



ATTACHMENT 20

LTWP Detailed Design Report - Appendix E - Pump Calculations

Appendix E

Pump Calculations

City of Iqaluit - Raw Water Pumping Station

1.0 Design Criteria

To meet the projected population growth to year 2050 it is anticipated that an additional **1,824,500 m³** of raw water is required. (RFP, page 8 of 66)

Water is expected to be continuously pumped during the unnamed Lake Open-Water season .

To satisfy the raw water pipeline hydraulic requirements set the pumping capacity = **556.0 L/s** = 8813.00 GPM

If pumps run for 30 days in June the volume of water taking = 30 days x 86,400 seconds/day = 2,592,000 seconds

At a pump rate of 556 L/s the volume of water that can be pumped in 30 days = 1,441,152 m³

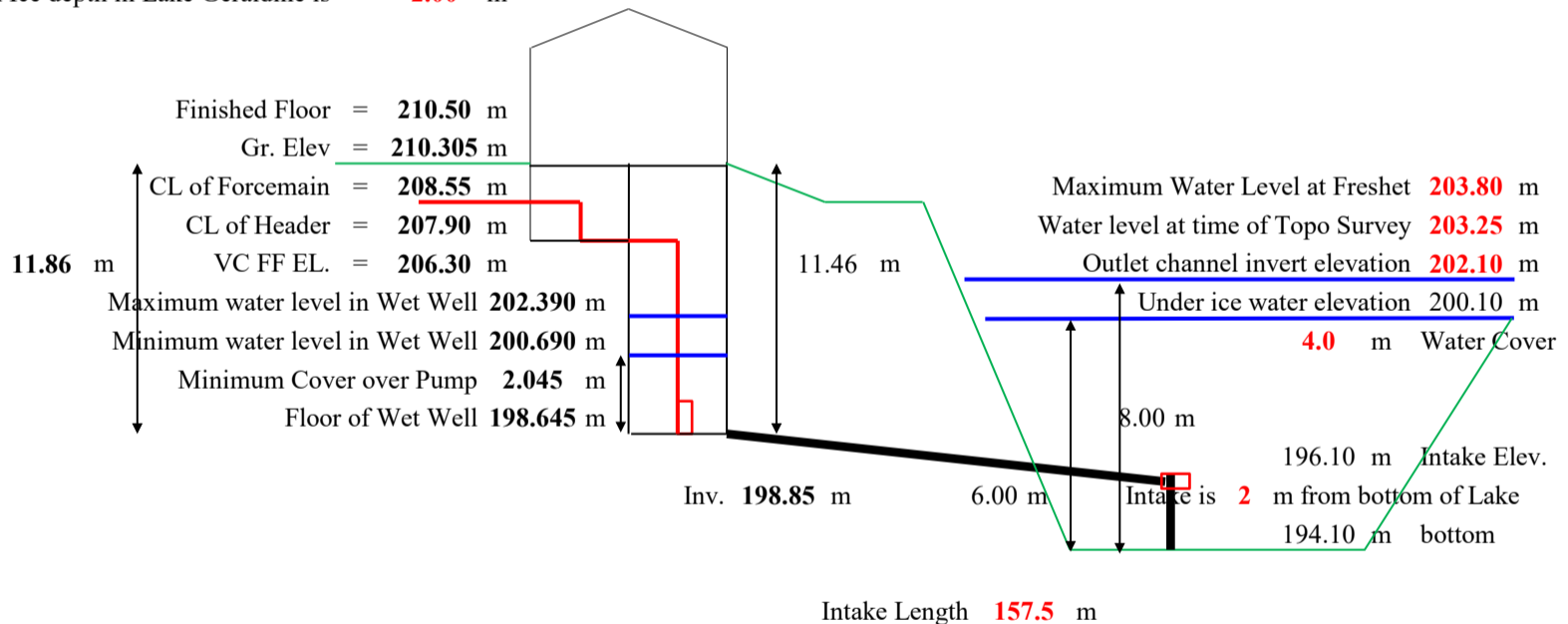
The remaining volume of water required = 1,824,500 m³ - 1,441,152 m³ = 383,348 m³

Using one pump at 278.00 L/s the remaining volume will be provided in 16.0 days

Using two pumps at 556.00 L/s the remaining volume will be provided in 8.0 days

**With 2 Duty Pumps & 1 Standby Pump each rated at 278.0 L/s @ 16.70 m TDH
@ 23.75 psi TDH
@ 163.7 kPa TDH**

Maximum Ice depth in Lake Geraldine is = **2.00 m**





Comparative Evaluation of Sylvia Grinnell River and Unnamed Lake as Long-Term Water Supply for City of Iqaluit

Final

December 6, 2022

The UNL water balance study (Golder 2021) assumed that UNL's outlet channel invert elevation is at 202.1 m. Stage-storage curves for each of UNL's three sub-basins were provided in that study and suggest that there is a total volume of 5,534,000 m³ in UNL during open water, and at the point where no outflow occurs



Unnamed Lake Water Balance for Withdrawals Interim Report

DECEMBER 11, 2023
 ISSUED FOR REVIEW
 FILE: 704-ENG.WTRI03087-01

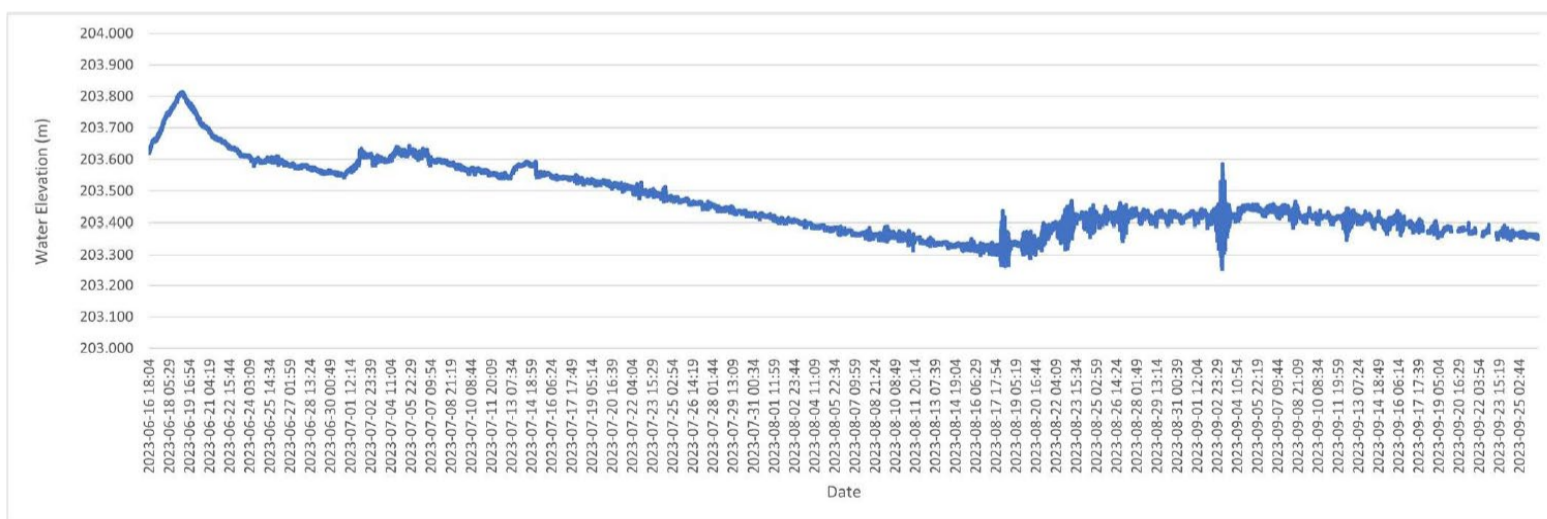


Figure 5-10: OTTLK Water Elevations (Unnamed Lake Water Levels)

2.0 Intake

Excerpt from "Long Term Water - Water Balance Assessment for Unnamed Lake – Modelling Report (Golder 2021)"

