Air & Waste Management Association

A System Approach to Pumping Leachate

May 2, 2023 10:15 am

Presented by
Mark Pearson

A&MWA 30th Annual Environmental Technical Conference

SCS ENGINEERS

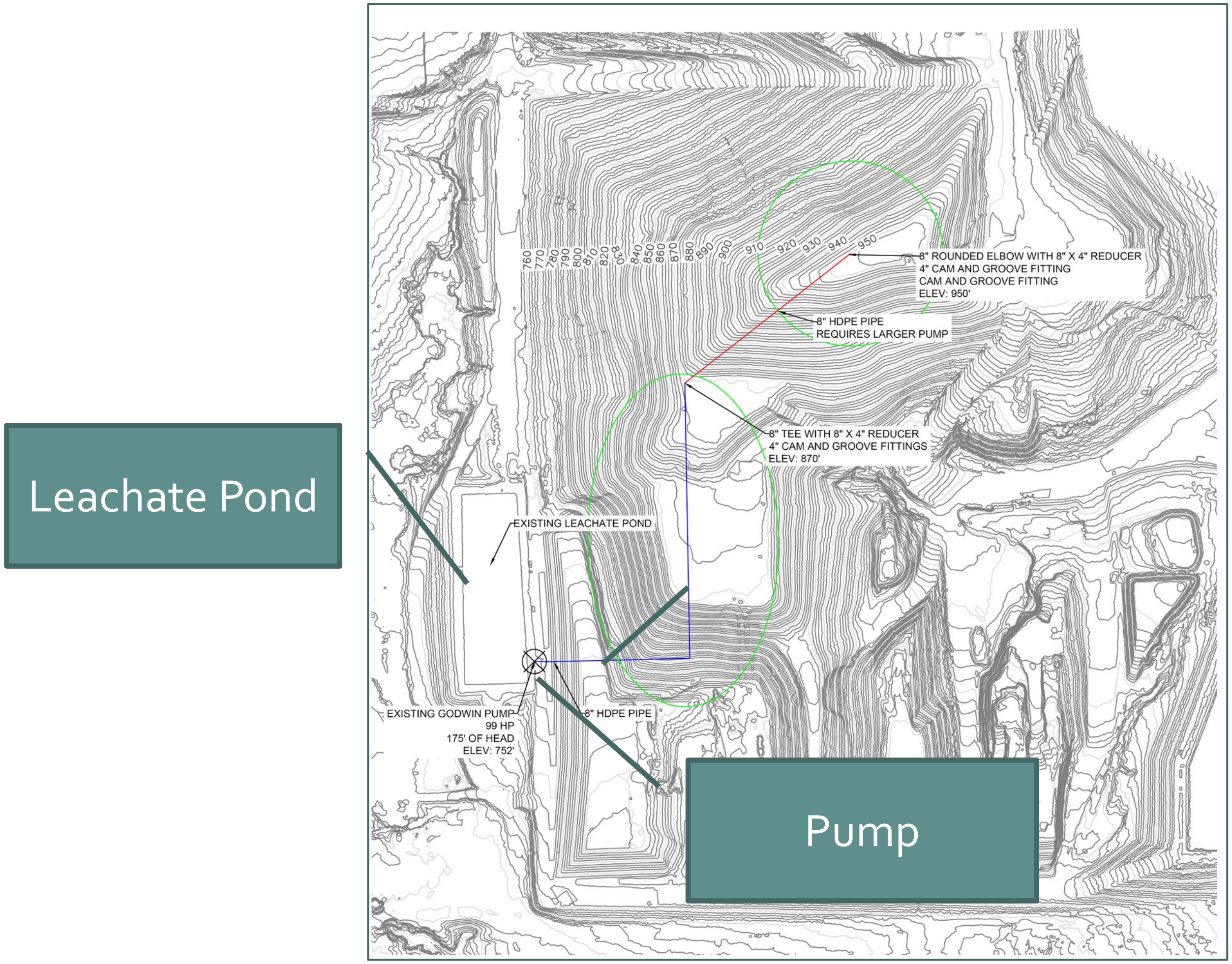
Meet Our Presenter

Mark Pearson, PE

- Mark is a Project Director based in the Overland Park, Kansas Office of SCS Engineers. He has been with SCS approaching 4 years.
- Mark has over four decades of experience in environmental engineering, with an emphasis on wastewater design and potable water treatment plants, wells, pumping stations, sewers and waterlines.
- Expertise includes project management through facility planning, design, and construction phases. He has worked on a wide range of projects throughout the United States and around the world.
- Mark is a Professional Engineer licensed in Missouri, Kansas, and Nebraska.

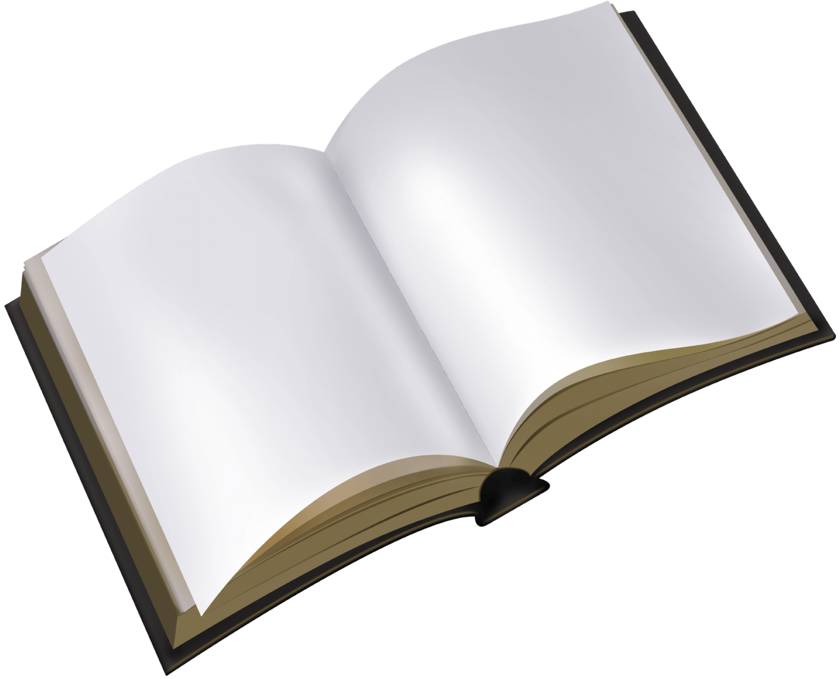
Pumps are part of a system which must be defined before a pump is selected.

