JLR No.: 27456-010
Revision: 1

July 20, 2021

Prepared for:

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Technical Summary Report

Gemmill's Bay SPS Twin Forcemain Upgrade

J.L.Richards
ENGINEERS · ARCHITECTS · PLANNERS

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1.0 Introduction

J.L. Richards & Associates Limited (JLR) was retained by the Municipality of Mississippi Mills (Municipality) to provide preliminary and detailed design services for modifications to the Gemmill's Bay Sewage Pumping Station (GBSPS) to increase the capacity and reduce infrequent sewage bypasses during wet weather events. As indicated in the JLR proposal dated April 13, 2020, the original vision for the project was to increase pumping capacity to match the ECA rated capacity using an existing secondary forcemain between the GBSPS and the Mississippi Mills Wastewater Treatment Plant (WWTP).

During the initial hydraulic assessment of the GBSPS it became evident that the pumping system may not be functioning as intended, with tested flow rates that do not align with published pump curves or theoretical system curves. Through discussions with the Municipality, the decision was made to put the current twinned forcemain upgrade project on hold in order to evaluate longer term solutions for the GBSPS.

The purpose of this Report is to summarize JLR's findings from the preliminary review and hydraulic assessment of the GBPSPS and WWTP and provide recommendations with the understanding that long-term wastewater infrastructure planning will be reviewed as part of future Master Plan updates.

1.1 Background

The Almonte Ward is the only area within the Municipality that is serviced by a communal wastewater system. The existing system was established in the 1960s and generally consists of 30 km of gravity sewers/ forcemains, several sub-area pumping stations, a main pumping station known as the GBSPS, and an extended aeration WWTP with tertiary treatment. The sewage collection system is owned and operated by the Municipality, while the Ontario Clean Water Agency (OCWA) is presently contracted to operate and maintain the pumping and treatment systems.

The WWTP and GBSPS operate in accordance with the Ministry of the Environment, Conservation and Parks (MECP) Environmental Compliance Approval (ECA) No. 2425-8DXR5U, dated February 16, 2011, which allows for an average day treatment capacity of 4,700 m^3/day and a peak treatment capacity of 14,100 m^3/day.

The Municipality recently updated the Almonte Ward Water and Wastewater Infrastructure Master Plan (JLR, February 2018), which noted raw sewage bypasses occurring at the GBSPS since 2012. The total duration of each bypass event is summarized in Table 1.

Table 1: Raw Sewage Bypasses at GSPS (2012 to October 2017)

Year	Number of Events	Total Duration (h)
2012	2	7.8
2013	1	3.0
2014	2	23.1

Year	Number of Events	Total Duration (h)
2015	1	1.5
2016	0	0.0
2017 (to Oct. 30)	8	155.3

In 2021, the Municipality completed Official Plan Amendment No. 22, Comprehensive Review – Addendum Almonte Settlement Area Boundary (JLR, April 2021), that proposes an expansion to the current Almonte ward urban boundary. This development area expansion would affect the existing wastewater collection and treatment systems that include GSPS and the WWTP and as a result, the Municipality is planning an update to the Water and Wastewater Masterplan anticipated in 2022.

2.0 Existing Systems

JLR commenced the preliminary design scope of work by completing an evaluation of the existing infrastructure both at the GBSPS and the WWTP. This included review of existing documentation, including drawings and the ECA as well as a site review of both sites.

2.1 GBSPS

All sewage generated in the Almonte Ward service area is ultimately conveyed to the GBSPS. The primary infrastructure of importance for this project at the GBSPS is summarized as follows:

- A manual 25 mm bar screen on the wet well inlet with high level bypass.
    - Three dry-pit submersible vertical centrifugal pumps each rated for 243 L/s at 33.7 m of Total Dynamic Head (TDH) in a dry well/ wet well configuration. *Note: existing documentation indicated pumps were rated for 163 L/s at 44.31 m TDH.*
- Three dampened swing check valves.
- Two forcemains (400 mm & 500 mm) approximately 1,325 m in length between the GBSPS and the WWTP, combining to a single 500 mm forcemain at the WWTP property limit.
    - *Note: The 400 mm forcemain is no longer in use.*

The firm pumping capacity remains unknown; however, the WWTP Design Report (TRG, 2010) lists a design capacity of 326 L/s, which appears to be the summation of two individual pumps each rated at 163 L/s.

2.2 WWTP

The WWTP headworks receives pumped wastewater flow directly from the GBSPS. The primary infrastructure of importance for this project at the WWTP is summarized as follows:

- Two parallel screen channels measuring 5,650 mm long, 600 mm to 915 mm wide and 1,400 mm deep.
- Two parallel, 6 mm fine screens, 1 duty, 1 standby each rated for a maximum flow capacity of 28,100 m^3/d (325 L/s).

- Two parallel vortex grit chambers rated for a maximum flow capacity of 28,100 m^3/d (325 L/s) complete with bypass sluice gates.
- Two 305 mm parshall flumes complete with level instruments for plant influent flow measurement.
- A 600 mm diameter overflow pipe that outlets to the peak flow attenuation pond.
- Conversion of a lagoon cell into a 94,000 m^3 peak flow attenuation pond.
- Two transfer pumps rated for 82 L/s at 9.29 m TDH to return the attenuated flow from the pond back to the WWTP headworks.

3.0 Hydraulic Assessment

JLR completed hydraulic assessments of both the GBSPS pumping system as well as the WWTP headworks with the purpose of quantifying increased flow potential and evaluating the affects on existing infrastructure at the WWTP.

3.1 Headworks Hydraulics

3.1.1 Process Arrangement

As indicated in the existing P&IDs (Appendix A) the existing WWTP is arranged such that all sewage discharged from the GBSPS must flow through the headworks process including screening and degritting. Following headworks, the primary flow path is through the splitter box to the anoxic tanks and the remainder of the WWTP. A 600 mm overflow pipe is included off the splitter box to direct excess flows to the peak flow attenuation pond.

The intent of the twin forcemain project was to increase sewage flows from the GBSPS, which would also include increased flows through the WWTP headworks. It was anticipated that this excess flow would then be directed to the peak flow attenuation pond through the existing overflow pipe.

3.1.2 Hydraulic Assessment

Appendix B shows the existing hydraulic gradeline, which identifies design liquid elevations at average day flow (4,700 m^3/d) and peak instantaneous flow (28,100 m^3/day). The target for the twin forcemain project was to achieve a raw sewage discharge of 325 L/s (28,100 m^3/d). JLR completed a hydraulic model of the headworks to compare against the original design documents. A summary of the modeled liquid elevations is provided in Table 2 below.

Table 2: WWTP Headworks Hydraulic Model Summary (28,100 m^3/d)

Location	Design Liquid Elevation (m)	Model Liquid Elevation (m)	Comments
Anoxic Zone	131.10	131.10	Starting elevation for analysis from existing drawings
Splitter Box	131.58	131.60	
Downstream of Parshall Flume	132.01	132.04	
Upstream of Parshall Flume / Downstream of Grit Tanks	132.26	132.26	

Location	Design Liquid Elevation (m)	Model Liquid Elevation (m)	Comments
Upstream of Grit Tanks / Downstream of Screens	132.27	132.30	Assumed minimal loss across grit tank
Upstream of Screens	132.47	132.50	Equipment supplier indicated 200 mm headloss @ 28,800 m^3/d

3.1.3 Conclusions

As shown in Table 2, the hydraulic model completed by JLR showed no significant discrepancies from the original design gradeline. Based on the hydraulic assessment, no hydraulic concerns are anticipated with discharging 28,100 m^3/d through the existing headworks process and to the peak flow attenuation pond.

3.2 GBSPS Hydraulics

The focus of the hydraulic assessment of the GBSPS was to evaluate potential flow rates that could be achieved through use of the existing 400 mm forcemain in parallel with the current operational 500 mm forcemain.

3.2.1 Existing Pumps

As indicated in Section 2.1 of this report, JLR identified discrepancies between existing P&ID (Appendix C) and the Supplier pump curve (Appendix D) regarding the rated capacities of the installed pumps. The factory acceptance test reports from pump Supplier confirmed that the rated capacity of the installed pumps matches the published pump curve. Test reports can be found in Appendix E.

3.2.2 System Curve

In order to evaluate the potential discharge capacity of the existing pumps within the GBSPS, JLR developed a theoretical system curve using fluid hydraulics principals. System curves were developed for both single (500 mm) forcemain operation as well as twin forcemain operation (400 mm & 500 mm). The system curves were based on the piping and forcemain arrangements found within the existing drawings including pipe lengths, fittings, valves, and starting & finishing liquid elevations.

A graphical representation of the system curves is included in Appendix F; however, a summary of critical information highlighting the effects of twinning the forcemain can be found in Table 3 below.

Table 3: System Curve Summary

Item	Single Forcemain	Twin Forcemain	Comments
Static Head	32.58 m	32.58 m	Elevation difference between peak flow at headworks and wet well
C-Value	110	110	Value used to fit system curve to pump testing data
TDH at 125 L/s	34.68 m	34.05 m	Tested flow from a single pump operation at 58 Hz

Item	Single Forcemain	Twin Forcemain	Comments
TDH at 175 L/s	36.51 m	35.17 m	Tested flow from 221 and 231 parallel pump operation at 58 Hz
TDH at 205 L/s	37.86 m	36.01 m	Tested flow from 222 and 231 parallel pump operation at 58 Hz
TDH at 230 L/s	39.12 m	36.78 m	Tested flow from 221 and 211 parallel pump operation at 58 Hz
TDH at 325 L/s	45.02 m	40.44 m	Target GBSPS capacity

3.2.3 OCWA Pump Testing

At the onset of the project OCWA indicated that flow testing had been completed at the GBSPS in 2018. Detailed documentation of the testing was not available; however, OCWA noted the following:

- Single pump operation (58 Hz): 210 L/s to 220 L/s
- Parallel pump operation (58 Hz): 245 L/s
- Operating pressure: 345 kPa (50 psi)

JLR reviewed the OCWA flow test data against the system curve and the pump curve and it was identified that the flow rates and operating pressure did not align with either curve.