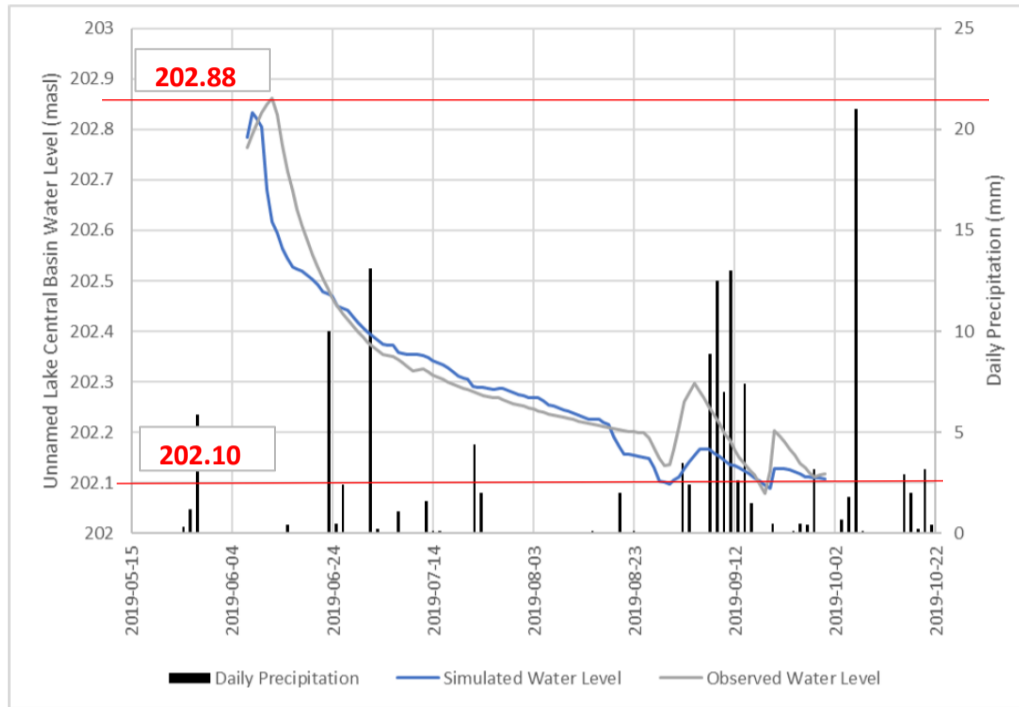
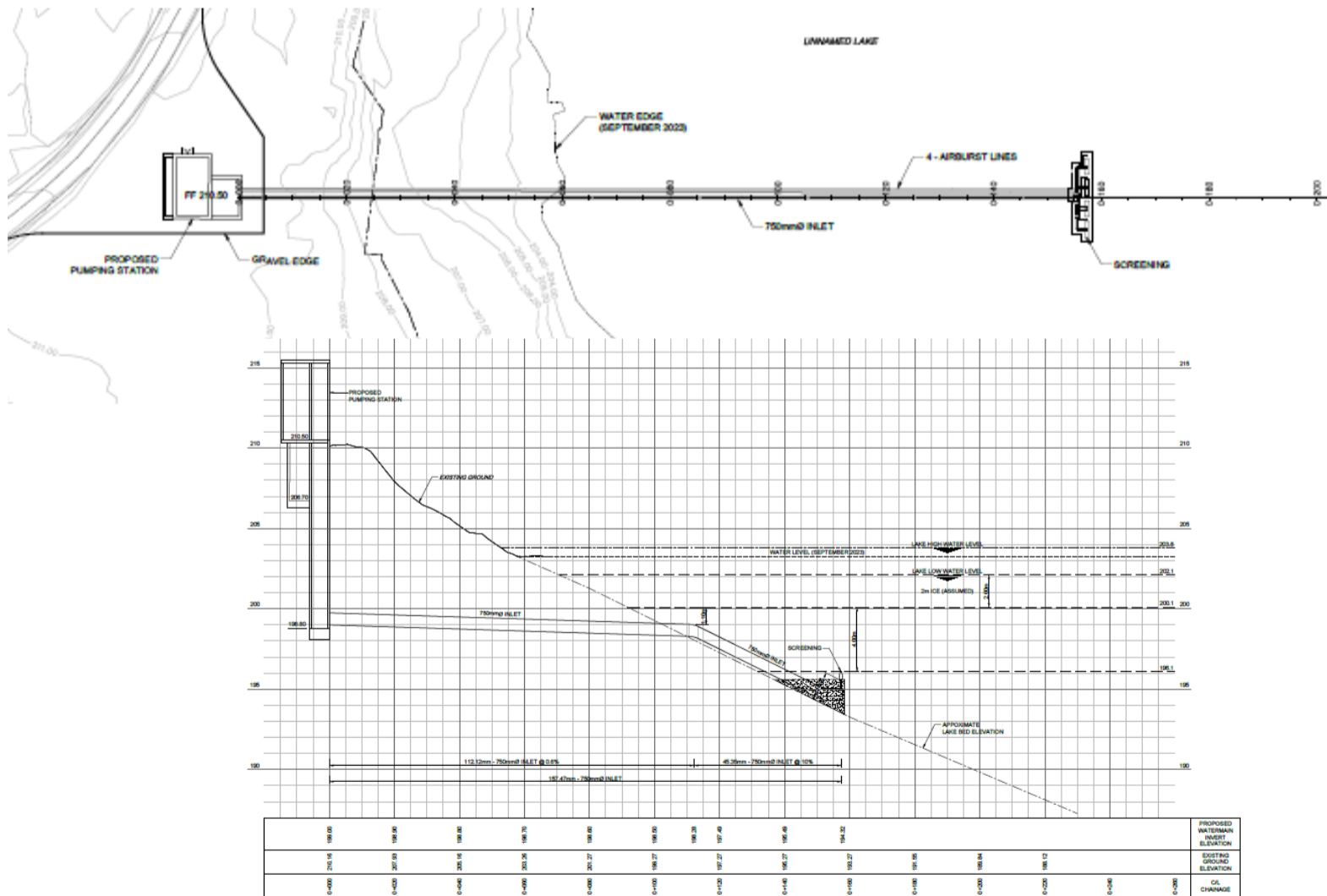


Figure 8: Comparison of Simulated Water Levels Versus Measured Following 2019 Spring Freshet



Intake Sizing
Ultimate Design $Q = 556.0$ L/s

Estimate Required Diameter of the Intake Piping.

 Set outlet piping velocities between **0.80** and **2.50** m/s

 Set velocity at **1.00** m/s $A = Q/V$ $A = 0.5560$ m²

$$A = \frac{\pi \cdot D^2}{4.00} \quad D = 0.84 \text{ m}$$

Use - 750 mm (30 in.) diameter HDPE DR 11

 Pipe ID = **24.218** in. **615.1** mm

 Actual Velocity = $Q/A = 1.90$ m/s 6.23 ft/s **OK**

 Minimum flow (scouring velocity) = **1.00** m/s = 3.28 ft/s

 Minimum scouring flow for each pipe $Q_p = V \times A = 1.00 \text{ m/s} \times 0.2972 \text{ m}^2 = 0.2972 \text{ m}^3/\text{s} = 297.2 \text{ L/s}$
2.01 Losses in Intake Line from the Unnamed Lake
Losses in the Intake Structure

Pressure Drop Thru Assembly: <12" of water (from Hendrick Screen Company quote dated November 13, 2023)

 Assume pressure drop of **12** in. = 310.00 mm = **0.310** m

Losses from Intake to Wet Well

 Inside Dia. of pipe = **0.6151** m

Minor losses in piping :

$$h_m = k \cdot (v^2/2g)$$

$$k = 1.30$$

$$v = 1.87 \text{ m/s}$$

$$g = 9.81 \text{ m}^2/\text{s}$$

$$h_m = 0.240 \text{ m}$$

 $h_t = \text{Minor losses} + \text{Friction losses}$

$$h_t = 1.100 \text{ m} = 1.564 \text{ psi} = 3.609 \text{ feet}$$

Total Intake Losses = 1.410 m

 Minimum water level in the Wet Well = Low Lake Level - Losses in the Intake and Pipe
 = $202.10 \text{ m} - 1.41 \text{ m}$
 = 200.69 m

 Maximum water level in the Wet Well = High Lake Level - Losses in the Intake and Pipe
 = $203.80 \text{ m} - 1.41 \text{ m}$
 = 202.39 m

Minor Losses - 'k' values			
	k	#	T
Swing Check	2.50	0	0.00
Gate Valve	0.19	0	0.00
Plug Valve	0.77	0	0.00
11.25 deg. Bend	0.15	0	0.00
22.5 deg. Bend	0.15	0	0.00
45 deg. Bend	0.20	0	0.00
90 deg. Bend	0.30	1	0.30
Wye	1.00	0	0.00
90 deg - Tee	1.80	0	0.00
180 deg - Tee	0.60	0	0.00
Reducer / Increase	0.25	0	0.00
Bell Mouth Inlet	0.04	0	0.00
Exit	1.00	1	1.00
Total			1.30

2.02 Intake Screen

Artic Char have a subcarangiform swimming mode. (Reference DFO "Freshwater intake End-of-Pipe Fish Screen Guideline, 1995)