It's a System – Develop System Thinking



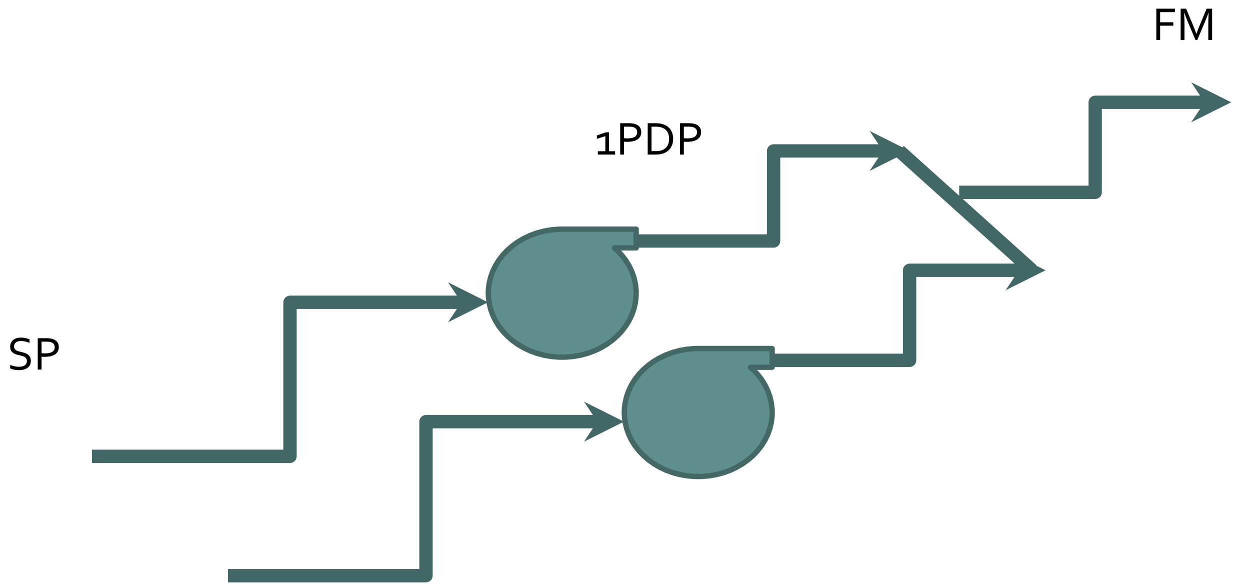
Tell a Story - Documentation

- Every Story Has…
  - A Beginning
  - A Middle
  - An End

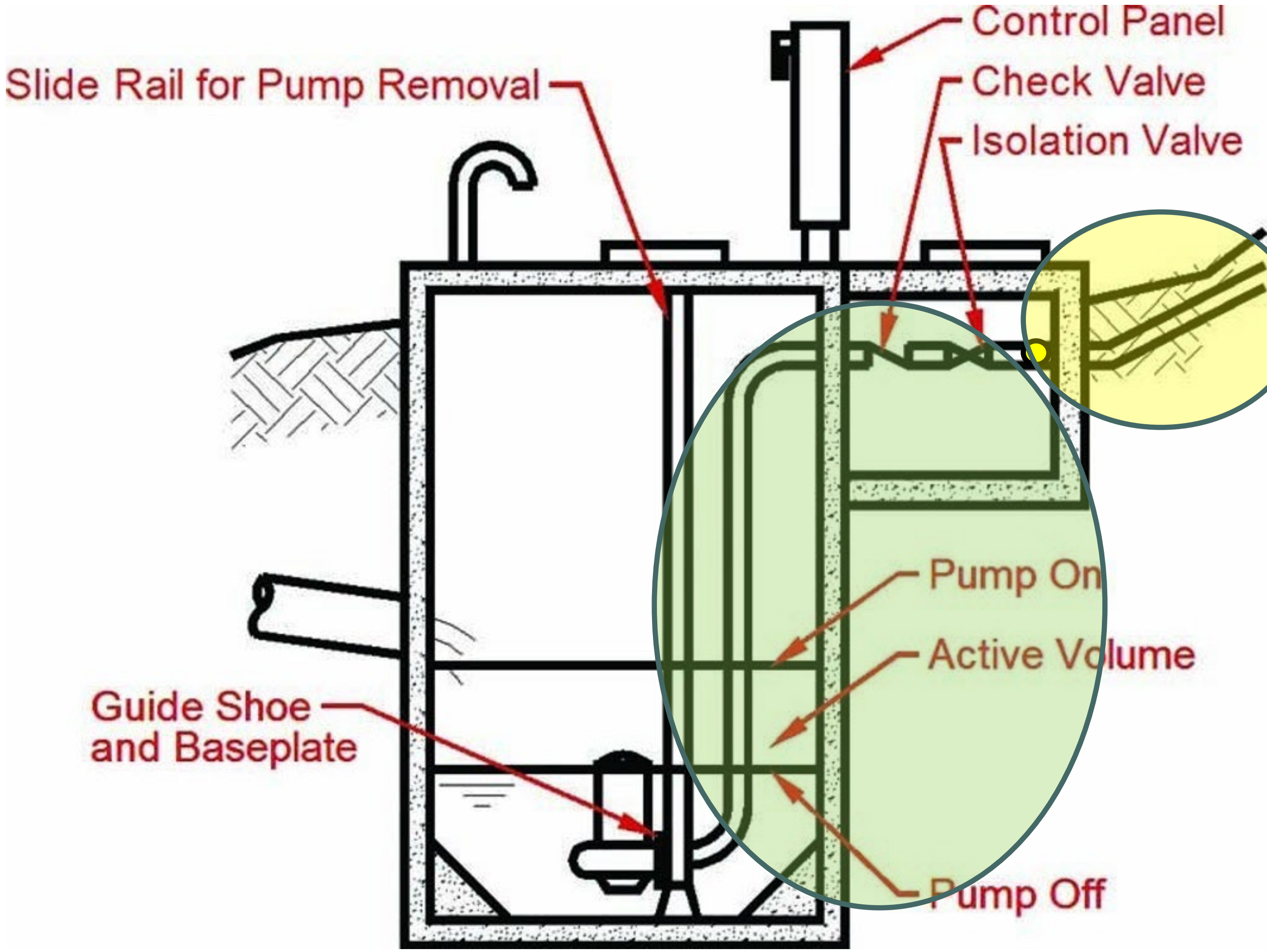


In System Curve Development There Is:

- Suction Piping
- One Pump Discharge Piping
- Force Main

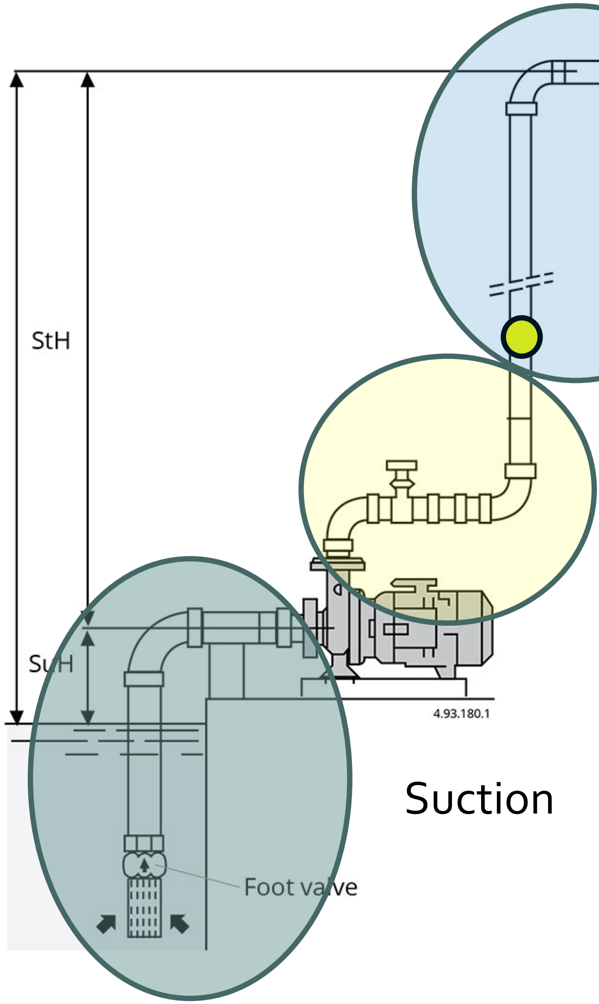


Submersible Pump Station



Discharge
Mult
Pumps

Suction Lift Pump Arrangement

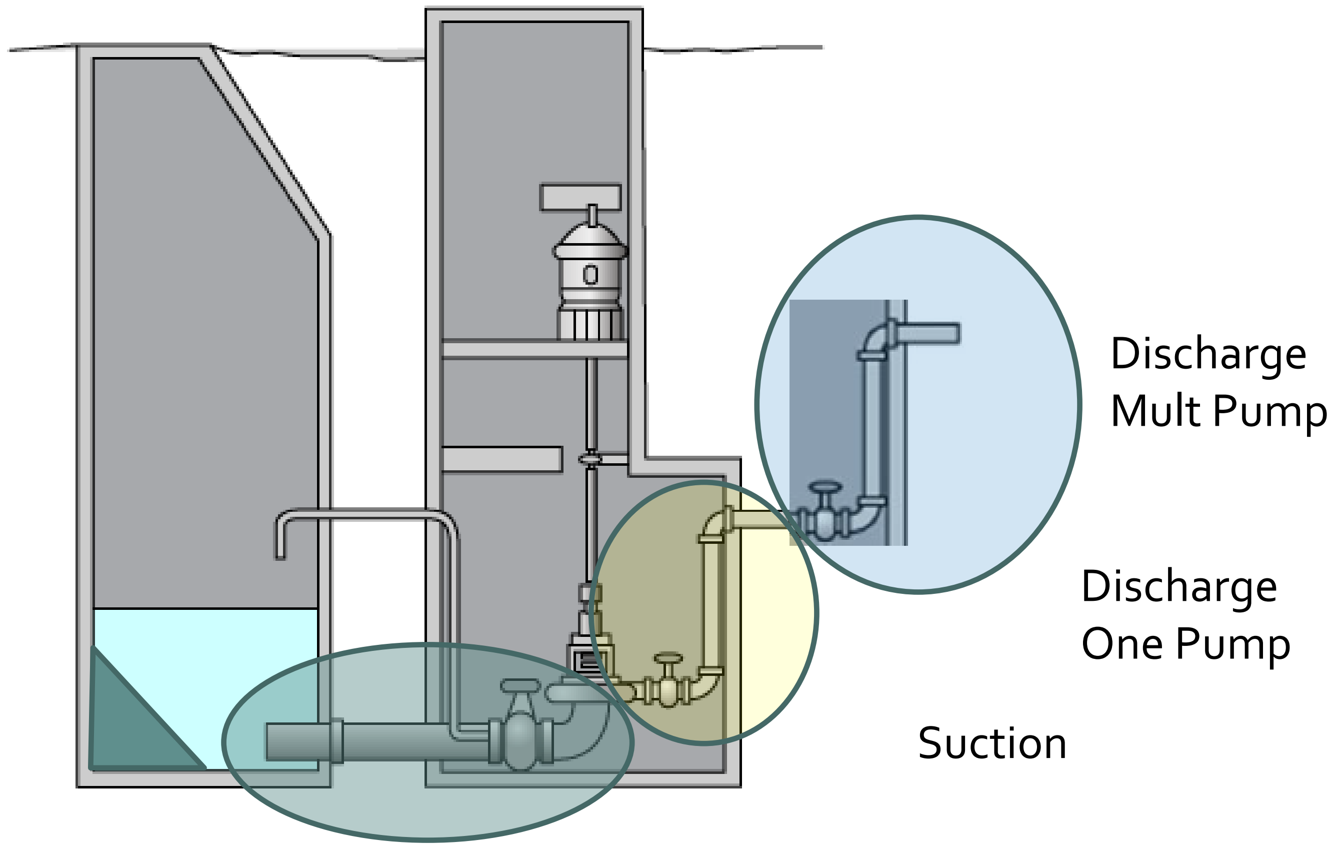


- TDH Calculation:
- Static Head (StH) = 24m
- Suction Head (SuH) = 2.4m
- Friction Loss = 8.6m
- Total = 35m

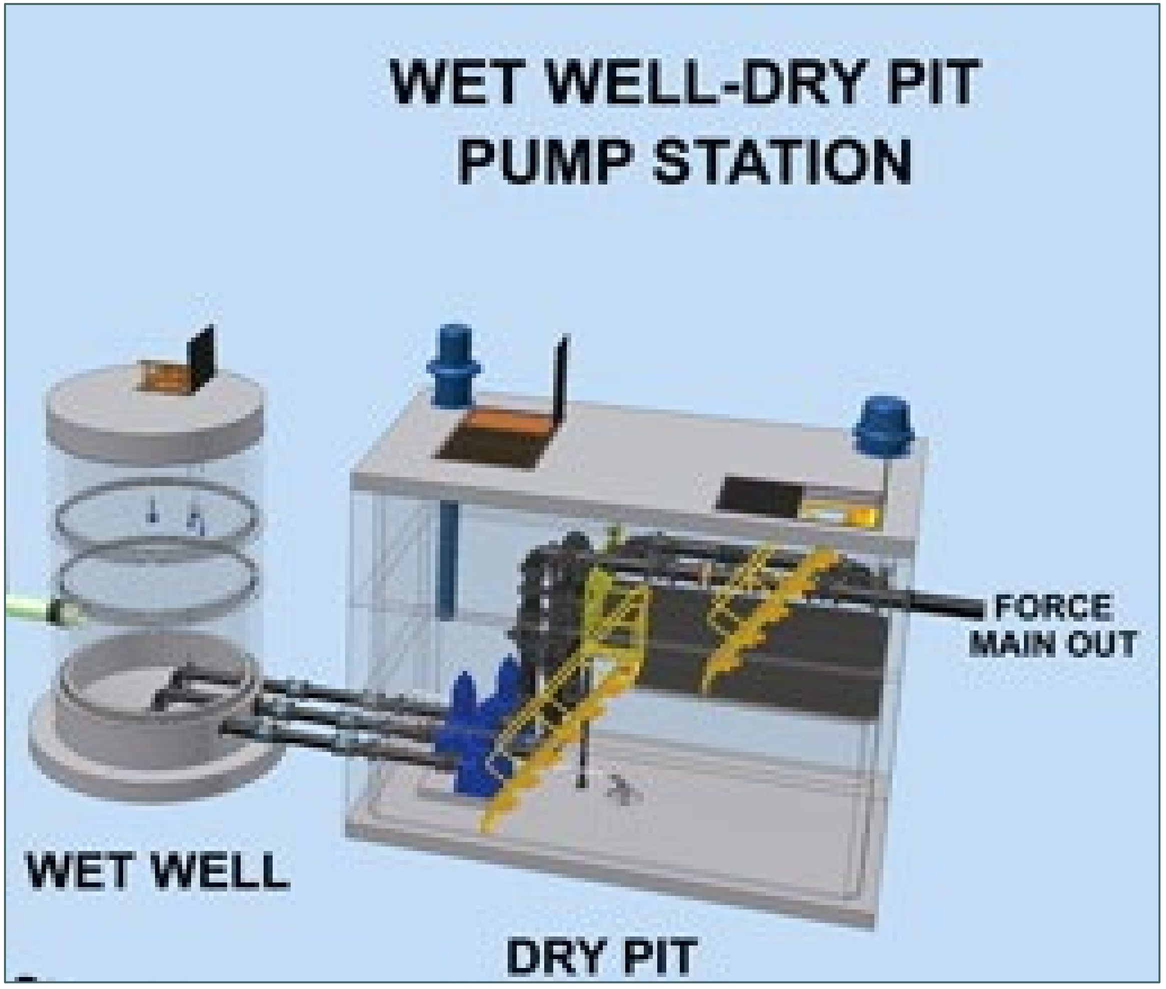
Discharge
Mult Pump

Discharge
One Pump

Dry Well Pump Isolated from Wet Well



Multiple Pumps



PIPE

2.	INPUT LENGTH AND SIZE OF SUCTION AND DISCHARGE PIPING FOR THE SYSTEM YOU WISH TO EXAMINE. BE CAREFUL TO SEPARATE DATA FOR UNIT SUCTION, UNIT DISCHARGE AND SYSTEM HEADER PIPING:					
	Note: Three sizes of pipe are available for each section of piping.					
		Nominal Dia, in	DR type	ID in.	C	L ft
SUCTION	HDPE	4	DR 11	3.633	140	0
		6	DR 11	5.348	140	0
		8	DR 11	6.963	140	8
DISCHARGE - EACH PUMP		3	DR 11	2.825	140	0
		4	DR 11	3.633	140	0
		6	DR 11	5.348	140	5
DISCHARGE - COMMON TO ALL PUMPS		6	DR 11	5.348	140	946
		4	DR 11	3.633	140	0
		8	DR 11	6.963	140	0

Minor Losses: K-Values

- The K-value, Resistance Coefficient, Velocity Head, Excess Head or Crane method allows the user to characterize the pressure loss through fittings in a pipe. The K-value represents the multiple of velocity heads that will be lost by fluid passing through the fitting.
- Velocity Head, ft
- $K*V^2/2g$
  - K = value of velocity head lost through a fitting or valve
  - V = velocity ft/sec
  - G = acceleration of gravity = 32.2 fps

K-Values

			GATE	GLOBE	Sum/product
Diam.	ENT.	EXIT	VALVE	VALVE	
-------	-------	-------	-------	-------	
in.	0.5	1	0.2	10	
--SUCT					
3.633	0	0	0	0	0
5.348	0	0	0	0	0
6.963	1	0	0	0	3.3
DISC					
2.825	0	0	0	0	0
3.633	0	0	0	0	0
5.348	0	0	1	0	3
HEADER					
5.348	0	1	0	0	3.3
3.633	0	0	0	0	0
6.963	0	0	0	0	0