3.2.4 Updated Pump Testing

Through discussion with the Municipality it was decided that new flow testing at the GBSPS would be completed to further evaluate the pumping system against the theoretical system curve and published pump curves.

OCWA was retained by the Municipality to complete flow and pressure data monitoring over a two (2) week period in order to capture typical operation of each pump. After the first week the check valves were cleaned to see if this would affect pump flow rates; however, the data showed no significant changes in pump discharge output.

At the end of the testing period parallel pump operation was monitored with each combination of the three (3) existing pumps. All pump flow testing was completed with pump speeds programmed at 58 Hz (97% pump speed).

WWTP influent flow rate was also monitored during the same time frame to compare to pump GBPSP flows; however, the resolution of the parshall flume data made it difficult to compare. Graphical representation of the flow testing results is included in Appendix G. A summary of the results is included in Table 4 below.

Table 4: JLR Flow Testing Results

Operation	Pump Flow (L/s)	Pump Pressure (psi)
Pump 221	130	50

Operation	Pump Flow (L/s)	Pump Pressure (psi)
Pump 222	120	50
Pump 231	125	50
Pump 221 & 222	225	55
Pump 221 & 231	175	55
Pump 222 & 231	205	55

The flow testing data was plotted against the system curve and the pump curve. It was noted that the flow data appeared to fit the theoretical system curve; however, the pump curves did not align with the flow test data.

3.2.5 Conclusions

As shown on the system curve graph in Appendix F, the pumps at the GBSPS appear to be operating significantly below their published pump curves. Based on the evaluation completed to date, it is difficult to concretely determine the reason for the reduced performance. The potential causes for the performance issues that were discussed with the Municipality include:

- Poor influent characteristics
- Rag build-up on pump impellers
- Impeller wear and/or damage

Further evaluation of the pump performance issues at the GBPS, including potential computational fluid dynamic (CFD) analysis of influent characteristics were discussed with the Municipality; however, it was determined that a short term solution may not be the most effective approach for upgrading the pump station based on the planned urban area settlement expansion.

4.0 Additional GBSPS Observations

Through the review of the GBSPS and discussions with OCWA and the Municipality, several other design and operational concerns were identified. These are briefly summarized below:

- Volume of screenings captured by the manual bar screen require frequent (almost daily) cleaning of the screen.
    - As a result of this, the bar screen is no longer cleaned and therefore provided minimal screenings removal
- The existing wet well configuration offers very little volume for the pumps and includes poor influent hydraulic characteristics
- Pump station was originally designed to operate on a constant level basis, however, due to operational constraints with pump operation below 55 Hz, the station is operated as a fill/ draw type system
    - This operation causes the existing pumps to start and stop frequently, increasing wear on the equipment
    - The GBSPS is the only source of sewage to the WWTP, resulting in a plug-flow type operation. This does not meet best practices for WWTP design and results in operational inefficiencies of the WWTP.

- The Municipality expressed concerns with the existing outdoor automatic transfer switch at the GBSPS.
- Existing electrical infrastructure is located within a sea can container adjacent to the GBSPS and has been noted to have poor ventilation and cooling for the electrical equipment.

5.0 Future Planning for GBSPS

5.1 Current GBSPS Concerns

As identified herein, several deficiencies with respect to both operational performance and capacity limitations have been identified.

The existing station appears to be experiencing hydraulic inefficiencies causing the pumps to operate significantly below their rated duty points. Theoretically, the use of the inactive 400 mm forcemain in combination with the active 500 mm forcemain would result in an increased flow capacity from the station, however, without with the hydraulic existing conditions the capacity increase is difficult to quantify.

In addition to the pump performance and capacity concerns, the Municipality identified several design and operational concerns that affect both the GBSPS and WWTP performance and reliability. These items would not have been addressed through the twinned forcemain project.

5.2 GBSPS Capacity Increase

As a result of the proposed expansion to the Almonte urban boundary, the Municipality is planning to commence an update to the Water and Wastewater Masterplan in 2022. It is expected that the proposed expansion will have significant impacts on the existing wastewater collection and treatment systems. The resulting impacts will likely increase flow to the WWTP beyond the current rated capacity of the GBSPS.

The GBSPS has already received a significant capacity upgrade to achieve the current design capacity of 325 L/s. In our opinion the GBSPS is not suitable for further capacity upgrade without extensive below grade structural work and a building expansion. The feasibility of an extensive upgrade to the GBSPS has not been reviewed in detail; however, the following items should be considered:

- Implementation of automatic screening system
- Expansion and rearrangement of wet well
- Expansion of the dry well
- Complete pump replacement with focus on achieving a continuous operation
- Building expansion
- Considerations to facilitate future pump removal
- Relocation of existing electrical equipment into the main SPS building
- Replacement of back-up generator

The works anticipated for further capacity upgrades at the existing GBSPS would require extensive modifications or complete replacement of nearly all critical infrastructure.

Furthermore, site constraints at the current SPS location may have a significant impact on the feasibility of such an upgrade. It is also noted that maintaining operation of the GBSPS through construction of an upgrade may require significant temporary bypass pumping.

5.3 Recommendation

Considering the operational concerns and apparent hydraulic inefficiencies of the GBSPS at the current design capacity, and the potential need for capacity upgrades in the near future, it is recommended that longer term solutions for raw sewage pumping be evaluated by the Municipality in lieu of investing in short term upgrades to the GBSPS.

Due to the extensive work and feasibility concerns associated with expansion of the existing GBSPS, it is recommended that the Municipality quantify the future growth projections and peak flow capacity anticipated as part of the 2022 Water and Wastewater Master Plan Update. The updated Master Plan can identify the corresponding Municipal Class Environmental Assessment required to evaluate and select the preferred SPS upgrade/construction option to service flows beyond a flow rate of 325 L/s (28,100 m^3/d).

This report has been prepared for the exclusive use of the Municipality, for the stated purpose, for the named facility. Its discussions and conclusions are summary in nature and cannot be properly used, interpreted or extended to other purposes without a detailed understanding and discussions with the client as to its mandated purpose, scope and limitations. This report was prepared for the sole benefit and use of the Municipality and may not be used or relied on by any other party without the express written consent of J.L. Richards & Associates Limited.

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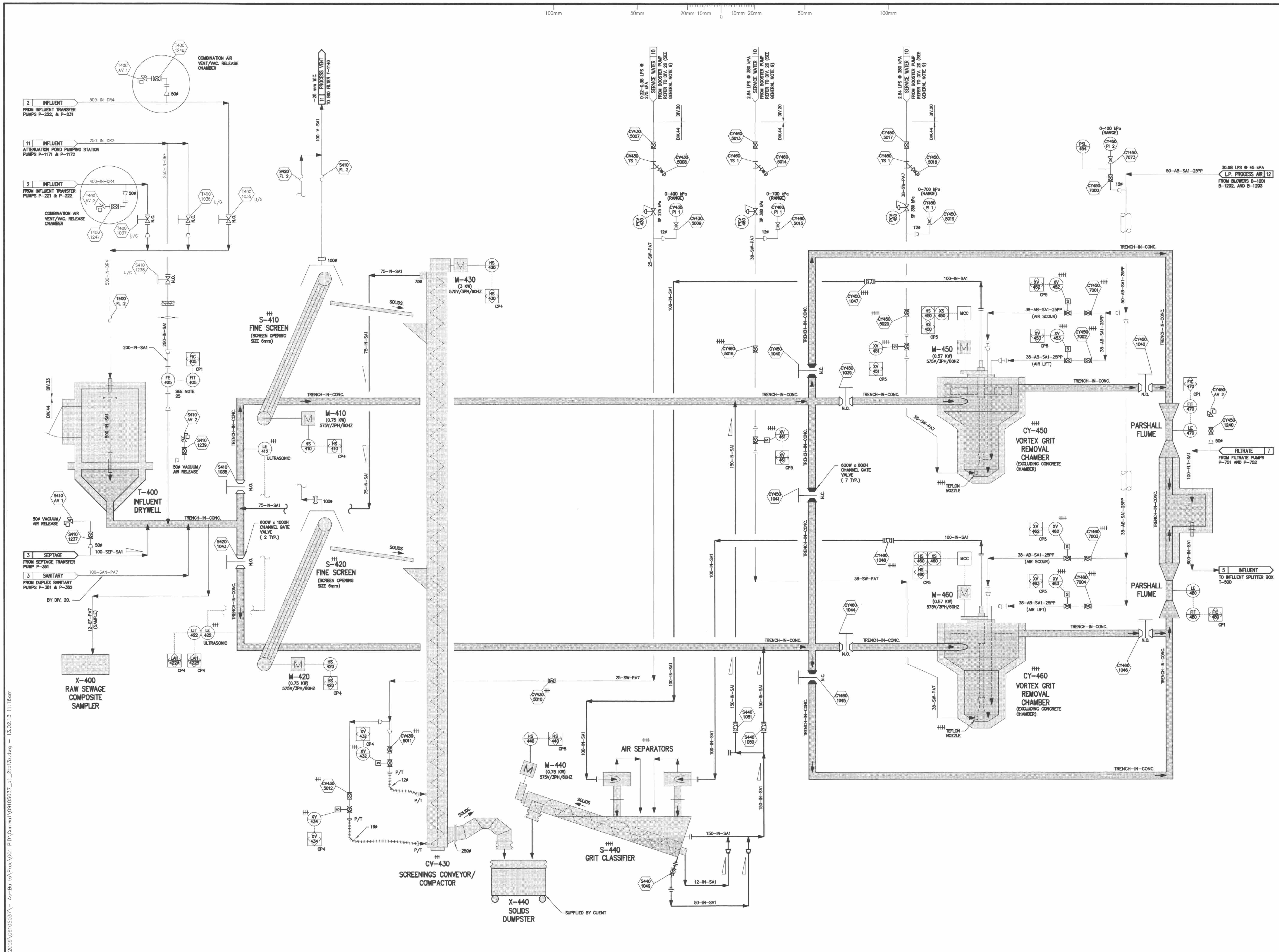
Appendix A