Screen approach velocity of approximately **0.11** m/s = 0.361 fps is required for the subcarangiform fish

$$\begin{aligned} \text{Open Screen Area} &= \text{Flow} / \text{Approach Velocity} \\ &= 0.5560 \text{ m}^3/\text{s} / 0.11 \text{ m/s} \\ &= 5.050 \text{ m}^2 \end{aligned}$$

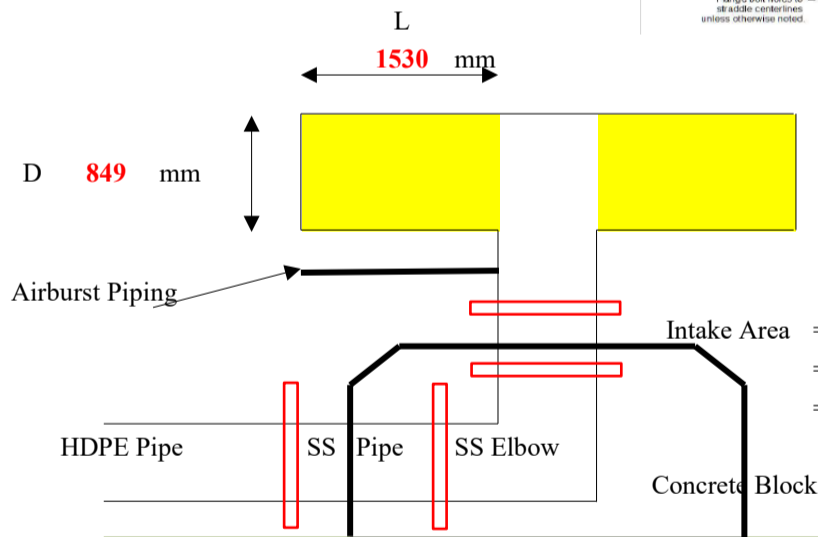
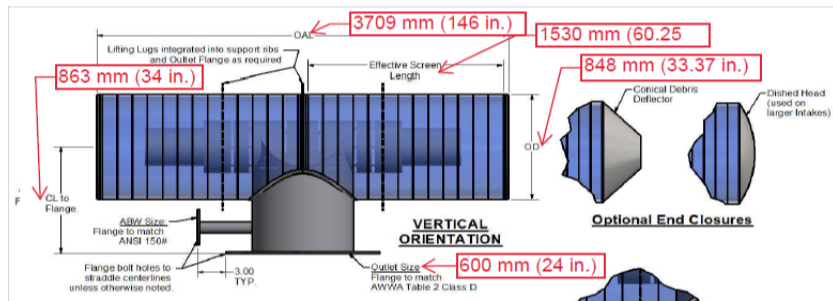
Freshwater Intake End-of-Pipe Fish Screen Guideline

Table 3 Examples of Screen Material

Material	Wire Thickness	Opening Width	% Open Area
8 x 8 Stainless Steel Alloy Mesh	0.711 mm (0.028")	2.44 mm (0.096")	60
#7 Mesh Wire Cloth	1.025 mm (0.041")	2.54 mm (0.100")	51
#8 Mesh Wire Cloth	0.875 mm (0.035")	2.25 mm (0.089")	52
#8 Mesh Wire Cloth	0.700 mm (0.028")	2.54 mm (0.100")	62
#60 Wedge Wire Screen	1.50 mm (0.059")	2.54 mm (0.100")	63
#45 Wedge Wire Screen	1.10 mm (0.080")	2.54 mm (0.100")	69

$$\begin{aligned} \text{Effective Screen Area} &= \frac{\text{Open Screen Area}}{\% \text{ Open Area}/100} \\ &= \frac{5.05 \text{ m}^2}{0.63} = 8.02 \text{ m}^2 \end{aligned}$$

The % Open Area of a #60 Wedge Wire Screen = 63%



$$\begin{aligned} \text{Intake Area} &= 3.1416 \times D \times L \times 2 \\ &= 3.1416 \times 0.849 \times 1.53 \times 2.0 \\ &= 8.16 \text{ m}^2 \quad \text{OK} \end{aligned}$$

3.0 Pumping Station Design

3.01 Pump Discharge Piping

Ultimate Design $Q = 278.0 \text{ L/s}$

Estimate Required Diameter of the Discharge Piping.

Set outlet piping velocities between **0.80** and **2.50** m/s

Set velocity at **1.65** m/s $A = Q/V$ $A = 0.17 \text{ m}^2$ $A = \frac{\pi \cdot D^2}{4.00}$ **D= 0.46 m**

Use - **450 mm** (18 in.) diameter **304L Stainless STD**

Pipe ID = **17.250 in.** **438.2 mm**

Actual Velocity = $Q/A = 1.84 \text{ m/s}$ **OK**

Minimum flow (scouring velocity) = **0.80** m/s = 2.62 ft/s

Minimum scouring flow for each pipe $Q_p = V \times A = 0.80 \text{ m/s} \times 0.15 \text{ m}^2 = 0.12 \text{ m}^3/\text{s} = 120.65 \text{ L/s}$

3.02 Pump Header Piping 1 Pump Running

Ultimate Design $Q = 278.0 \text{ L/s}$

Estimate Required Diameter of the Discharge Piping.

Set outlet piping velocities between **0.80** and **4.00** m/s

Set velocity at **2.40** m/s $A = Q/V$ $A = 0.12 \text{ m}^2$ $A = \frac{\pi \cdot D^2}{4.00}$ **D= 0.38 m**

Use - **450 mm** (18 in.) diameter **304L Stainless STD**

Pipe ID = **17.250 in.** **438.2 mm**

Actual Velocity = $Q/A = 1.84 \text{ m/s}$ **OK**

Minimum flow (scouring velocity) = **0.80** m/s = 2.62 ft/s

Minimum scouring flow for each pipe $Q_p = V \times A = 0.80 \text{ m/s} \times 0.15 \text{ m}^2 = 0.12 \text{ m}^3/\text{s} = 120.65 \text{ L/s}$

3.03 Pump Header Piping 1 Pumps Running

Ultimate Design $Q = 278.0 \text{ L/s}$

Estimate Required Diameter of the Discharge Piping.

Set outlet piping velocities between **0.80** and **4.00** m/s

Set velocity at **2.40** m/s $A = Q/V$ $A = 0.12 \text{ m}^2$ $A = \frac{\pi \cdot D^2}{4.00}$ **D= 0.38 m**

Use - **600 mm** (24 in.) diameter **304L Stainless STD**

Pipe ID = **23.250 in.** **590.6 mm**

Actual Velocity = $Q/A = 1.01 \text{ m/s}$ **OK**

Minimum flow (scouring velocity) = **0.80** m/s = 2.62 ft/s

Minimum scouring flow for each pipe $Q_p = V \times A = 0.80 \text{ m/s} \times 0.27 \text{ m}^2 = 0.22 \text{ m}^3/\text{s} = 219.16 \text{ L/s}$

3.04 Pump Header Piping 2 Pumps Running

Ultimate Design $Q = 556.0 \text{ L/s}$

Estimate Required Diameter of the Discharge Piping.

Set outlet piping velocities between **0.80** and **4.00** m/s

Set velocity at **2.40** m/s $A = Q/V$ $A = 0.23 \text{ m}^2$ $A = \frac{\pi \cdot D^2}{4.00}$ **D= 0.54 m**

Use - **600 mm** (24 in.) diameter **304L Stainless STD**

Pipe ID = **23.250 in.** **590.6 mm**

Actual Velocity = $Q/A = 2.03 \text{ m/s}$ **OK**

Minimum flow (scouring velocity) = **0.80** m/s = 2.62 ft/s

Minimum scouring flow for each pipe $Q_p = V \times A = 0.80 \text{ m/s} \times 0.27 \text{ m}^2 = 0.22 \text{ m}^3/\text{s} = 219.16 \text{ L/s}$

3.05 Forcemain Sizing

Ultimate Design $Q = 556.0 \text{ L/s}$

Estimate Required Diameter of the Forcemain Piping.