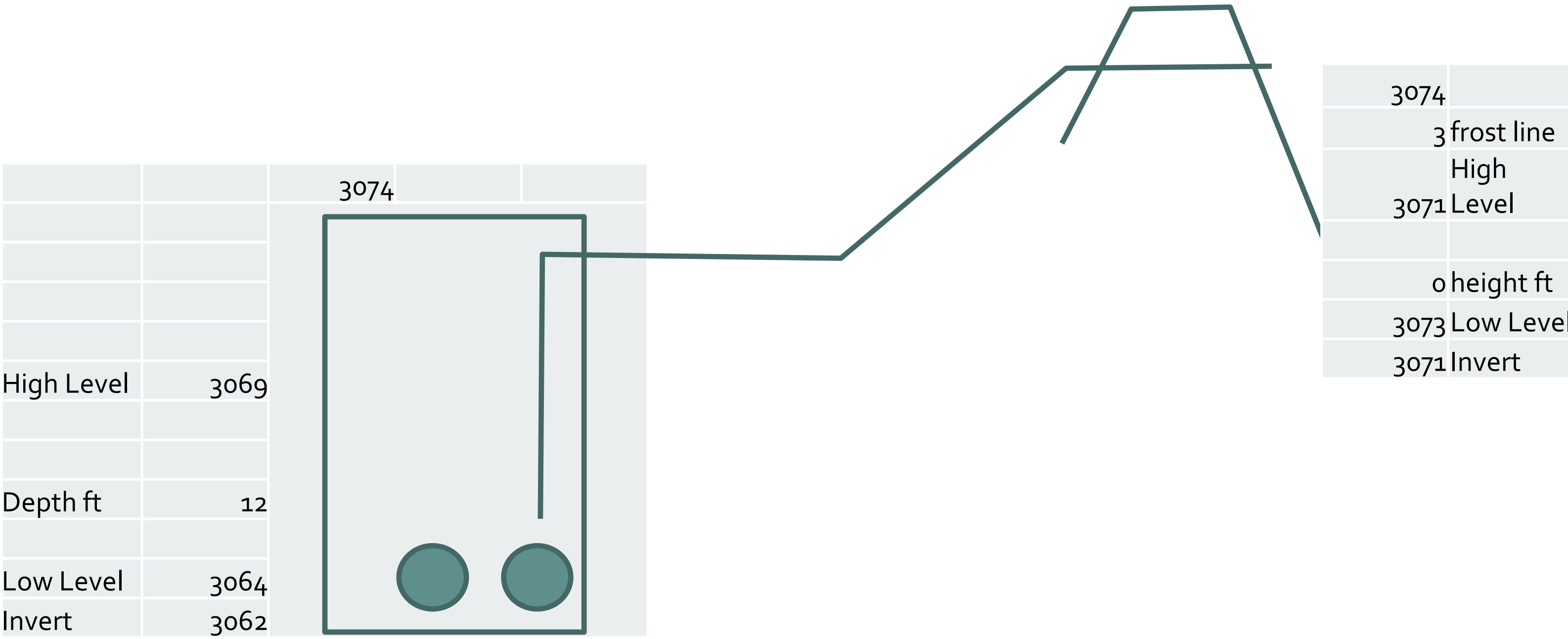
Flow

6.	ENTER THE FLOW INTERVALS TO BE USED ON THE X AXIS						
	FOR THE SYSTEM CURVE.						
		GPM					
		-					
	1	0					
	2	95					
	3	195					
	4	295		Enter flow for one pump range.			
	5	395		Enter flow for ideal operating point			
	6	495					
	7	595					
		100		Enter interval between x axis points			

Velocity Check (2 fps -10 fps)

	Trial & Error Velocity Check			
	Input			
A-->	2.5	fps		
	B	Diam.		If the velocity in the pipe is A, the flow in the pipe is B
	gpm	in.		
4	81	3.633	SUCTION	
6	176	5.348		
8	297	6.963		
3	49	2.825	DISCHARGE - EACH PUMP	
4	81	3.633		
6	176	5.348		
6	176	5.348	DISCHARGE - COMMON TO ALL PUMPS	
4	81	3.633		
8	297	6.963		
				A minimum of 2.0 fps should be provided at least once a cycle to
				keep solids moving in the pipelines

Sketch Your Head



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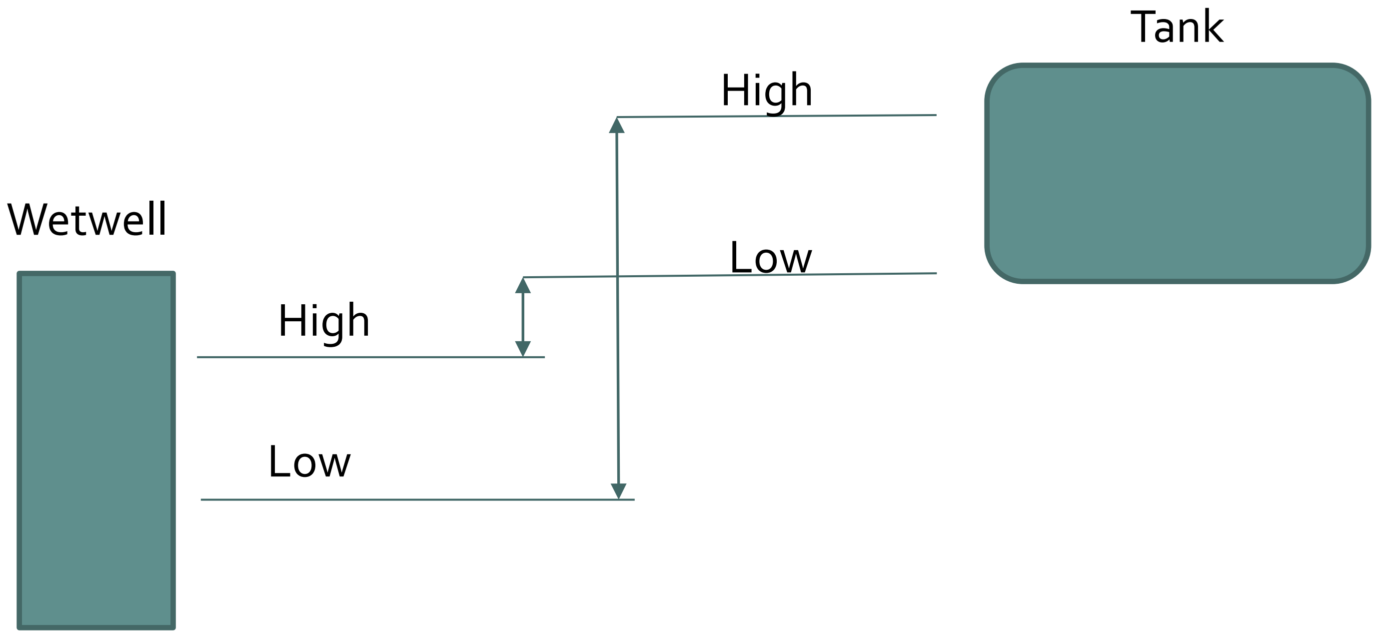
Head

	LOW	HIGH	STAT. SUCT. HEAD =			
Discharge	3071	3073	3064	low level in the wet well		
Wet Well	3064	3069	3063	centerline of pump		
	7	4	1			
			NPSH			

Static Head =	High	7	'
Static Head =	Low	4	'
		1	'
Temperature		70	degrees F
Elevation of Pump		3063	ft above sea level

High and Low Head

- High Wet Well/Low Tank Level
- Low Wet Well/High Tank Level



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Types of Head

- Elevation "I yam what I yam"
  - Centerline of Pump to Water Surface in Wet Well – Lift Required
- Vapor Pressure (-) in Pipe
  - Imagine Liquid wanting to evaporate in the pipe fighting back against suction
- Atmospheric Pressure (+)
  - Pushes down liquid into the pipe for an assist

- Net Positive Suction Head (NPSH)a

Factors of Net Positive Suction Head

Temp	Vapor					
;F	Press	VP	Elev.	Atm. Press.		AtmP
	psia	0.36	feet	psi		13.2
32	0.09		0	14.7		
40	0.12		500	14.43		
50	0.18		1000	14.2		Elev
60	0.26		2000	13.7		3063
70	0.36	Temp	3000	13.2		
80	0.51	70	4000	12.7		
90	0.7		5000	12.1		
100	0.95		6000	11.8		
110	1.27		7000	11.4		
120	1.69		8000	10.7		
130	2.22		9000	10.5		
140	2.89		10000	10.1		
150	3.72					
160	4.74					
170	5.99					
180	7.51					
190	9.34					
200	11.52					
212	14.7					

Done with Inputs - Time for Outputs

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SINGLE PUMP HAZEN - WILLIAMS FORMULA

ITEM : Leachate Pump No. 1 V= 1.318*C*(D/4)^0.63*((HI)l/L)^0.54 V Pres 0.36 psi

RUN : From Leachate Pond to Sewer Manhole No. 9 or (HI)l= 4.72*(Q/C)^1.85*D^-4.87*L Atm Pres 13.2 psi