Existing WWTP P&IDs



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drawn by	GK	job no.	09105037
checked by		drawing no.	P1.4
approved by			
date	APR. 2010		

OWNER
TOWN OF MISSISSIPPI MILLS

PROJECT
MISSISSIPPI MILLS WASTEWATER TREATMENT PLANT
ALMONTE ONTARIO

TITLE
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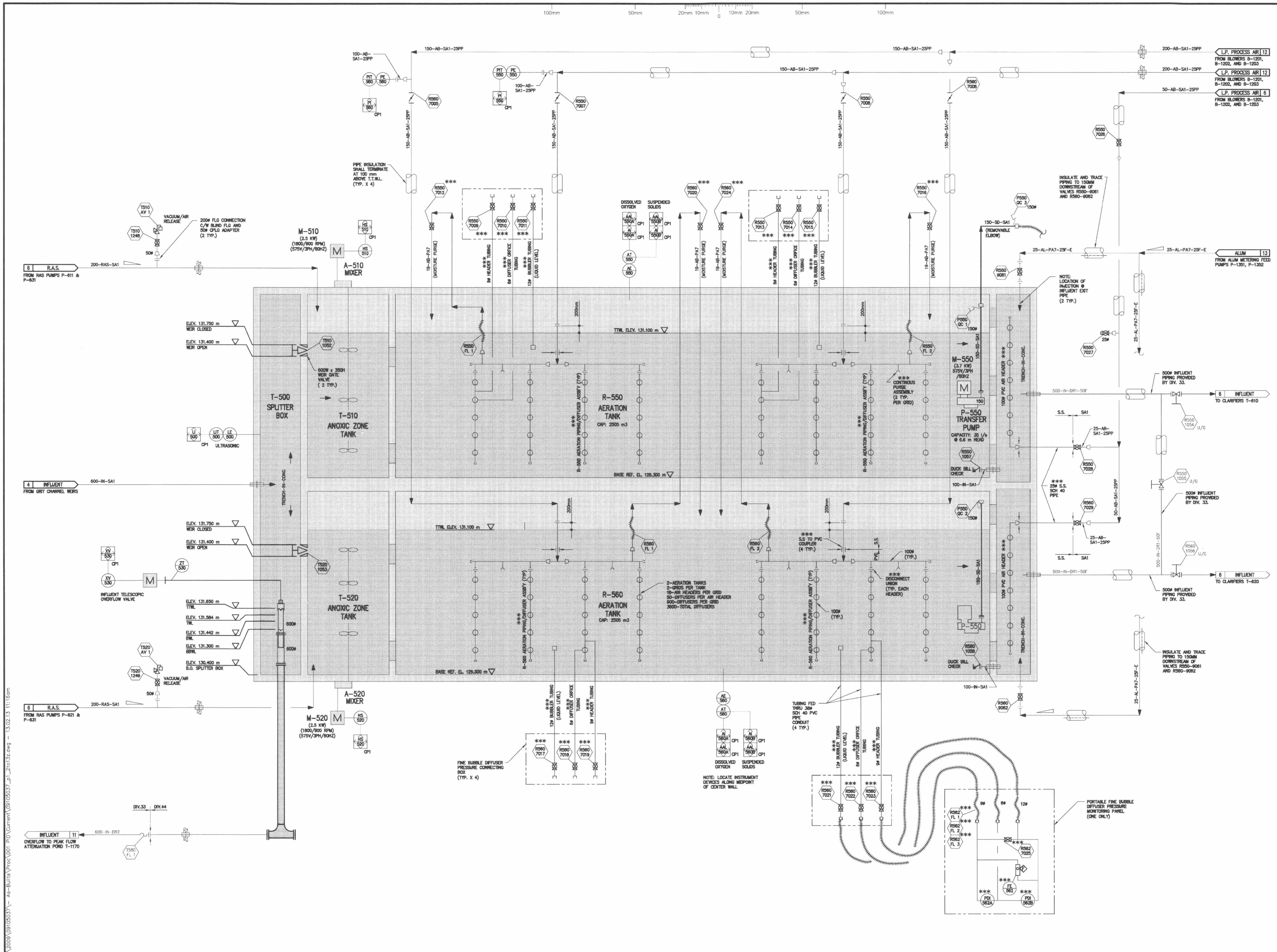

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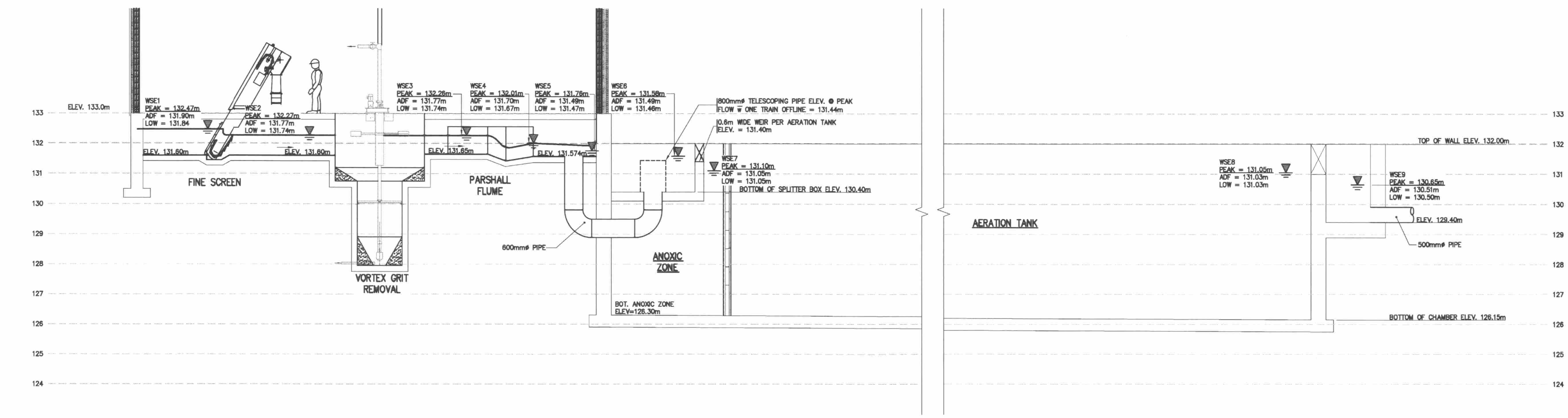
Appendix B

Existing WWTP Hydraulic Gradeline



PROFILE VIEW
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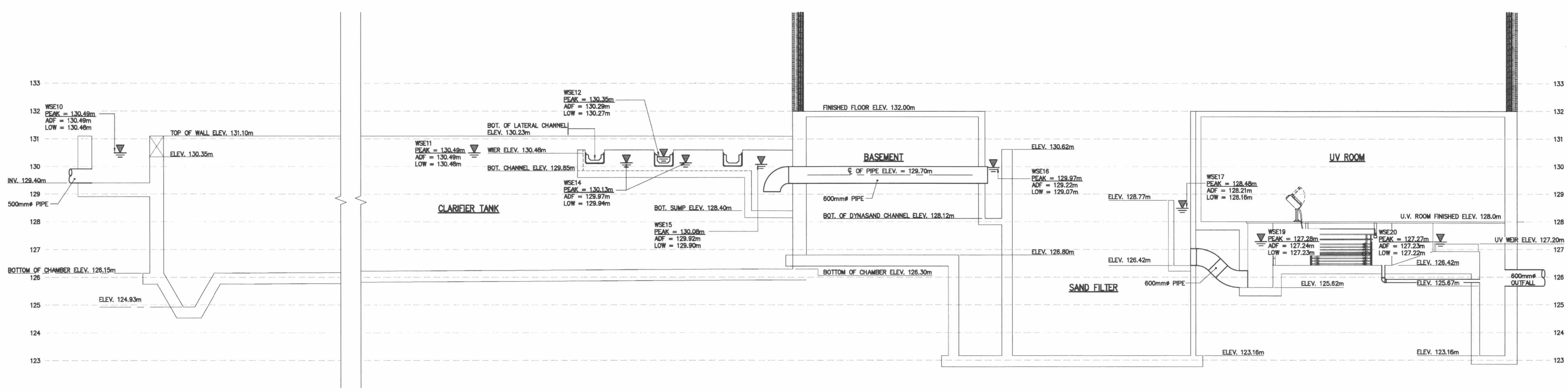

PROFILE VIEW
SCALE: 1:75

DATE	No.	REVISION
2011.01.21	4	REVISED FORCEMAIN ALIGNMENT
2010.06.10	3	ISSUED FOR CONSTRUCTION
2010.04.20	2	ISSUED FOR TENDER