Set outlet piping velocities between **0.80** and **3.00** m/s

Set velocity at **1.90** m/s $A = Q/V$ $A = 0.2926 \text{ m}^2$

$$A = \frac{\pi \cdot D^2}{4.00} \quad D = 0.61 \text{ m}$$

Use - 600 mm (24 in.) diameter HDPE DR 11

Pressure Rating = **160.0** psi **1103.2** kPa **112.5** m

Pipe OD = **24.00** in. **609.6** mm

Pipe Thickness = **1.778** in. **45.20** mm

Pipe ID = **19.375** in. **492.10** mm

Operating pressure + surge pressure rating = **320.00** psi **225.0** m

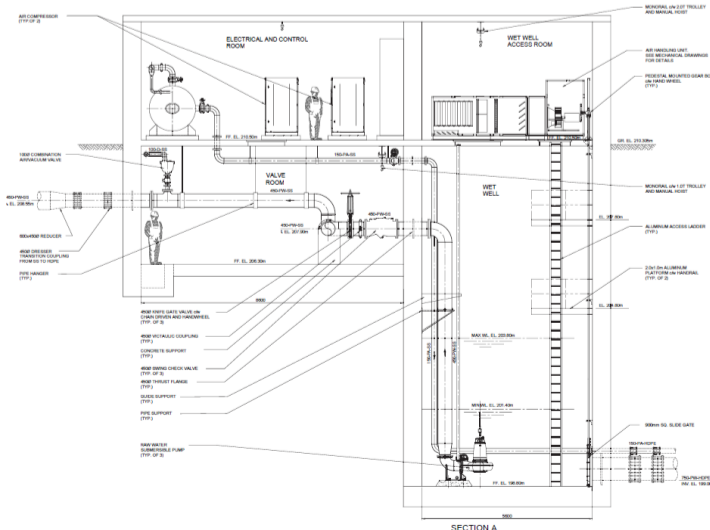
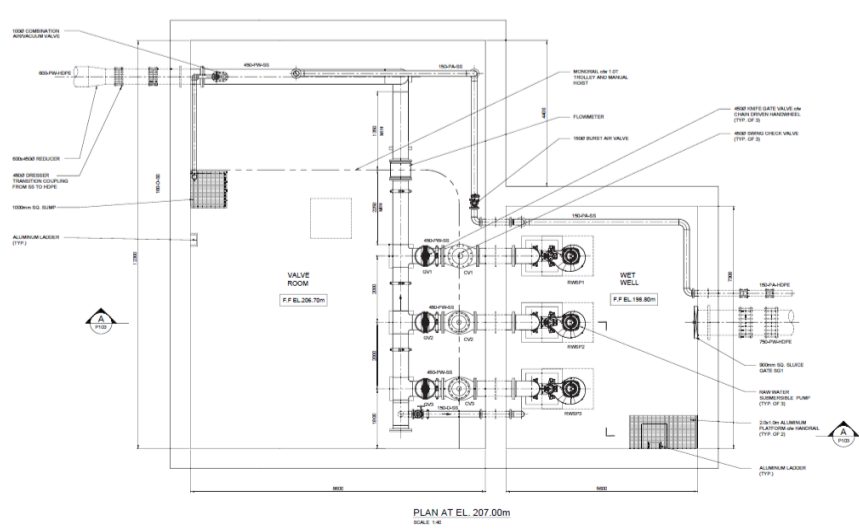
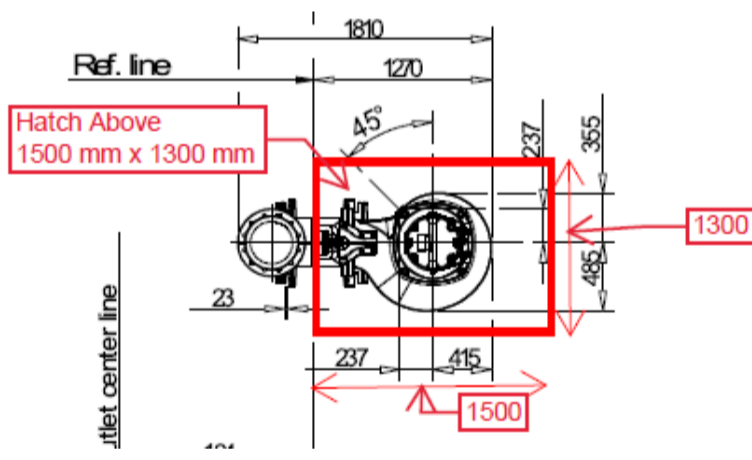
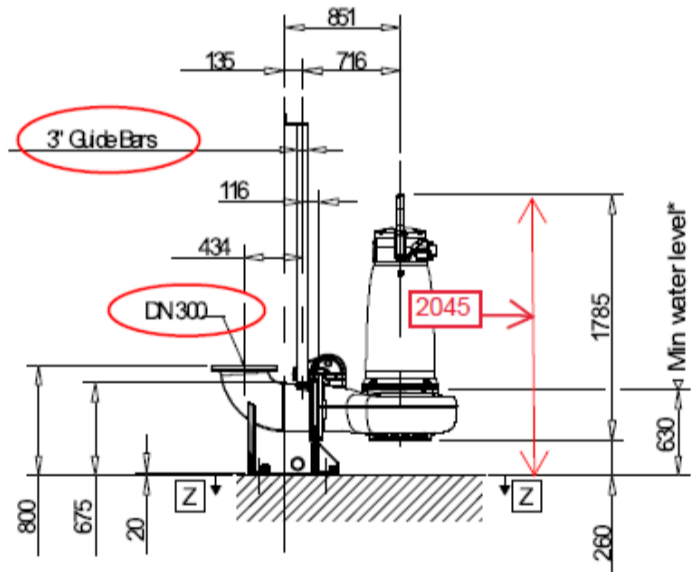
Actual Velocity = $Q/A = 2.92 \text{ m/s}$ **OK**

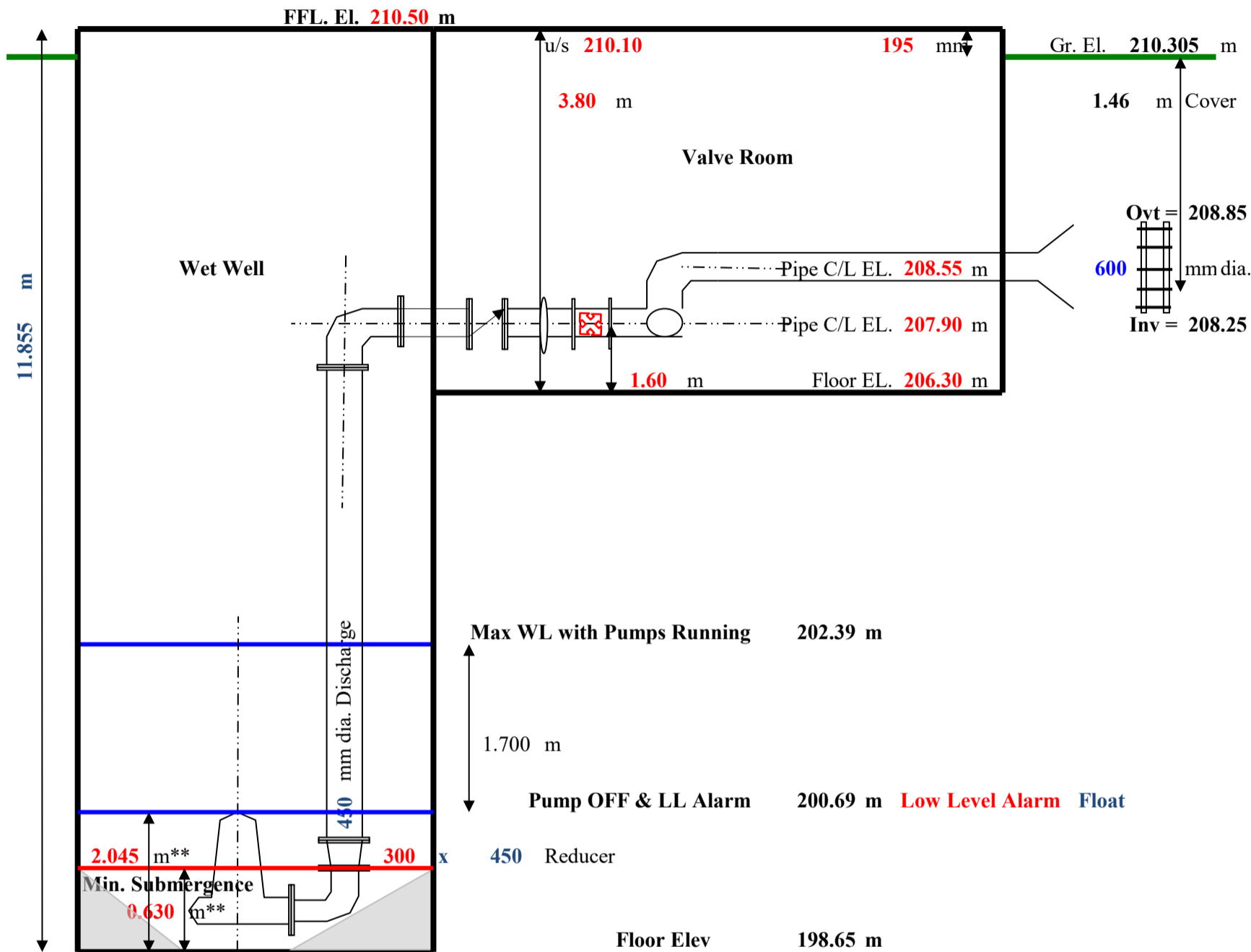
Minimum flow (scouring velocity) = **1.00** m/s = 3.28 ft/s