PROJECT : Wayward Landfill Phase IV 2022

FILE : SYSTEMX V0.6 Wayward Landfill 2022 ^ |

	FLOW	FLOW	Diam.	C	L	Area	V	Hv	K's	(HI)l	(HI)k		Sludge System Losses TOTAL PIPE HI	THL	TDH	Water System Losses FLOW	TOTAL PIPE HI	THL	TDH	
	gpm	cfs	in.		ft	sf	fps			ft	ft		ft	ft	ft	gpm	ft	ft	ft	
	-------	------	------	-----	------	-------	------	------	------	------	------		------	------	-----	------	------	------	-----	
SUCTION																				
	395	0.880	0	140	0	0.00	0.00	0.00	0	0.00	0.00		0.00				0.00			
	395	0.880	0	140	0	0.00	0.00	0.00	0	0.00	0.00		0.00		NPSH(a)		0.00		NPSH(a)	
	395	0.880	6.963	140	8	0.26	3.33	0.17	3.3	0.05	0.57		0.63	0.63	30.03		0.61	0.61	30.04754	
													-----	-----						
DISCHARGE - EACH PUMP																				
	395	0.880	0	140	0	0.00	0.00	0.00	0	0.00	0.00		0.00				0.00			-
	395	0.880	0	140	0	0.00	0.00	0.00	0	0.00	0.00		0.00				0.00			
	395	0.880	5.348	140	5	0.16	5.64	0.49	3	0.10	1.48		1.62	1.62			1.59	1.59		
													-----	-----		395				
DISCHARGE - COMMON TO ALL PUMPS																				
	395	0.880	5.348	140	946	0.16	5.64	0.49	3.3	19.33	1.63		27.55				20.96			
	395	0.880	0	140	0	0.00	0.00	0.00	0	0.00	0.00		0.00				0.00			
	395	0.880	0	140	0	0.00	0.00	0.00	0	0.00	0.00		0.00	27.55			0.00	20.96		
													-----	-----	36.79	395			30.16	12.89
::															=====					

System Curve Data

GPM		FT				High	Low			SLUDGE SYSTEM CURVES			WATER SYSTEM CURVES		
FLOW		TDH	_			HPSHa	NPSH(a)		Low		High		Low		High
0		7	ONE	4		35.7	30.7	ONE	7.0		4.0		7.0		4.0
95		9.2		6.2		35.6	30.6		9.2		6.2		8.6		5.6
195		15.1	PUMP	12.1	^	35.5	30.5	PUMP	15.1		12.1		13.2		10.2
295		24.4	SYSTEM	21.4	|	35.3	30.3	SYSTEM	24.4		21.4		20.4		17.4
395		36.8	<-->	33.8	STATIC	35.0	30.0	<-->	36.8		33.8		30.2		27.2
495		52.2	STATIC	49.2	HEAD	34.7	29.7	STATIC	52.2		49.2		42.4		39.4
595		70.4	HEAD 1	67.4	2	34.2	29.2	HEAD 1	70.4		67.4		56.9		53.9

Summarize System Curves

- High Head Water Curve
- Low Head Water Curve
- High Head Sludge Curve
- Low Head Sludge Curve

Sludge vs Water

Pipe Friction Head Loss in Transportation of High-Concentration Sludge for Centralized Solids Treatment

Hisashi Murakami, Hideaki Katayama, Hidetsugu Matsuura

August 2016

Sludge Headloss

Solids concentration ranges between 2 and 5%.

Turbulent flow

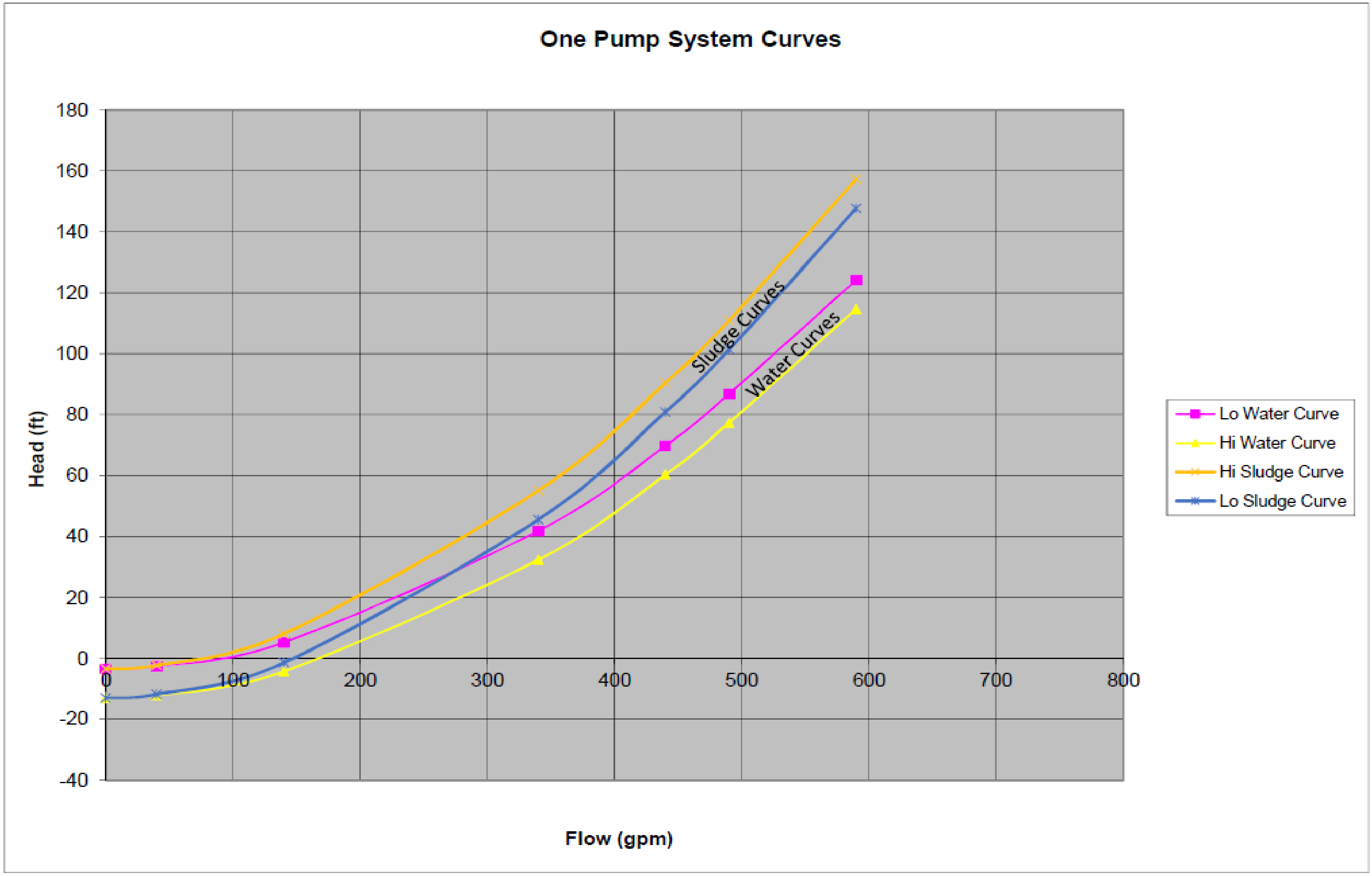
solids concentration, C,

$$H_f\,(\text{m}) = 9.06\left(\frac{1}{C_H}\right)^{1.93\times(1-C/100)} \frac{L}{D^{1.18}} V^{1.82}$$

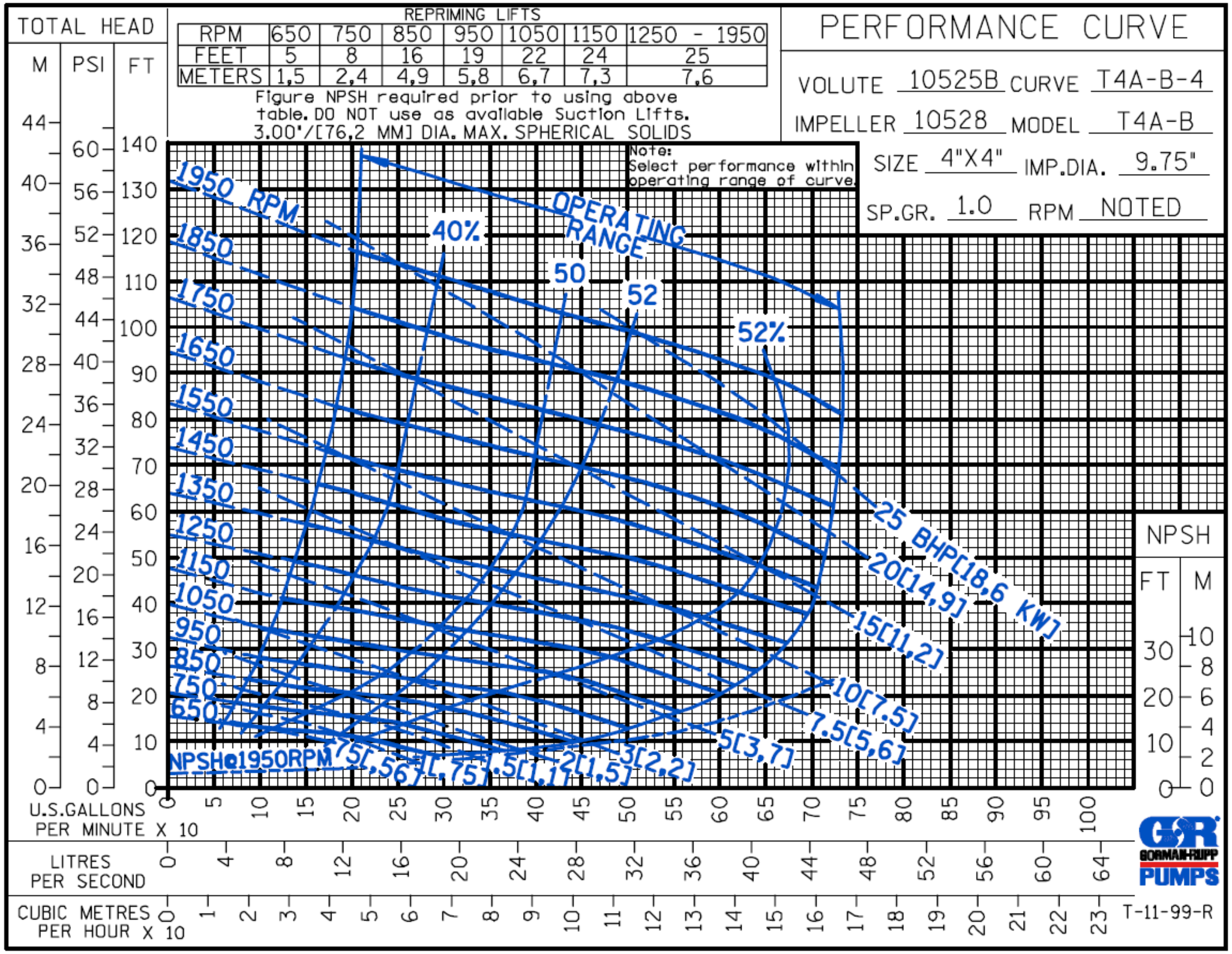
Δh = pipe friction head loss (m),
D = pipe diameter (m),
L = pipe length (m),
V = average velocity (m/s), and
g = gravitational acceleration (m/s^2).