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date	APR. 2010		

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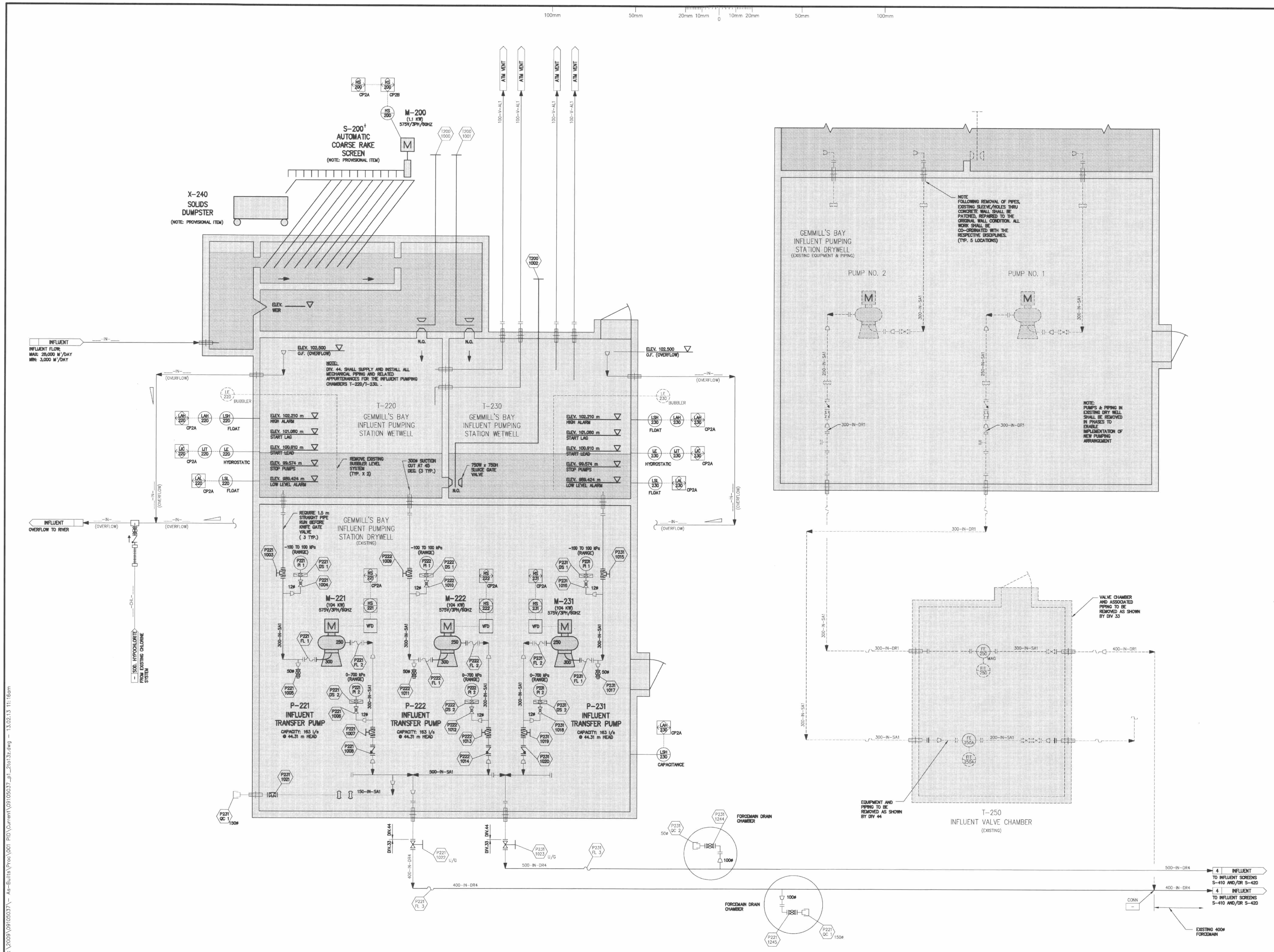
Appendix C

Existing GBSPS P&ID



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Appendix D

GBSPS Installed Pump Curve

FLYGT

Performance Curve

Product	Type
NP3315.180	MT

Date	Project	Curve No	Issue
2020-06-02		63-634-00-3130	2

	1/1-Load	3/4-Load	1/2-Load
Power Factor	0.79	0.74	0.62
Efficiency	92.5 %	93.0 %	92.5 %
Motor Data	---	---	---

Rated Power ...	140 hp (104.40 kW)	
Starting Current ...	905	A
Rated Current ...	137	A
Rated Speed ...	1185	rpm
Tot. Mom. of Inertia ...	3.0	kgm2
No. of Blades	3	

Impeller Diameter 447 mm

Motor #	Stator	Rev
35-45-6AA	04D	11

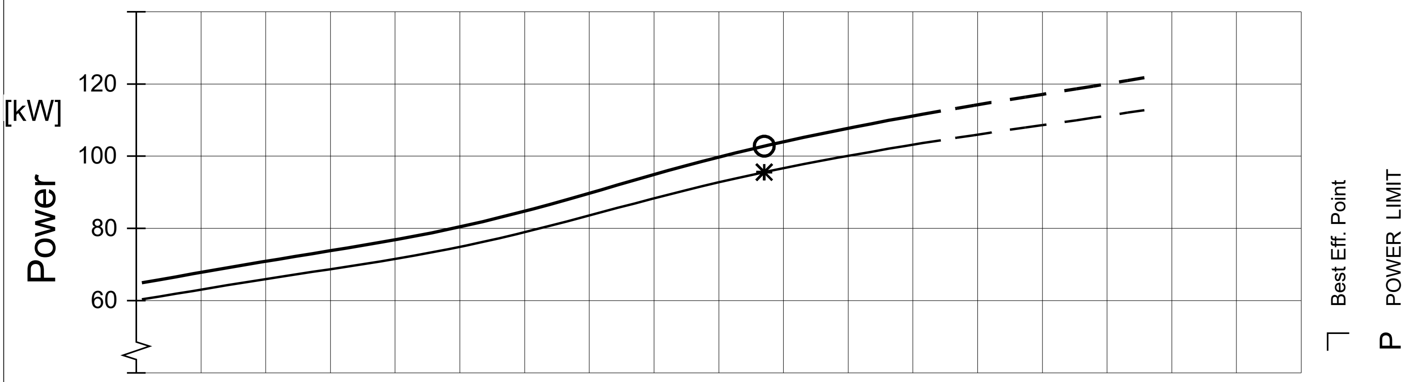
Freq.	Phases	Voltage	Poles
60 Hz	3	600 V	6

Geartype	Ratio
---	---

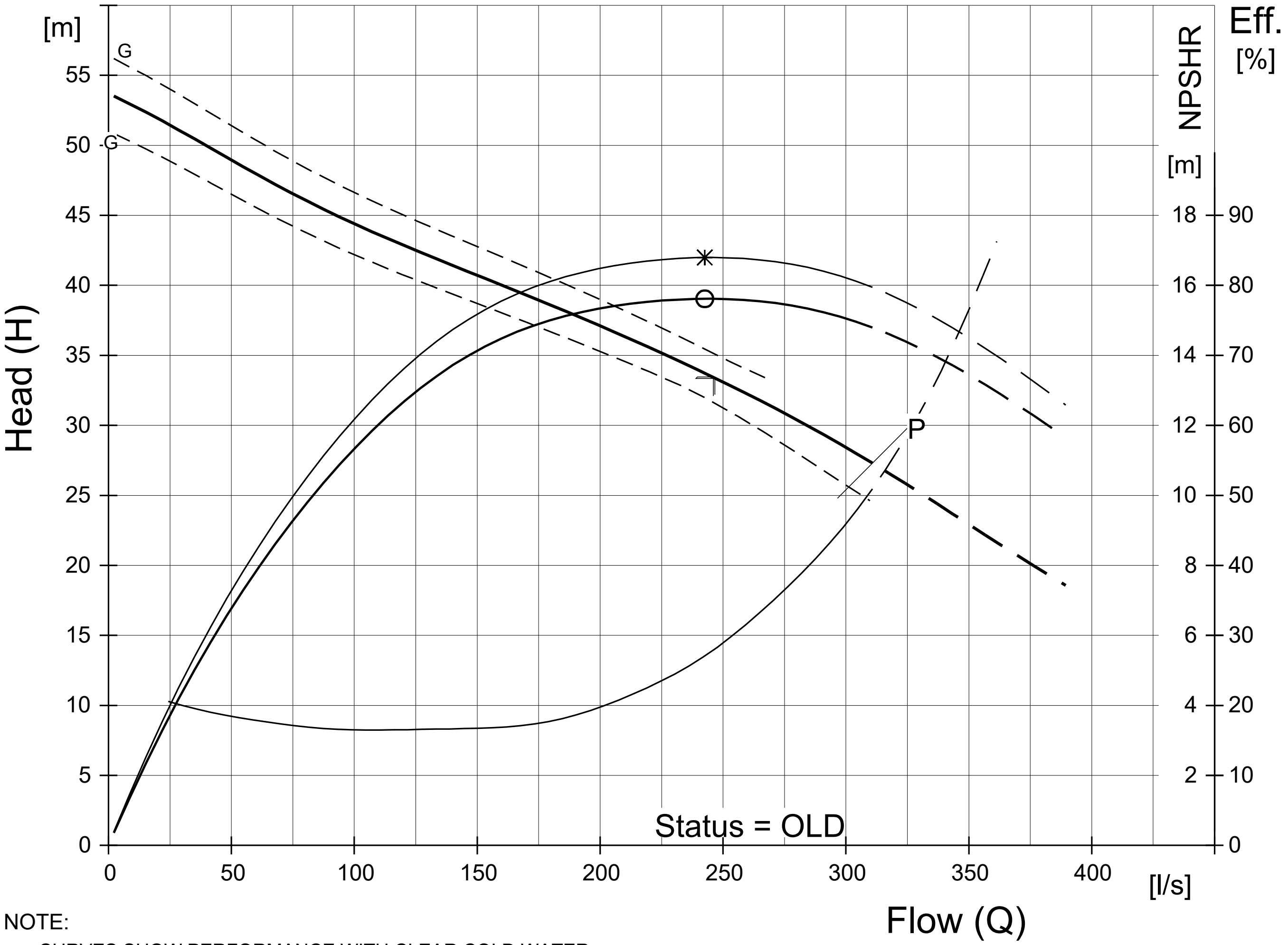
Comments

Inlet/Outlet -/250 mm

Imp. Throughlet ---



Duty-Point	Flow [l/s]	Head [m]	Power [kW]	Eff. [%]	NPSHR[m]
B.E.P.	243	33.7	103 (95.6)*	78.1 (84.0)*	5.5



unix AUTHOR: EMONDOU SACU (rev:8.1)