Minimum scouring flow for each pipe $Q_p = V \times A = 1.00 \text{ m/s} \times 0.1902 \text{ m}^2 = 0.1902 \text{ m}^3/\text{s} = 190.2 \text{ L/s}$

4.0 Pump Sizing

NP 3315 LT 3~ 627





4.01 TDH on Pumps

Losses in Pump Discharge Elbow

Inside Dia. of pipe = 0.300 m

Minor losses in piping :

$$h_m = k \cdot (v^2 / 2g)$$

$$k = 0.55$$

$$v = 3.93 \text{ m/s}$$

$$g = 9.81 \text{ m}^2/\text{s}$$

$$h_m = 0.440 \text{ m}$$

Static difference = Elev. @ Header Centerline - Elev. @ Header Centerline

$$h_s = 198.65 - 198.65 = 0.00 \text{ m}$$

$h_t = \text{Minor losses} + \text{Friction losses} + \text{Static Difference}$

$$h_t = 0.440 \text{ m} = 0.626 \text{ psi} = 1.444 \text{ feet}$$

Flow in pipe = 0.2780 m³/s

Friction losses in piping:

$$h_f = (0.54rt(Q/(0.278 \cdot C \cdot D^{2.63})) \cdot L)$$

$$L = 0.0 \text{ m}$$

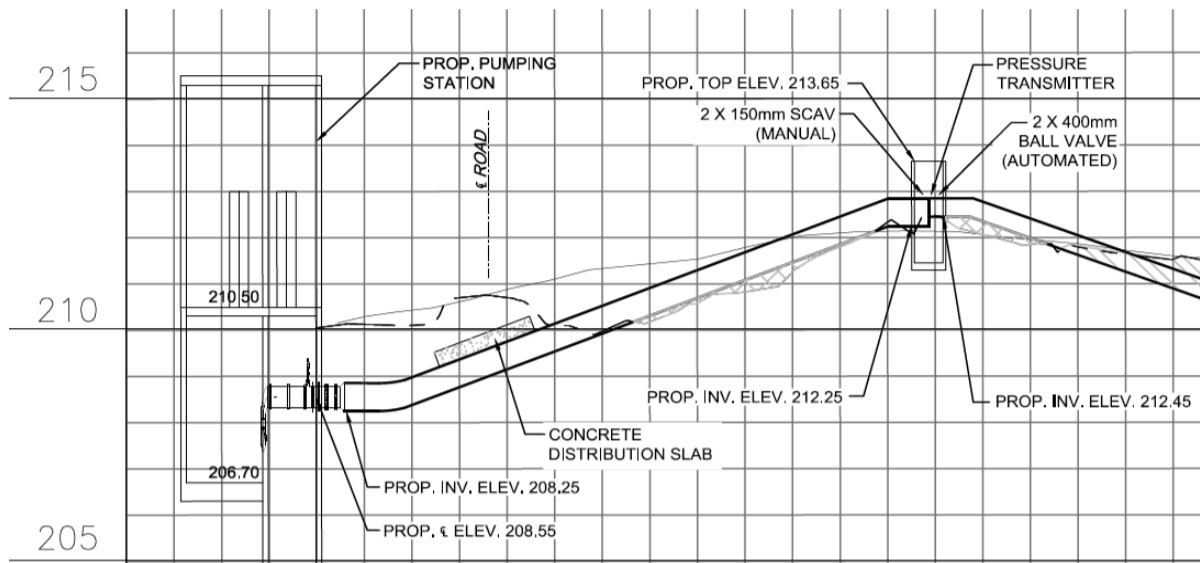
$$D = 0.300 \text{ m}$$

$$Q = 0.2780 \text{ m}^3/\text{s}$$

$$C = 150$$

$$h_f = 0.000 \text{ m}$$

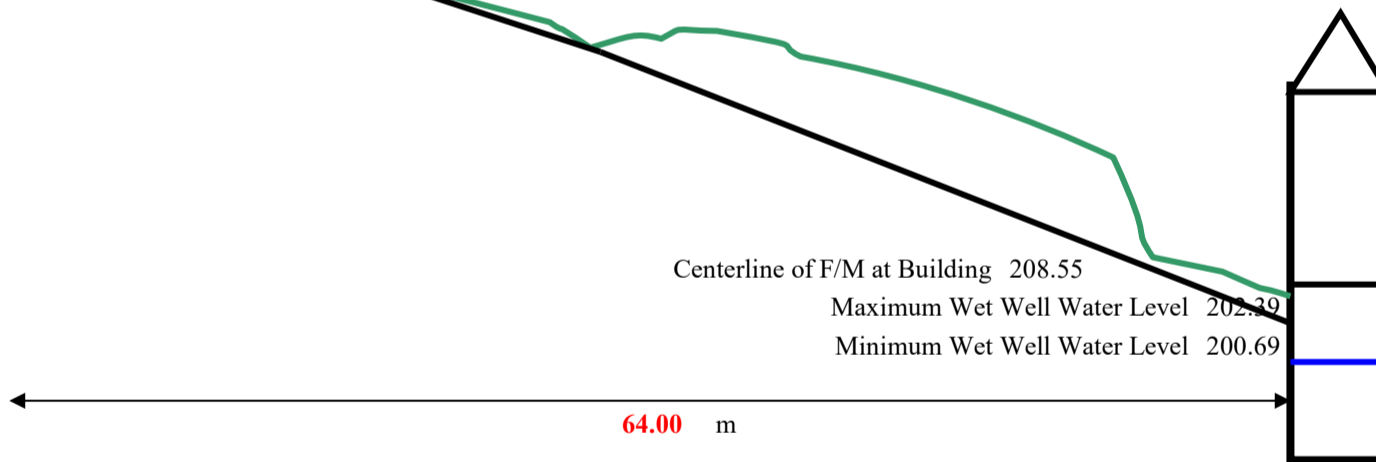
Minor Losses - 'k' values			
	k	#	T
Swing Check	2.50	0	0.00
Gate Valve	0.19	0	0.00
Plug Valve	0.77	0	0.00
11.25 deg. Bend	0.15	0	0.00
22.5 deg. Bend	0.15	0	0.00
45 deg. Bend	0.20	0	0.00
90 deg. Bend	0.30	1	0.30
Wye	1.00	0	0.00
90 deg - Tee	1.80	0	0.00
180 deg - Tee	0.60	0	0.00
Reducer / Increase	0.25	1	0.25
Bell Mouth Inlet	0.04	0	0.00
Exit	1.00	0	0.00
Total			0.55



HGL = 215.91 m HGL = 219.09 m

HGL = 214.21 m HGL = 217.39 m

- 212.30 m** = Ground Elevation at High Point
- 212.74 m** = Top of Pipe Elevation at High Point
- 212.50 m** = Centerline of Pipe at High Point
- 212.25 m** = Invert of Pipe at High Point



Losses in Forcemain from P/Stn to High Point

Inside Dia. of pipe = **0.4921 m**

Flow in pipe = **0.5560 m³/s**

Minor losses in piping :

$$h_m = k \cdot (v^2 / 2g)$$

k = 1.40

v = 2.92 m/s

g = 9.81 m²/s

h_m = 0.610 m

Friction losses in piping:

$$h_f = (0.54rt(Q / (0.278 * C * D^{2.63})) * L)$$

L = **64.0 m**

D = 0.4921 m

Q = 0.556 m³/s

C = **150**

h_f = 0.690 m

Static difference = Centerline at High Point - Elev. @ Forcemain Leaving the Building

$$h_s = 212.496 - 208.550 = 3.946 \text{ m}$$

h_t = Minor losses + Friction losses + Static Difference

$$h_t = 5.246 \text{ m} = 7.460 \text{ psi} = 17.211 \text{ feet}$$

Minor Losses - 'k' values			
	k	#	T
Swing Check	2.50	0	0.00
Gate Valve	0.19	0	0.00
Plug Valve	0.77	0	0.00
11.25 deg. Bend	0.15	0	0.00
22.5 deg. Bend	0.15	0	0.00
45 deg. Bend	0.20	2	0.40
90 deg. Bend	0.30	0	0.00
Wye	1.00	0	0.00
90 deg - Tee	1.80	0	0.00
180 deg - Tee	0.60	0	0.00
Reducer / Increase	0.25	0	0.00
Bell Mouth Inlet	0.04	0	0.00
Exit	1.00	1	1.00
Total			1.40