C_H coefficient of the Hazen–Williams equation

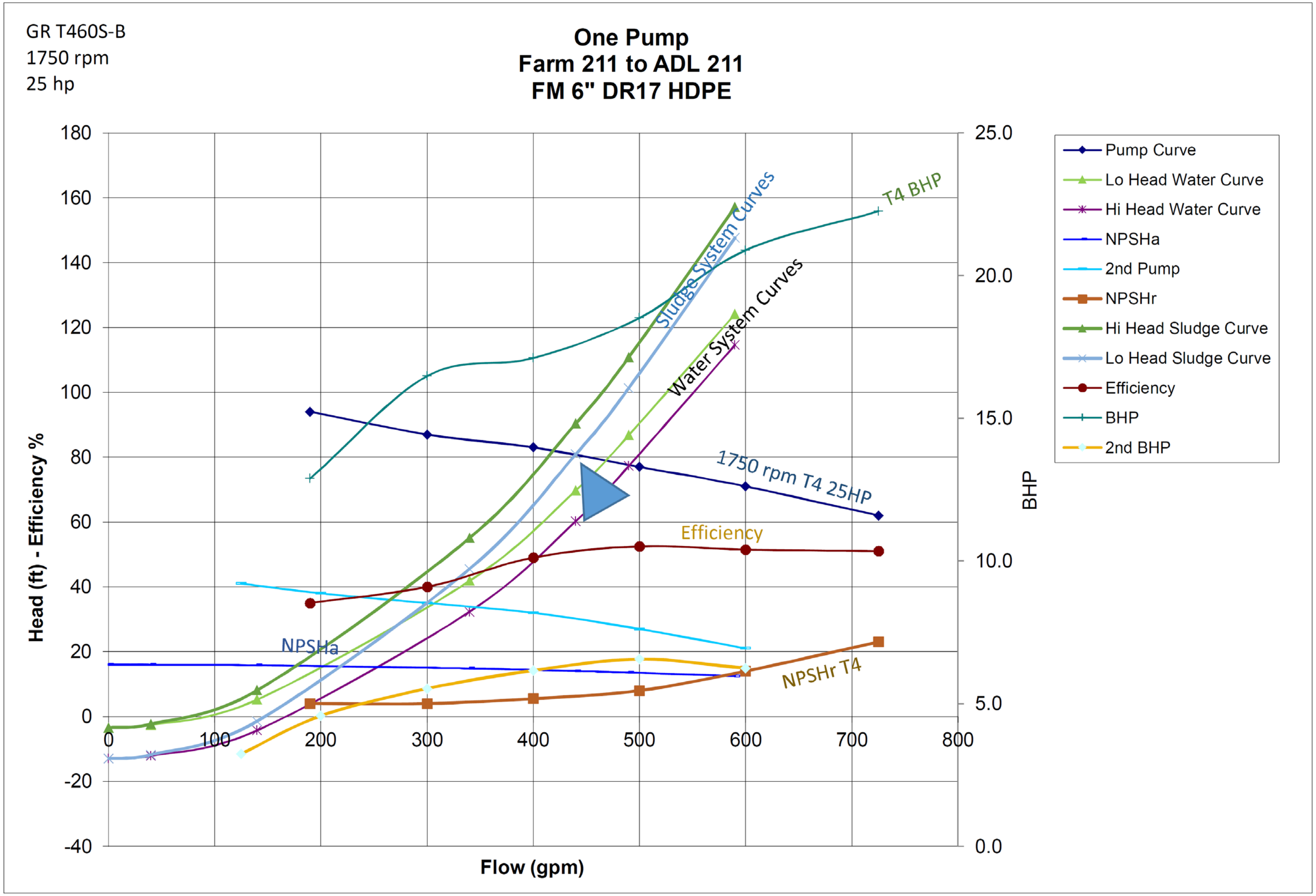
System Curves



Pump Curve from Manufacturer



Pump Curves



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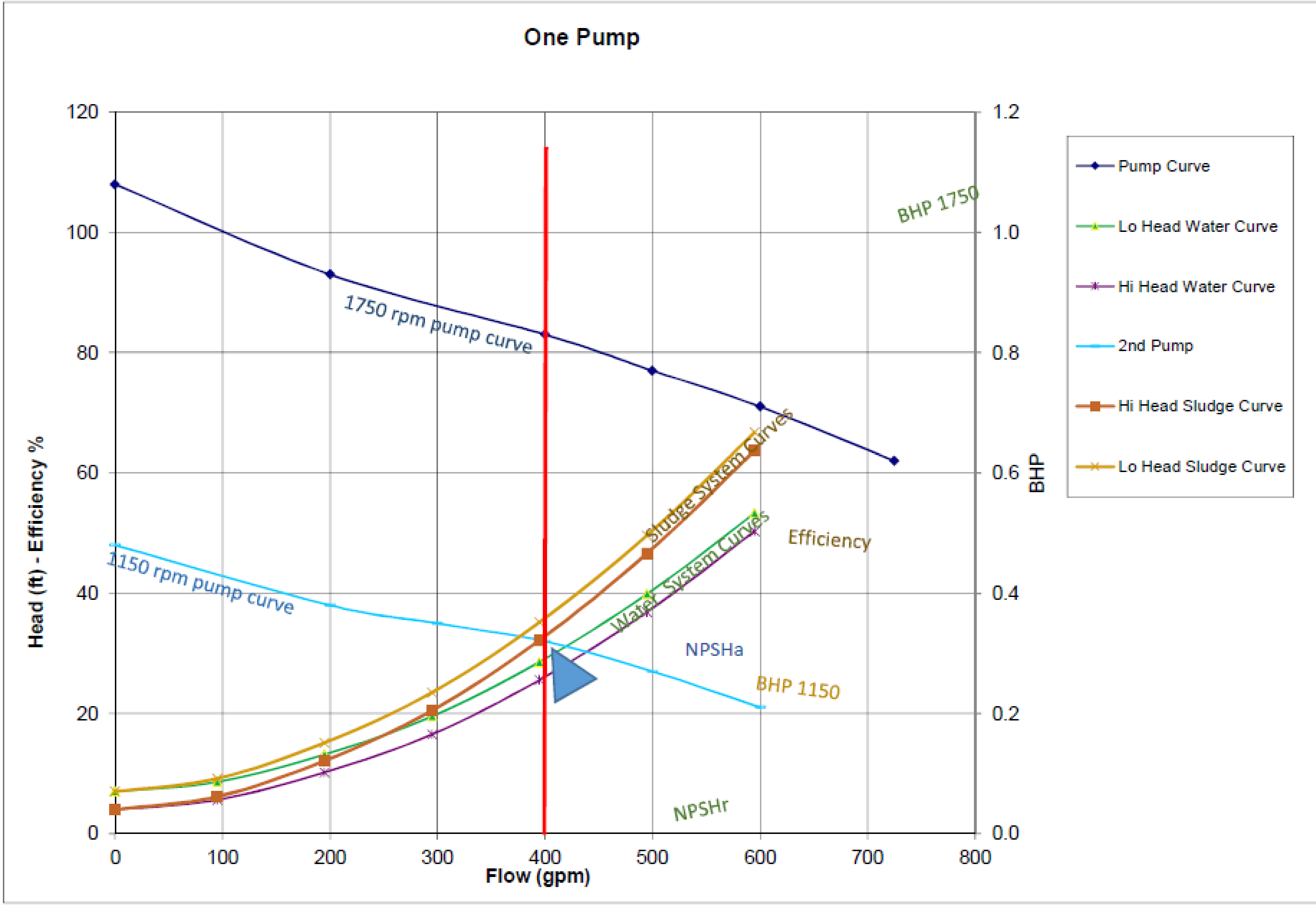
Pump Data

