and using the conventional case 8 model. We evaluated the new rating based on measured flows. Flows calculated by the new rating equation show better agreement with measured flows than by the existing equation. We recommend that the new rating equation be implemented to generate flows through Pump Station S3.

We conducted an impact analysis to evaluate if historical flows through pump station S3 need to be recomputed. A comparison between the daily flows computed using the existing and new rating equation indicates that the percentage of data with the absolute relative difference larger than 5% is 10, and hence we recommend that the historical flows be recomputed with the new rating equation, and be reloaded into DBHYDRO.

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