NOTE:

CURVES SHOW PERFORMANCE WITH CLEAR COLD WATER

* : Pump EFFICIENCY/Shaft POWER

O : Overall EFFICIENCY/Input POWER

NPSHR = NPSH3 + min. operational margin

Guarantee between limits (G) acc. to

ISO 9906:2012 & ANSI/HI 11.6:2012 / grade 2B-

Appendix E

GBSPS Pump Factory
Acceptance Test Reports

Test Report

Product

Serial no		Performance curve No.		Motor module/type	Voltage (V)
3315.180	**1120010**	**63-634-3130**		**134**	**600**
Base module	Impeller No	Impeller module	Motorcode	Imp.diam/Blade angle	Water temperature (°C)
032	**708 72 29**	**234**	**35-45-6AA**	**447**	**19.0**

Test Results

(Measuring values are test speed corrected, using the affinity laws, to nominal speed at 60.0 Hz.)

Pump total head H (m)	Volume rate of flow Q (l/s)	Motor input power P (kW)	Voltage U (V)	Current I (A)
52.18	**1.31**	**62.97**	**598.7**	**90.4**
47.44	**50.86**	**70.55**	**598.6**	**96.1**
44.29	**92.53**	**77.00**	**598.7**	**100.6**
39.48	**149.83**	**84.34**	**598.6**	**107.5**
36.17	**198.17**	**93.89**	**598.7**	**116.3**
32.56	**246.00**	**103.37**	**598.6**	**125.2**
29.73	**287.90**	**112.56**	**598.4**	**134.7**

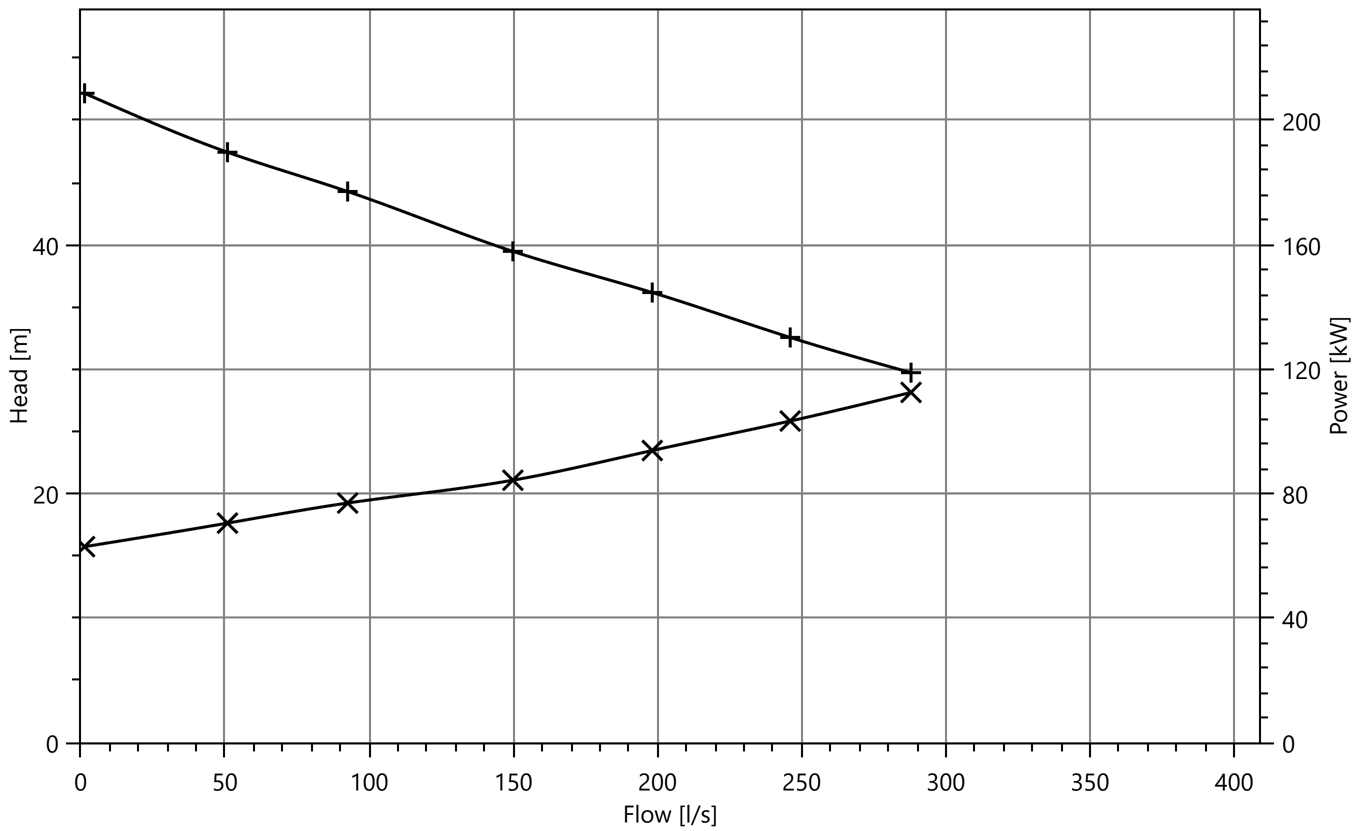
Accepted after	Test facility	Test date	Time	Chief tester
H.I. 11.6:2001 LEVEL A	Emmaboda, Sweden Q2	2011-03-09	15:40	2350

Plotted Test Results

Measured point: + = Q/H
× = Q/P

Calculated point: ◇ = Q/ETA overall

1



Test Report

Product

Serial no		Performance curve No.		Motor module/type	Voltage (V)
3315.180	**1120009**	**63-634-3130**		**134**	**600**
Base module	Impeller No	Impeller module	Motorcode	Imp.diam/Blade angle	Water temperature (°C)
032	**708 72 29**	**234**	**35-45-6AA**	**447**	**16.0**

Test Results

(Measuring values are test speed corrected, using the affinity laws, to nominal speed at 60.0 Hz.)

Pump total head H (m)	Volume rate of flow Q (l/s)	Motor input power P (kW)	Voltage U (V)	Current I (A)	Overall Efficiency η (%)
52.00	**1.30**	**66.88**	**598.7**	**91.3**	**1.0**
48.33	**46.05**	**71.28**	**598.7**	**96.6**	**30.6**
44.25	**95.00**	**77.98**	**598.8**	**101.3**	**52.9**
40.62	**139.26**	**83.61**	**598.8**	**106.8**	**66.4**
36.31	**201.36**	**95.83**	**598.5**	**118.1**	**74.8**
32.32	**253.22**	**106.33**	**598.8**	**127.9**	**75.5**
27.75	**305.41**	**116.20**	**598.0**	**137.9**	**71.6**

Duty Points, Required (Measured H and Q)					**Duty Points, Evaluated**				**Approved**
					Constructed		**Evaluated**		
H (m)	Q (l/s)	P (kW)	E (%)	Tolerance	H (m)	Q (l/s)	P (kW)	E (%)	Result
36.43 (35.76)	**209 (199.57)**	**0**	**0**	**HI/B**	**35.96**	**206.28**		**75.12**	**OK**

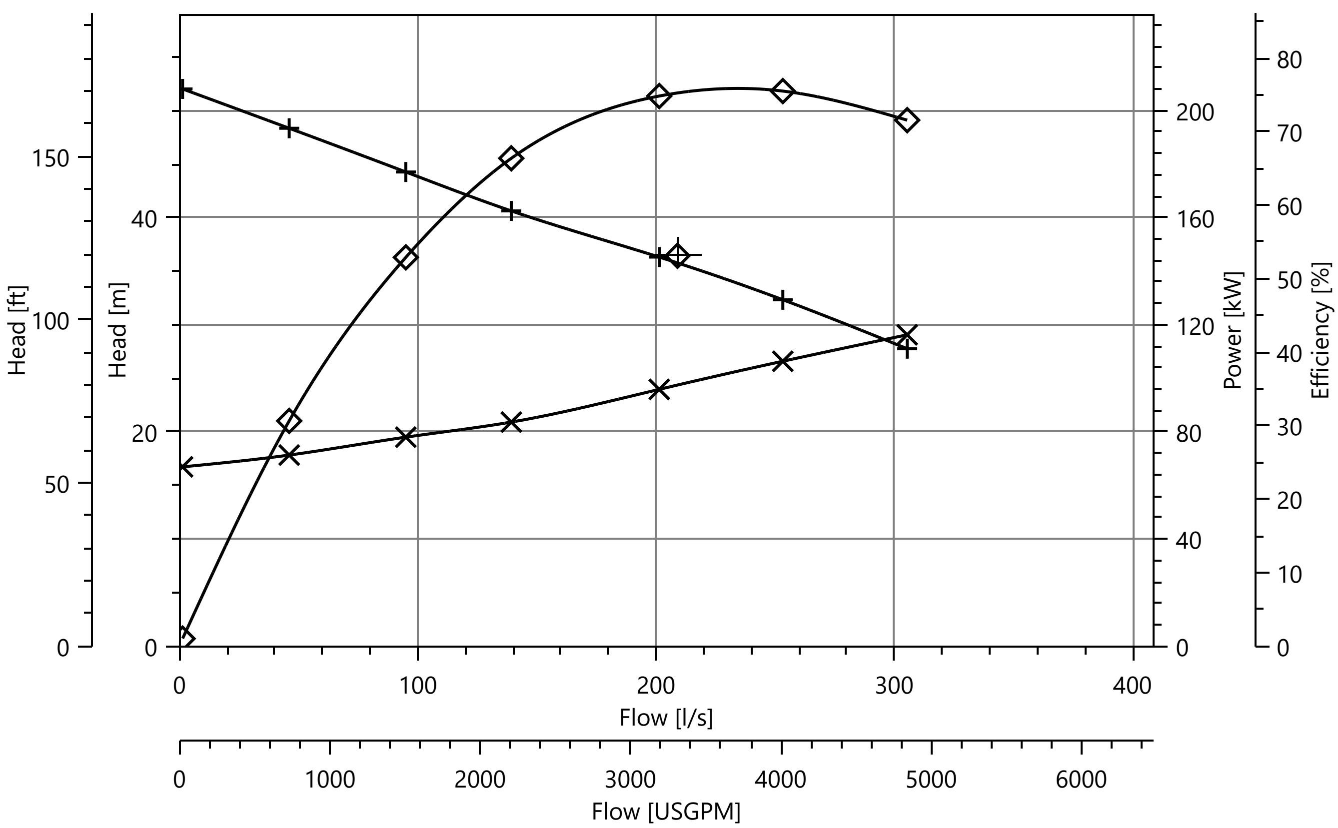
Accepted after	Test facility	Test date	Time	Chief tester
H.I. 11.6:2001 LEVEL B	Emmaboda, Sweden Q2	2011-03-04	10:20	2350