4.02 Conveyance Pipe Sizing
Ultimate Design $Q = 278.0 \text{ L/s}$
Estimate Required Diameter of the Conveyance Piping.

 Set outlet piping velocities between **0.80** and **3.00** m/s

 Set velocity at **1.90** m/s $A = Q/V$ $A = 0.1463 \text{ m}^2$

$$A = \frac{\pi \cdot D^2}{4.00} \quad D = 0.43 \text{ m}$$

Use 2 - 400 mm (16 in.) diameter HDPE DR 11

 Pressure Rating = **160.0** psi **1103.2** kPa **112.5** m

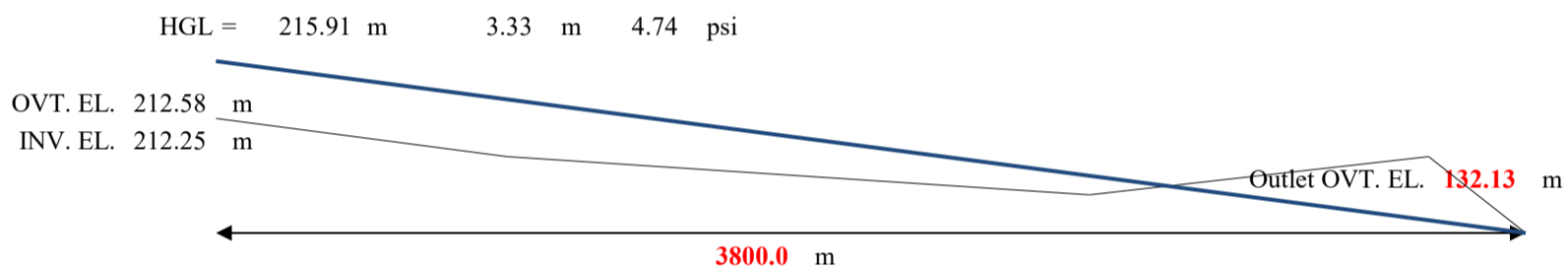
 Pipe OD = **16.00** in. **406.4** mm

 Pipe Thickness = **1.455** in. **37.00** mm

 Pipe ID = **12.916** in. **328.1** mm

 Actual Velocity = $Q/A = 3.29$ m/s

 Minimum flow (scouring velocity) = **1.00** m/s = 3.28 ft/s

 Minimum scouring flow for each pipe $Q_p = V \times A = 1.00 \text{ m/s} \times 0.0845 \text{ m}^2 = 0.0845 \text{ m}^3/\text{s} = 84.5 \text{ L/s}$
LOSSES IN CONVEYANCE PIPE to OUTFALL

 Inside Dia. of pipe = **0.328** m

Minor losses in piping :

$$h_m = k \cdot (v^2/2g)$$

$$k = 5.45$$

$$v = 3.29 \text{ m/s}$$

$$g = 9.81 \text{ m}^2/\text{s}$$

$$h_m = 3.010 \text{ m}$$

 Flow in pipe = **0.278** m³/s

Friction losses in piping:

$$h_f = (0.54 \cdot \text{rt}(Q/(0.278 \cdot C \cdot D^{2.63}))) \cdot L$$

$$L = 3800.0 \text{ m}$$

$$D = 0.328 \text{ m}$$

$$Q = 0.2780 \text{ m}^3/\text{s}$$

$$C = 150$$

$$h_f = 80.770 \text{ m}$$

Static difference = Elev. @ Forcemain Discharge Centerline - Elev. @ Pump Header Centerline

$$h_s = 132.13 - 212.58 = -80.450 \text{ m}$$

 $h_t = \text{Minor losses} + \text{Friction losses} + \text{Static Difference}$

$$h_t = 3.330 \text{ m} = 4.735 \text{ psi} = 10.925 \text{ feet}$$

Minor Losses - 'k' values			
	k	#	T
Swing Check	2.50	0	0.00
Gate Valve	0.19	0	0.00
Plug Valve	0.77	0	0.00
11.25 deg. Bend	0.15	0	0.00
22.5 deg. Bend	0.15	3	0.45
45 deg. Bend	0.20	17	3.40
90 deg. Bend	0.30	2	0.60
Wye	1.00	0	0.00
90 deg - Tee	1.80	0	0.00
180 deg - Tee	0.60	0	0.00
Reducer / Increase	0.25	0	0.00
Bell Mouth Inlet	0.04	0	0.00
Exit	1.00	1	1.00
Total			5.45

TDH on Pumps = **16.7** m = **23.747** psi = **54.790** feet

Static Lift at near zero flow = **-68.56** m = **-97.495** psi = **-224.941** feet

3 Three pumps, each with a capacity of 278.0 L/s @ 16.70 m TDH

 Three pumps each with a capacity of **4404** USGPM @ **54.8** ft TDH (**23.75** psi)

4.02 Hydraulic Horsepower = $\frac{Q \text{ (L/s)} \times \text{TDH (m)}}{102}$ = 45.5 kW = 61.0 hp

4.03 Brake Horsepower = $\frac{\text{Hydraulic Horsepower}}{\text{pump efficiency (\%)}}$ Eff = **75%** at runout say 82.1 kW
 = 60.7 kW = 81.4 hp **110.0** hp **OK**
 82.1 kW

DESIGN SUBJECT	UNIT	C = 130	C = 140	C = 150
PUMP DESIGN FLOW	L/s	556.0	556.0	556.0
FORCEMAIN DIAMETER	mm	600	600	600
VELOCITY	m/s	2.92	2.92	2.92
FORCEMAIN LENGTH	m	64.0	64.0	64.0
FORCEMAIN HEAD LOSS	m	1.55	1.43	1.30
SUCTION LINE HEAD LOSS	m	N/A	N/A	N/A
DISCHARGE LINE HEAD LOSS	m	1.76	1.74	1.88
TOTAL HEAD LOSS	m	3.31	3.17	3.18
LOW WATER LEVEL WET WELL	m	200.69	200.69	200.69
HIGH WATER LEVEL WET WELL	m	202.39	202.39	202.39
FORCEMAIN END C/L ELEVATION	m	212.50	212.50	212.50
STATIC HEAD	MAX.	m	11.81	11.81
	MIN.	m	10.11	10.11
TOTAL DYNAMIC HEAD	MAX.	m	15.12	14.99
	MIN.	m	13.42	13.29

4.04 Surge Pressure on Forcemain

The following calculations are performed to determine the transient pressures likely with instantaneous pump stoppage.

$$\text{Maximum Water Hammer Pressure (m)} = P = \frac{a * V}{g}$$

where:

$$a = \text{Wave velocity} = \text{sqrt} \left(\frac{K}{\rho \left(1 + \frac{K}{E} \times \psi \right)} \right) \quad \text{m/s}$$

V = velocity of water stopped	=	2.92	m/s
ρ = Density of fluid being conveyed	=	998	kg/m ³
K = Bulk modulus of elasticity of fluid	=	2.15E+09	N/m ²
E = Young's modulus of elasticity of pipe material; approx.	=	1.00E+09	Pa (HDPE)
μ = Poisson's ratio for the pipe material	=	0.40	dimensionless
R ₀ = pipe external radius	=	0.305	m
R _i = pipe internal radius	=	0.246	m
d = inside diameter of pipe	=	0.492	m
e = thickness of pipe wall	=	0.0452	m
g = acceleration caused by gravity	=	9.806	m/s ²
Q = maximum flow in the conduit	=	0.5560	m ³ /s
C = 1- μ^2	=	0.84	

h) Alternate Method

$$a = \text{Wave velocity} = \text{sqrt} \left(\frac{K}{\rho \left(1 + C \frac{K}{E} \times \frac{d}{e} \right)} \right)$$

$$a = 323 \quad P = 96.15 \text{ m} = 136.73 \text{ psi}$$

Therefore, pipe must handle a total pressure (working + surge) of: 16.70 m + 96.15 m = 112.85 m = 160.47 psi

total pressure rating = 320 psi **OK** 2206.4 kPa **No Surge Protection Needed**

5.0 Pump Curves

Pumping Station Piping Losses

Headloss in forcemain (not including Static Losses) = **6.510 m**

Equivalent length of HDPE pipe (L)

Friction losses in piping: $h_f = (0.54rt(Q/(0.278*C*D^{2.63}))*L)$ Where: $h_f = 6.510 \text{ m}$