Leachate Pump No. 1			PUMP:					
From Leachate Pond to Sewer Manhole No. 9			SPEED:	1750				
Wayward Landfill Phase IV 2022								
DATE:	05/17/2022			NUMBER OF PUMPS =		2		
PUMP AND SYSTEM CURVES								
=	=	=	=	=	=			
GPM	HEAD		EFF	BHP		NPSH(r)		
FLOW	FT	1750	%	(calculated)		ft		Flow Range
0	108		10	5.2		3	Base Pump	0
200	93		45	10.4		4		95
400	83		50	16.8		8		195
500	77		52	18.7		10		295
600	71		52.5	20.5		14		395
725	62		51	22.3		21		495
		1150						595
0	48		10	2.3		0	Compariason Pump	
200	38		42	4.6		8	Shows up only on One Pump curve to compare to the Base Pump	
300	35		48	5.5		10.6		
400	32		52.5	6.2		12		
500	27		52	6.6		14.5		
600	21		51	6.2		16		



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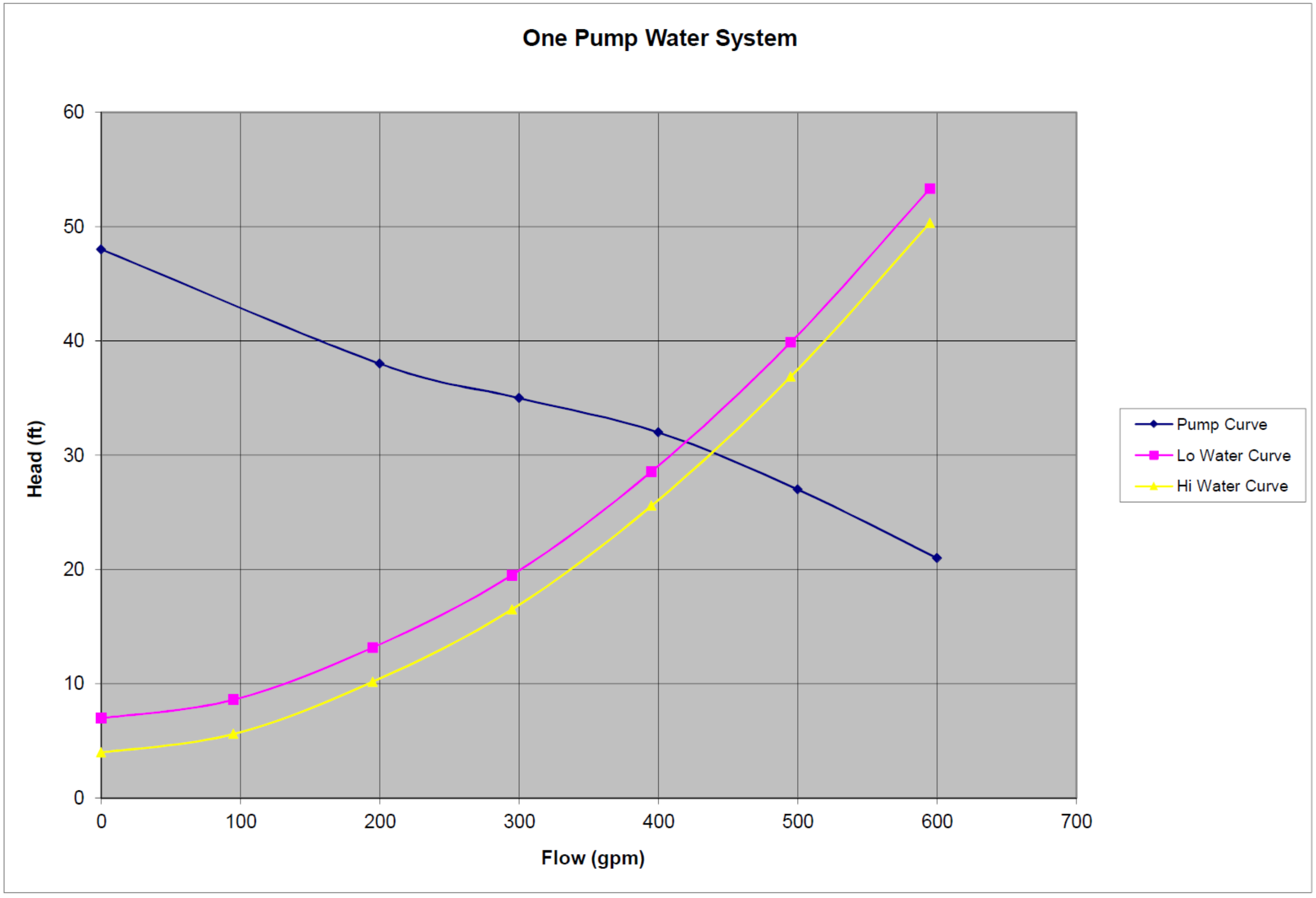
One Pump Water Curve

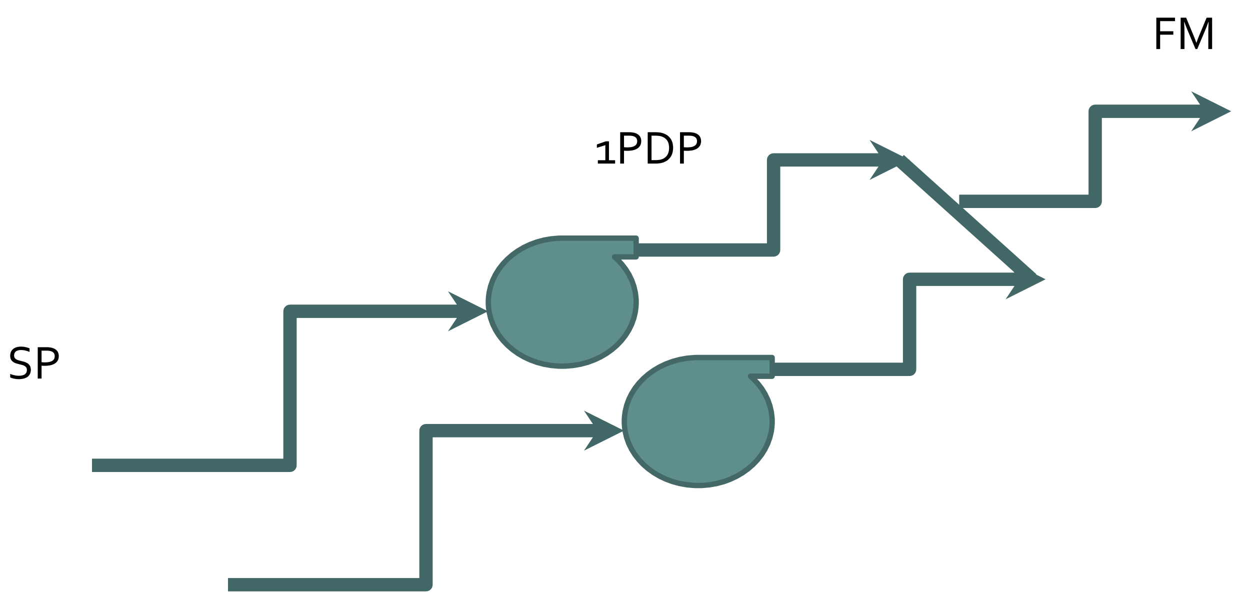


Multiple Pumps

	FLOW	FLOW	Diam.		L	Area	V
	gpm	cfs	in.	C	ft	sf	fps
	-------	------	------	-----	------	-------	------
395	GPM						
	SUCTION						
	395	0.880	3.633	140	0	0.07	0.00
	395	0.880	5.348	140	0	0.16	0.00
	395	0.880	6.963	140	8	0.26	3.33
	DISCHARGE - EACH PUMP						
	395	0.880	2.825	140	0	0.04	0.00
	395	0.880	3.633	140	0	0.07	0.00
	395	0.880	5.348	140	5	0.16	5.64
	DISCHARGE - COMMON TO ALL PUMPS						
	790	1.760	5.348	140	946	0.16	11.28
	790	1.760	3.633	140	0	0.07	0.00
	790	1.760	6.963	140	0	0.26	0.00