Plotted Test Results

Measured point: + = Q/H
× = Q/P

Calculated point: ◇ = Q/ETA overall

1



Test Report

Product

Serial no		Performance curve No.		Motor module/type	Voltage (V)
3315.180	**1120008**	**63-634-3130**		**134**	**600**
Base module	Impeller No	Impeller module	Motorcode	Imp.diam/Blade angle	Water temperature (°C)
032	**708 72 29**	**234**	**35-45-6AA**	**447**	**22.0**

Test Results

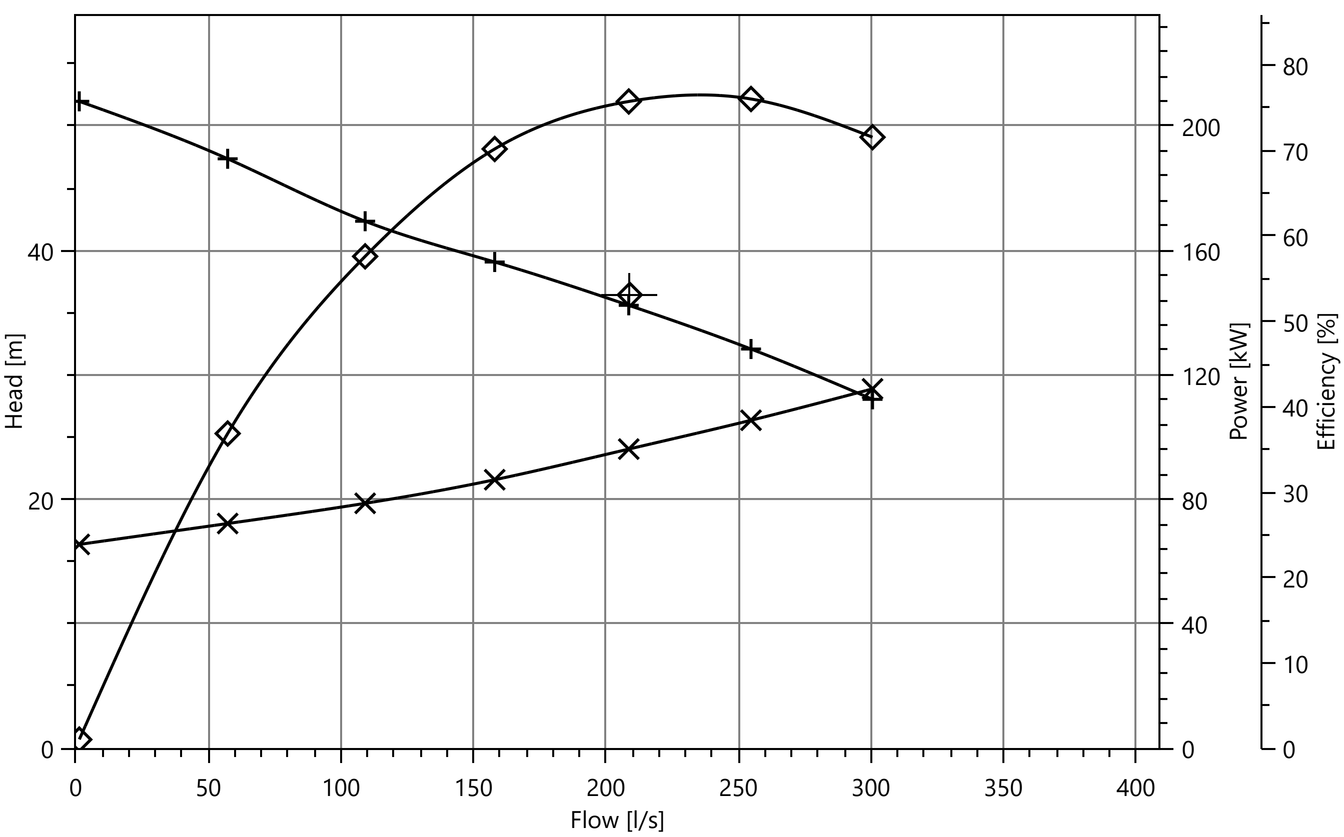
(Measuring values are test speed corrected, using the affinity laws, to nominal speed at 60.0 Hz.)

Pump total head H (m)	Volume rate of flow Q (l/s)	Motor input power P (kW)	Voltage U (V)	Current I (A)	Overall Efficiency η (%)
51.98	**1.30**	**65.50**	**599.1**	**90.5**	**1.0**
47.36	**57.29**	**72.22**	**598.6**	**95.7**	**36.9**
42.35	**109.16**	**78.71**	**598.7**	**102.3**	**57.6**
39.07	**158.03**	**86.29**	**598.7**	**108.5**	**70.2**
35.59	**208.61**	**96.15**	**598.5**	**118.1**	**75.8**
32.08	**254.74**	**105.41**	**598.4**	**126.6**	**76.0**
28.03	**300.58**	**115.50**	**598.0**	**136.7**	**71.6**

Duty Points, Required (Measured H and Q)					**Duty Points, Evaluated**				**Approved**
					Constructed		**Evaluated**		
H (m)	Q (l/s)	P (kW)	E (%)	Tolerance	H (m)	Q (l/s)	P (kW)	E (%)	Result
36.43 (35.56)	**209**	**0**	**0**	**HI/B**	**35.82**	**205.48**		**75.58**	**OK**

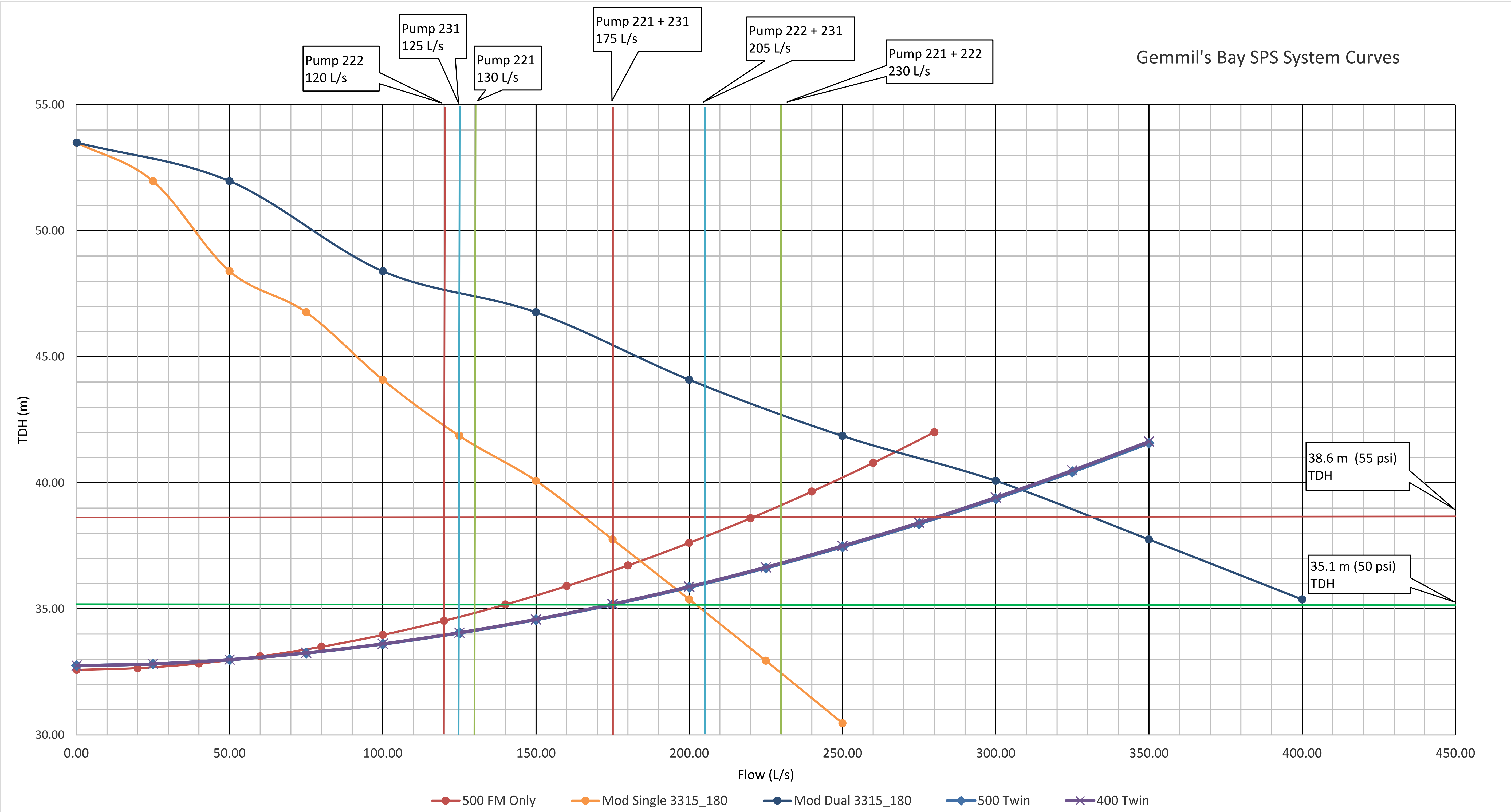
Accepted after	Test facility		Test date	Time	Chief tester
H.I. 11.6:2001 LEVEL B	Emmaboda, Sweden	Q2	2011-03-04	04:31	1517