$L = 611.09 \text{ m}$

$D = 0.4921 \text{ m}$

$Q = 0.5560 \text{ m}^3/\text{s}$

$C = 150$

Pipe Area = **0.190 m²**

Length of Forcemain = **611.09 m** HLL = **202.39 m**

Forcemain Discharge Elevation = **212.74 m** MLL = **201.54 m**

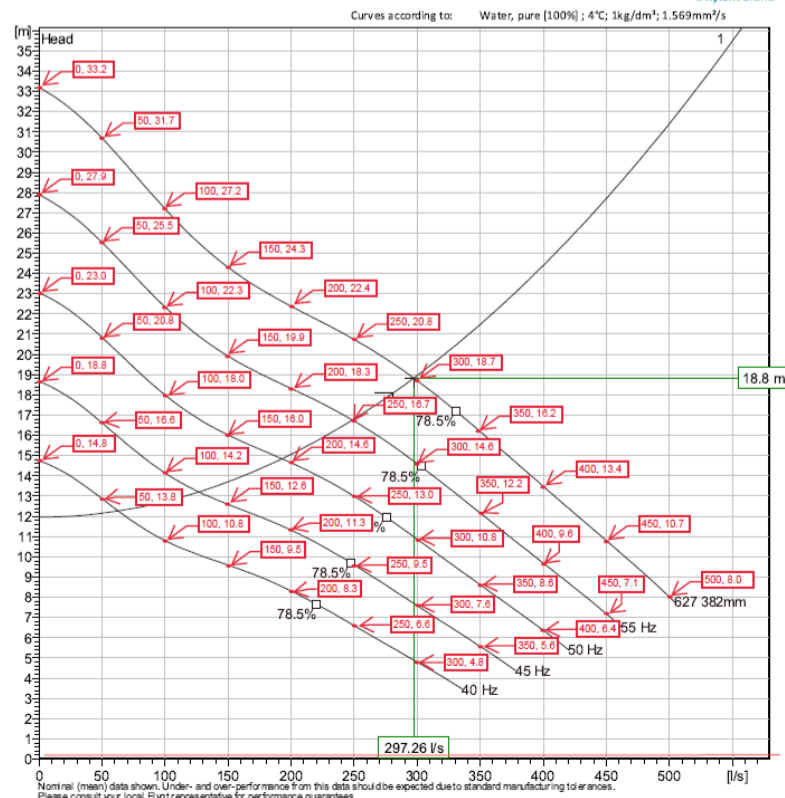
LLL = **200.69 m**

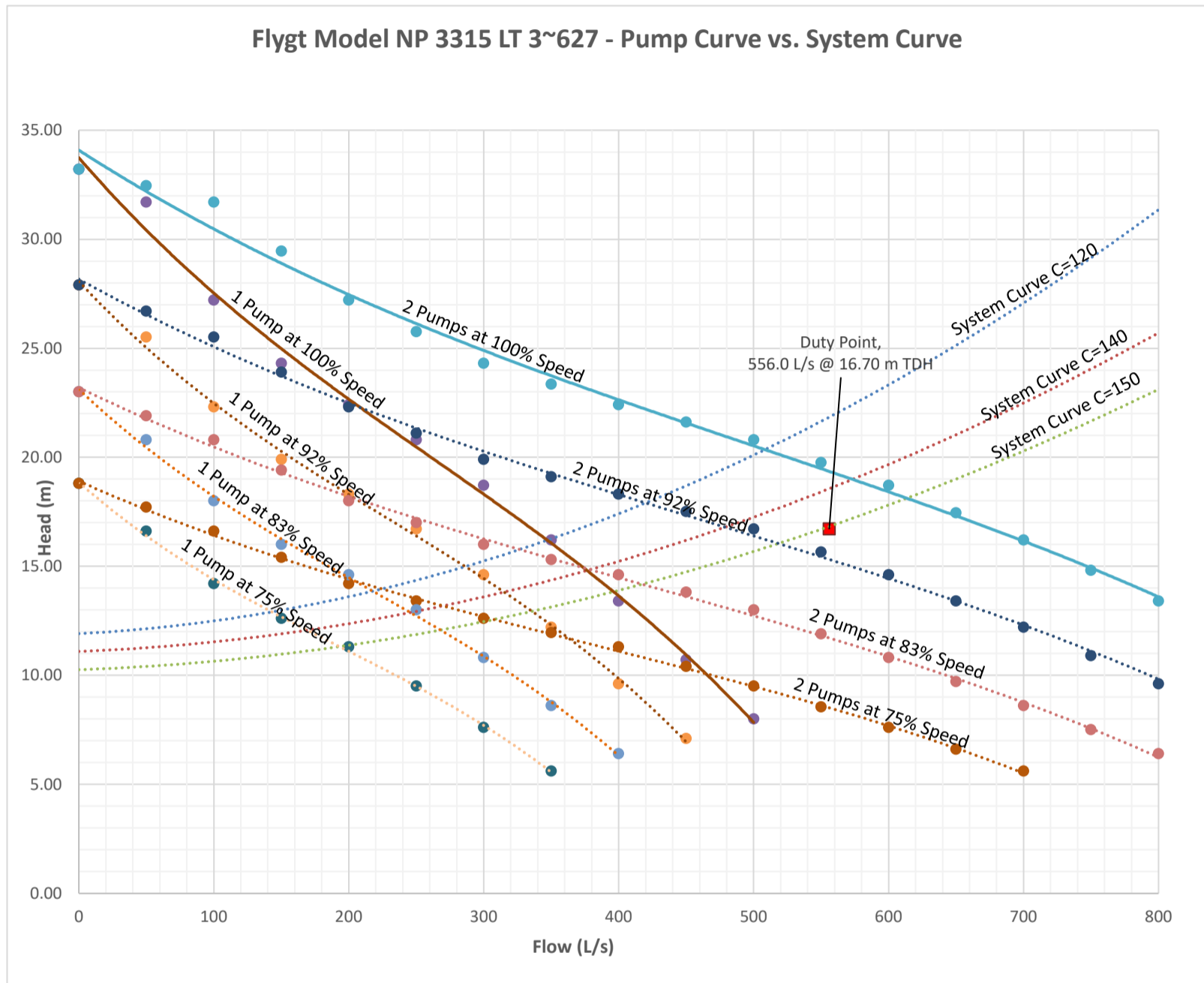
System Curve at PUMP [TDH (m)]															
Flow (L/s)	0	50	100	150	200	250	300	350	400	450	500	550	600	650	700
C Factor															
120	12.05	12.17	12.46	12.92	13.53	14.29	15.19	16.23	17.40	18.70	20.14	21.70	23.38	25.19	27.13
140	11.20	11.29	11.51	11.86	12.32	12.89	13.56	14.34	15.22	16.20	17.28	18.45	19.72	21.08	22.53
150	10.35	10.43	10.62	10.93	11.33	11.83	12.43	13.11	13.89	14.75	15.70	16.73	17.85	19.05	20.32

Flygt Model NP 3315 LT 3~627															
1 @ 100%	33.2	31.7	27.2	24.3	22.4	20.8	18.7	16.2	13.4	10.7	8.0				
2 @ 100%	33.2	32.5	31.7	29.5	27.2	25.8	24.3	23.4	22.4	21.6	20.8	19.8	18.7	17.5	16.2
3 @ 100%	33.2	32.7	32.2	31.7	30.2	28.7	27.2	26.2	25.3	24.3	23.7	23.0	22.4	21.9	21.3
1 @ 92%	27.9	25.5	22.3	19.9	18.3	16.7	14.6	12.2	9.6	7.1					
2 @ 92%	27.9	26.7	25.5	23.9	22.3	21.1	19.9	19.1	18.3	17.5	16.7	15.7	14.6	13.4	12.2
1 @ 83%	23.0	20.8	18.0	16.0	14.6	13.0	10.8	8.6	6.4						
2 @ 83%	23.0	21.9	20.8	19.4	18.0	17.0	16.0	15.3	14.6	13.8	13.0	11.9	10.8	9.7	8.6
1 @ 75%	18.8	16.6	14.2	12.6	11.3	9.5	7.6	5.6							
2 @ 75%	18.8	17.7	16.6	15.4	14.2	13.4	12.6	12.0	11.3	10.4	9.5	8.6	7.6	6.6	5.6
1 @ 67%	14.8	13.8	10.8	9.5	8.3	6.6	4.8								
2 @ 67%	14.8	14.3	13.8	12.3	10.8	10.2	9.5	8.9	8.3	7.5	6.6	5.7	4.8		