In System Curve Development There Is:

- Suction Piping
- One Pump Discharge Piping
- Force Main



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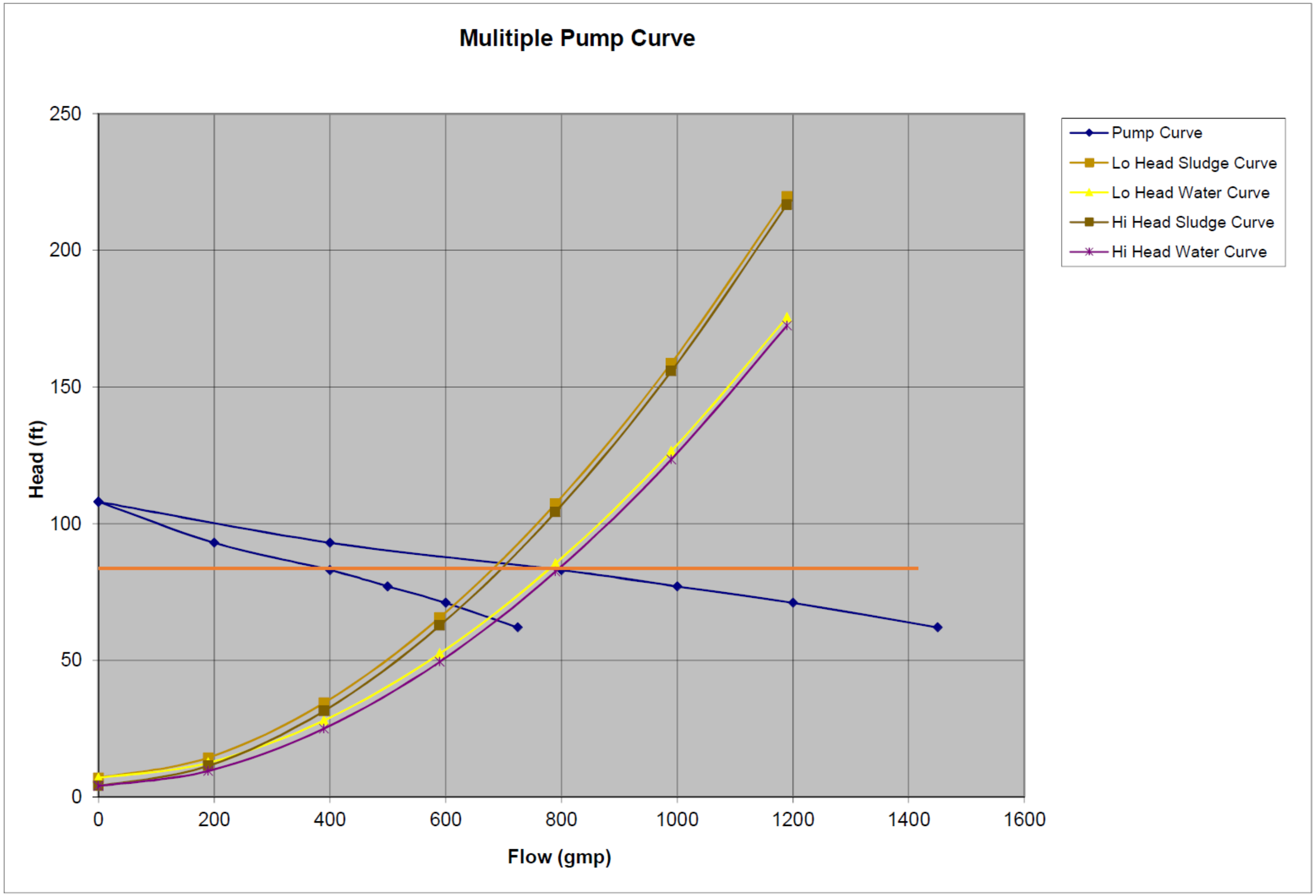
Multiple Pump Curve



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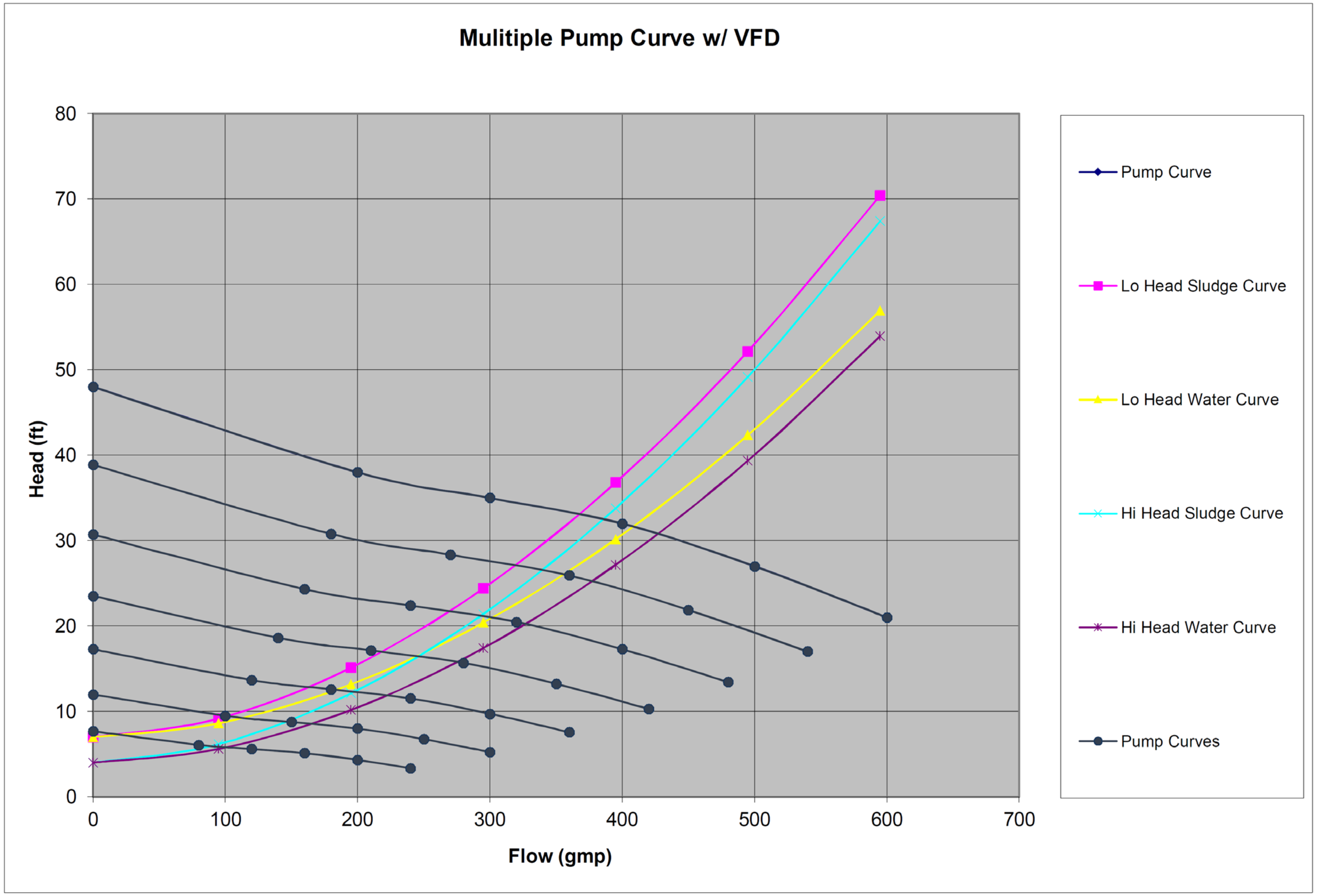
Consider All Possible Operating Conditions

- One Pump Operating Alone – How Often
- Multiple Pumps Operating Together – All the time?
- Larger Pump and Smaller Pump?

Variable Speed Pumping



Summary

- Define the System – Tell the Story
- Reliable Outputs
  - By the Numbers
    - Output
    - Mult
  - By the Figures
    - One Pump
    - 1PumpH2O
    - MultPmp
    - VFD

Wet Well Sizing

- Cycle Time
  - Fill Time
  - Pump Down Time
    - Output less Input
- 15 Minutes between Starts
- Motor Windings Heat Up (SPIKE) to Get the Motor Turning
    - Running the motor cools the windings
    - Pumped liquid in submersible pumps cools windings

Questions?