Plotted Test Results Measured point: + = Q/H   Calculated point: ◇ = Q/ETA overall
× = Q/P   1



Appendix F

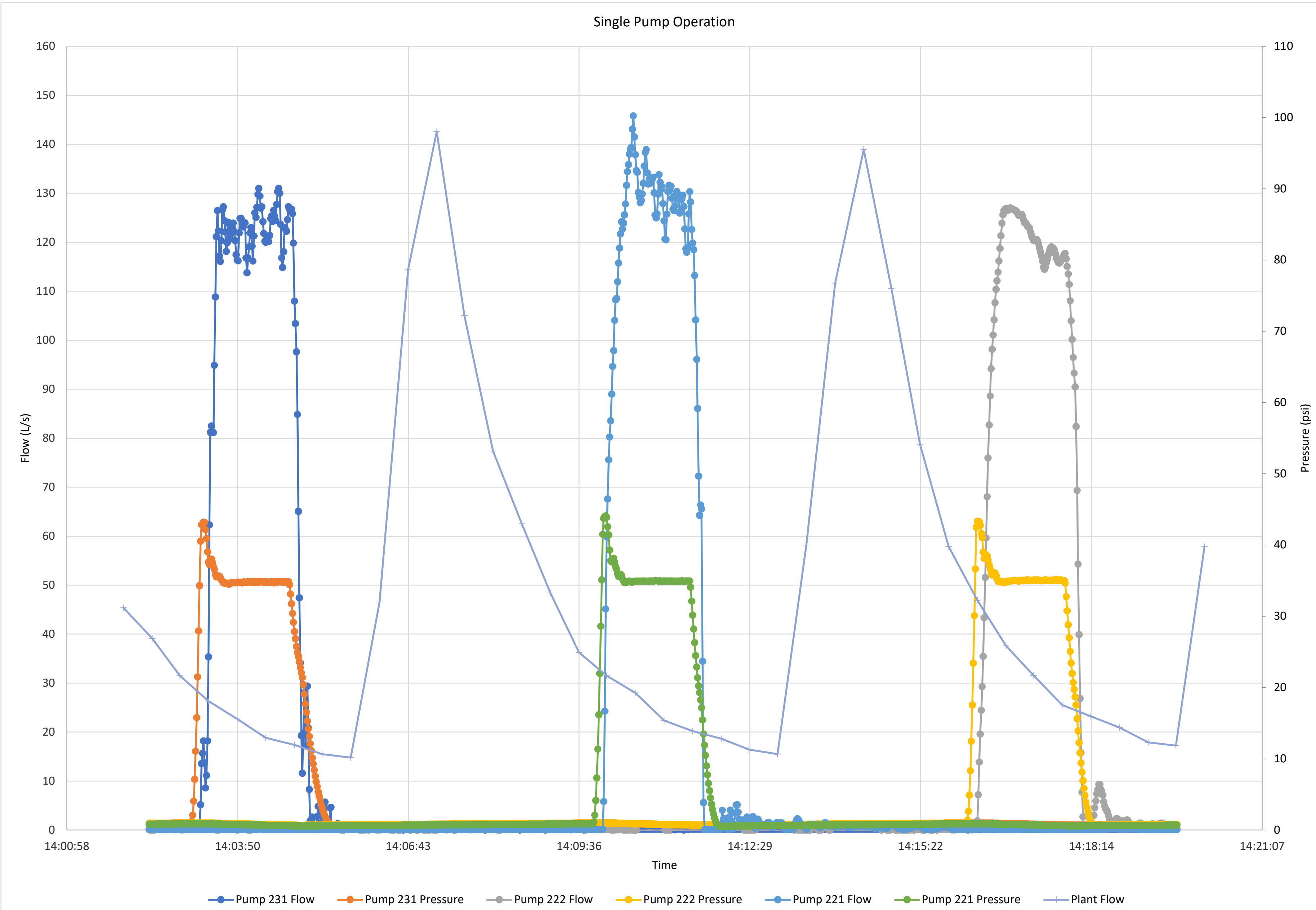
System Curves

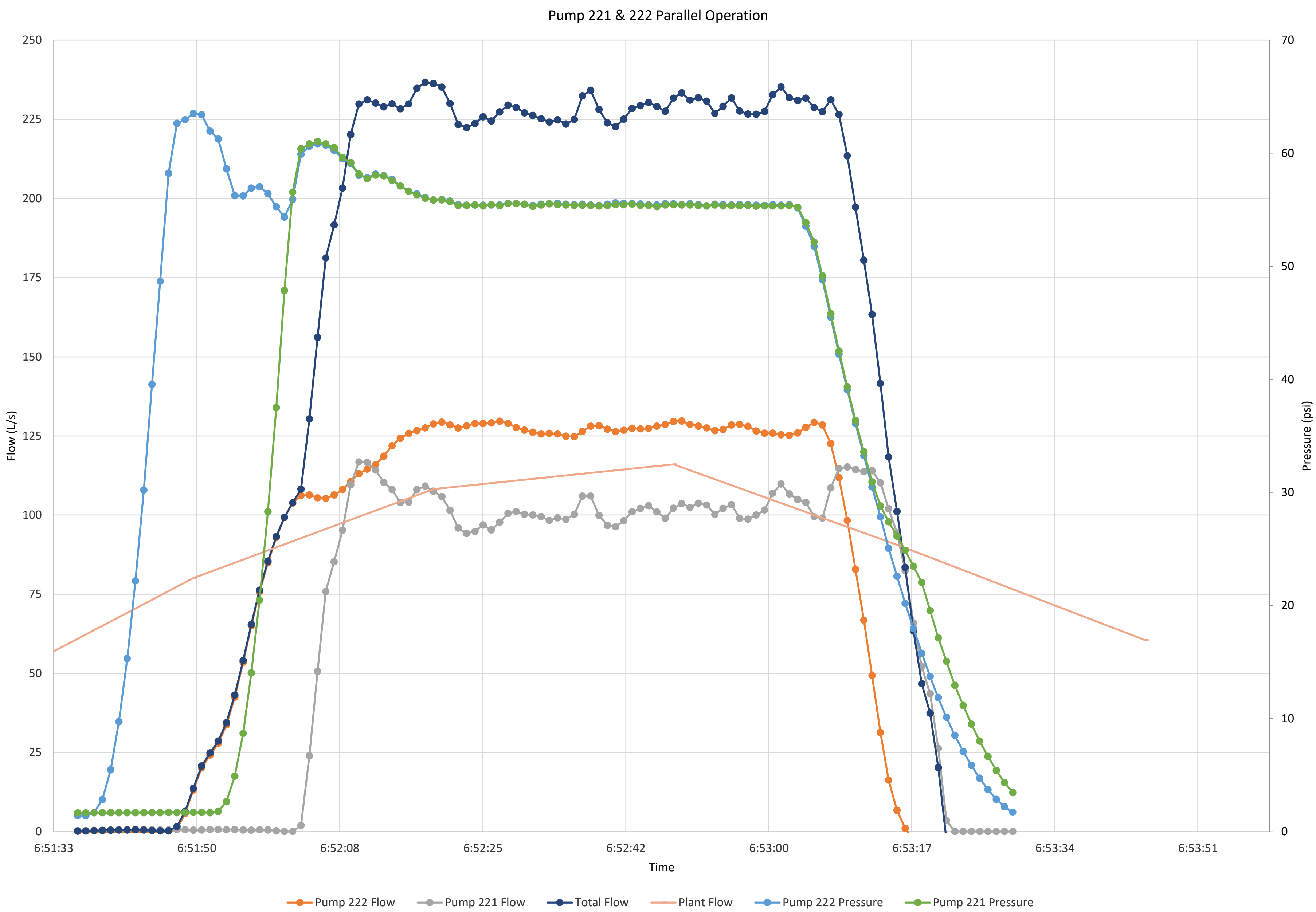


Gemmil's Bay SPS System Curves
Pump 222
120 L/s
Pump 231
125 L/s
Pump 221
130 L/s
Pump 221 + 231
175 L/s
Pump 222 + 231
205 L/s
Pump 221 + 222
230 L/s
38.6 m (55 psi)
TDH
35.1 m (50 psi)
TDH
TDH (m)
Flow (L/s)
55.00
50.00
45.00
40.00
35.00
30.00
0.00
50.00
100.00
150.00
200.00
250.00
300.00
350.00
400.00
450.00
500 FM Only
Mod Single 3315_180
Mod Dual 3315_180
500 Twin
400 Twin

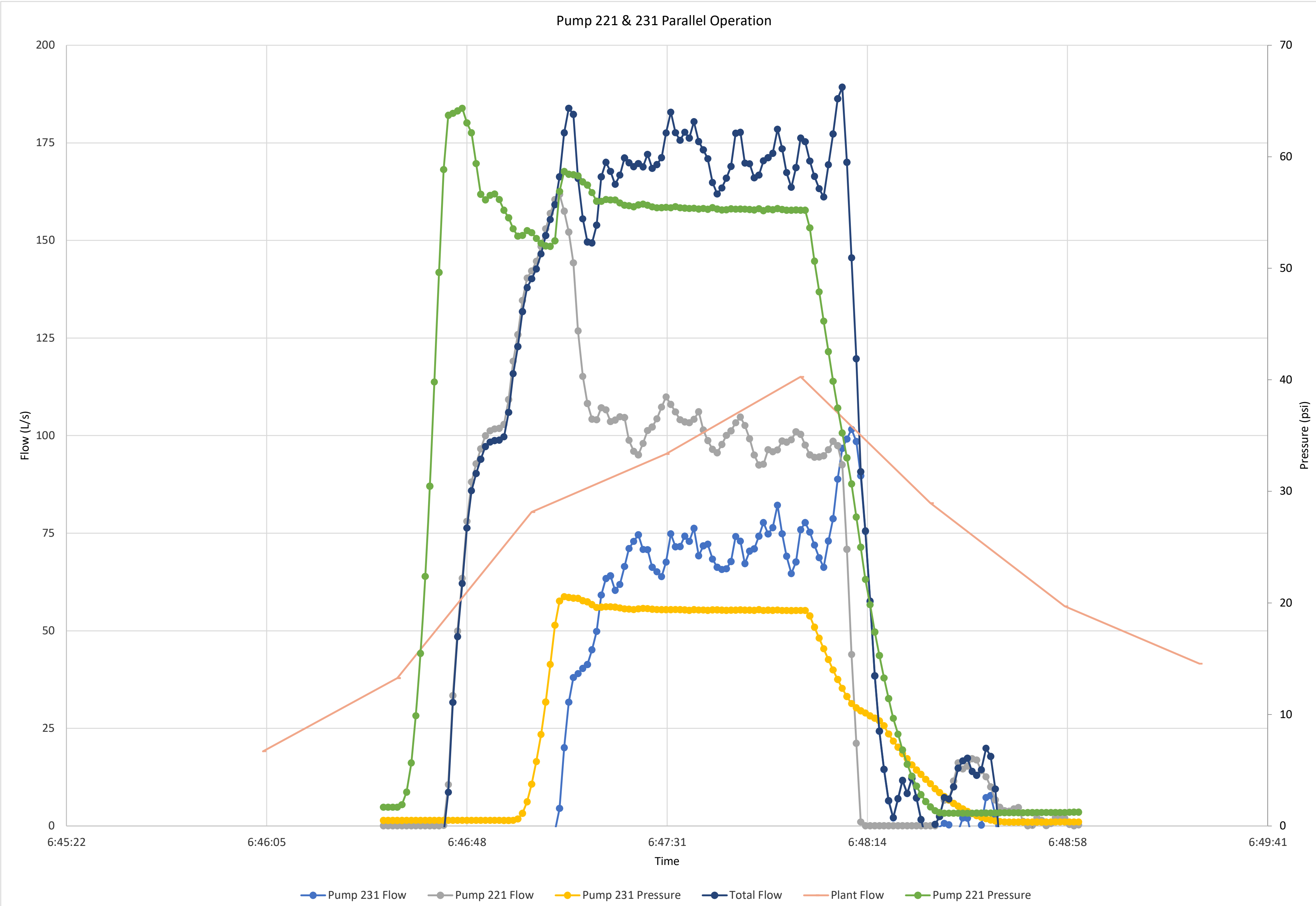
Appendix G

Flow Testing Results

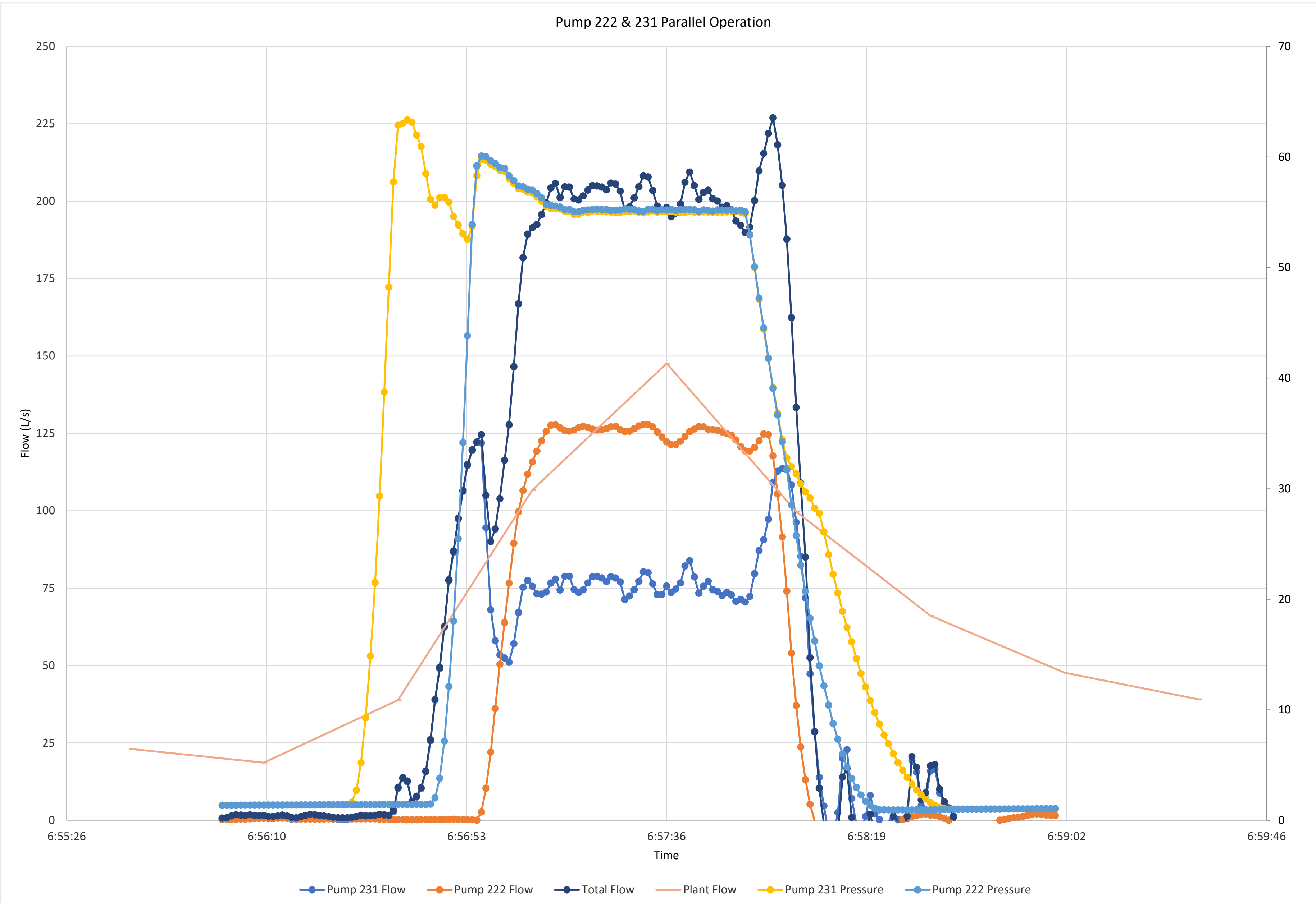

Single Pump Operation
Flow (L/s)
Pressure (psi)
Time
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
110
100
90
80
70
60
50
40
30
20
10
0
14:00:58
14:03:50
14:06:43
14:09:36
14:12:29
14:15:22
14:18:14
14:21:07
Pump 231 Flow
Pump 231 Pressure
Pump 222 Flow
Pump 222 Pressure
Pump 221 Flow
Pump 221 Pressure
Plant Flow



Pump 221 & 222 Parallel Operation
Flow (L/s)
Pressure (psi)
Time
0
25
50
75
100
125
150
175
200
225
250
0
10
20
30
40
50
60
70
6:51:33
6:51:50
6:52:08
6:52:25
6:52:42
6:53:00
6:53:17
6:53:34
6:53:51
Pump 222 Flow
Pump 221 Flow
Total Flow
Plant Flow
Pump 222 Pressure
Pump 221 Pressure



Pump 221 & 231 Parallel Operation
Flow (L/s)
200
175
150
125
100
75
50
25
0
Pressure (psi)
70
60
50
40
30
20
10
0
6:45:22
6:46:05
6:46:48
6:47:31
6:48:14
6:48:58
6:49:41
Time
Pump 231 Flow
Pump 221 Flow
Pump 231 Pressure
Total Flow
Plant Flow
Pump 221 Pressure



Pump 222 & 231 Parallel Operation
Flow (L/s)
250
225
200
175
150
125
100
75
50
25
0
70
60
50
40
30
20
10
0
6:55:26
6:56:10
6:56:53
6:57:36
6:58:19
6:59:02
6:59:46
Time
Pump 231 Flow
Pump 222 Flow
Total Flow
Plant Flow
Pump 231 Pressure
Pump 222 Pressure

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