NP 3315 LT 3~ 627

Duty Analysis





City of Iqaluit - Raw Water Pumping Station

1.0 Design Criteria

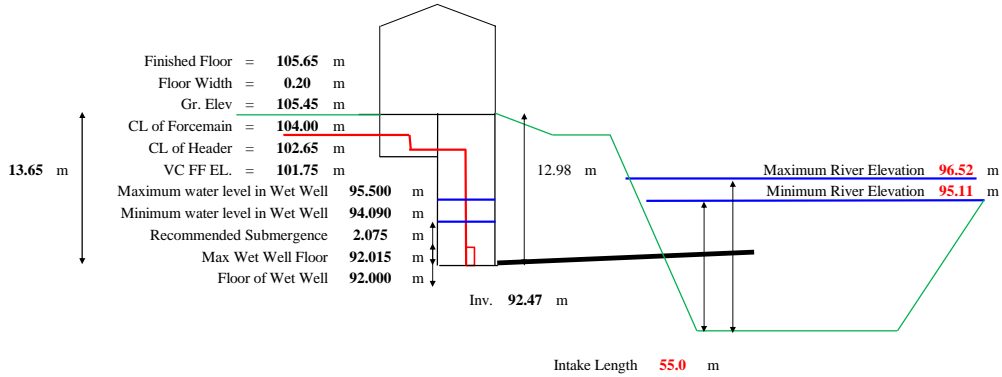
To meet 1,000,000 cubic meters of raw water (PDR page 12)

Based on historical flow data the required pumping capacity = **400.0 L/s** = 6340.00 GPM

To see the basis for this range, please see sheet entitled Apex River Flows in the Preliminary Design Report. (PDF pg 12)

Number of intakes:	2
Number of intake pipes	2

With 2 Duty Pumps & 1 Standby Pump each rated at 200.0 L/s @ 46.55 m TDH @ 66.19 psi TDH @ 456.1 kPa TDH



2.0 Intake

There are two intake screens that each have direct lines to the wet well. They are each sized to both handle the full and half the flow.

Intake Sizing - 1 Intake Active

Ultimate Design Q = 400.0 L/s

Estimate Required Diameter of the Intake Piping.

Set intake piping velocity between **0.80** and **2.50** m/s
 Set velocity at **1.00** m/s $A = Q/V$ $A = 0.4000 \text{ m}^2$ $A = \frac{\pi \cdot D^2}{4.00}$ **D= 0.71 m**

Use - 600 mm (24 in.) diameter HDPE DR 11
 Pipe ID = **20.829** in. **529.1** mm
 Actual Velocity = $Q/A = 1.80$ m/s = 5.91 ft/s **OK**
 Minimum flow (scouring velocity) = **1.00** m/s = 3.28 ft/s
 Minimum scouring flow for each pipe $Q_p = V \times A = 1.00 \text{ m/s} \times 0.2199 \text{ m}^2 = 0.2199 \text{ m}^3/\text{s} = 219.9 \text{ L/s}$

Intake Sizing - 2 Intakes Active (normal operations)

Ultimate Design Q = 200.0 L/s

Estimate Required Diameter of the Intake Piping.

Set intake piping velocity between **0.80** and **2.50** m/s
 Set velocity at **1.00** m/s $A = Q/V$ $A = 0.2000 \text{ m}^2$ $A = \frac{\pi \cdot D^2}{4.00}$ **D= 0.50 m**

Use - 600 mm (24 in.) diameter HDPE DR 11
 Pipe ID = **20.829** in. **529.1** mm
 Actual Velocity = $Q/A = 0.90$ m/s = 2.95 ft/s **OK**
 Minimum flow (scouring velocity) = **1.00** m/s = 3.28 ft/s
 Minimum scouring flow for each pipe $Q_p = V \times A = 1.00 \text{ m/s} \times 0.2199 \text{ m}^2 = 0.2199 \text{ m}^3/\text{s} = 219.9 \text{ L/s}$

Pipe Size (# Intakes = 1)	=	529.10 mm (400.00 L/s)
Pipe Size (# Intakes = 2)	=	529.10 mm (200.00 L/s)

2.01 Losses in Intake Line from Apex River

Losses in the Intake Structure

Pressure Drop Thru Assembly: <12" of water, conservative value
 Assume pressure drop of **12** in. = 310.00 mm = **0.310 m**

Losses from Intake to Wet Well

Inside Dia. of pipe = **0.53** m
 Minor losses in piping :
 $h_m = k \cdot (v^2/2g)$
 $k = 2.19$
 $v = 1.82 \text{ m/s}$
 $g = 9.81 \text{ m}^2/\text{s}$
 $h_m = 0.370 \text{ m}$

Flow in pipe = **0.400** m³/s
 Friction losses in piping:
 $h_f = (0.54 \cdot f \cdot (Q / (0.278 \cdot C \cdot D^{2.63}))) \cdot L$
 $L = 55.0 \text{ m}$
 $D = 0.5291 \text{ m}$
 $Q = 0.400 \text{ m}^3/\text{s}$
 $C = 120$
 $h_f = 0.340 \text{ m}$

$h_t = \text{Minor losses} + \text{Friction losses}$
 $h_t = 0.710 \text{ m} = 1.010 \text{ psi} = 2.329 \text{ feet}$

Minor Losses - 'k' values			
	k	#	T
Swing Check	2.50	0	0.00
Gate Valve	0.19	1	0.19
Plug Valve	0.77	0	0.00
11.25 deg. Bend	0.15	0	0.00
22.5 deg. Bend	0.15	0	0.00
45 deg. Bend	0.20	0	0.00
90 deg. Bend	0.30	0	0.00
Wye	1.00	0	0.00

Total Intake Losses = 1.020 m

Minimum water level in the Wet Well = Low River Elevation - Losses in the Intake and Pipe
 = 95.11 m - 1.02 m
 = 94.09 m

Maximum water level in the Wet Well = High River Elevation - Losses in the Intake and Pipe
 = 96.52 m - 1.02 m
 = 95.50 m

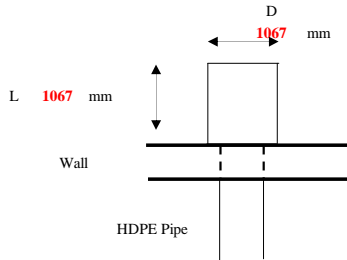
90 deg - Tee	1.80	0	0.00
180 deg - Tee	0.60	0	0.00
Reducer / In increaser	0.25	0	0.00
Bell Mouth Inlet	0.04	0	0.00
Exit	1.00	2	2.00
Total			2.19

2.02 Intake Screen

Artic Char have a subcarangiform swimming mode. (Reference DFO "Freshwater intake End-of-Pipe Fish Screen Guideline, 1995)
 Screen approach velocity of approximately **0.11** m/s = 0.361 fps is required for the subcarangiform fish

Open Screen Area = Flow / Approach Velocity
 = 0.4000 m³/s / 0.11 m/s
 = 3.640 m²

Effective Screen Area = $\frac{\text{Open Screen Area}}{\% \text{ Open Area}/100}$ The % Open Area of a #60 Wedge Wire Screen = 63%
 = $\frac{3.64 \text{ m}^2}{0.63}$ = 5.78 m²



Intake Area = 3.1416 x D/2 x L x 2
 = 3.1416 x 0.534 x 1.07 x 2.0
 = 3.58 m²
 Two Intake Screens = 7.15 m² **OK**

3.0 Pump Station Design

3.01 Pump Discharge Piping - 1 pump

Ultimate Design Q = 200.0 L/s

Estimate Required Diameter of the Discharge Piping.

Set outlet piping velocities between 0.80 and 2.50 m/s
Set velocity at 1.65 m/s A = Q/V A = 0.12 m² A = $\frac{\pi D^2}{4.00}$ D = 0.39 m

Use - 350 mm (14 in.) diameter 304L Stainless STD
Pipe ID = 13.624 in. 346.0 mm
Actual Velocity = Q/A = 2.13 m/s OK
Minimum flow (scouring velocity) = 0.80 m/s = 2.62 ft/s
Minimum scouring flow for each pipe Q_p = V x A = 0.80 m/s x 0.09 m² = 0.08 m³/s = 75.22 L/s

3.02 Pump Discharge 1 Pump Running

Ultimate Design Q = 200.0 L/s

Estimate Required Diameter of the Discharge Piping.

Set outlet piping velocities between 0.80 and 4.00 m/s
Set velocity at 2.40 m/s A = Q/V A = 0.08 m² A = $\frac{\pi D^2}{4.00}$ D = 0.33 m

Use - 350 mm (14 in.) diameter 304L Stainless STD
Pipe ID = 13.624 in. 346.0 mm
Actual Velocity = Q/A = 2.13 m/s OK
Minimum flow (scouring velocity) = 0.80 m/s = 2.62 ft/s
Minimum scouring flow for each pipe Q_p = V x A = 0.80 m/s x 0.09 m² = 0.08 m³/s = 75.22 L/s

3.03 Pump Header Piping 1 Pump Running

Ultimate Design Q = 200.0 L/s

Estimate Required Diameter of the Discharge Piping.

Set outlet piping velocities between 0.80 and 4.00 m/s
Set velocity at 2.40 m/s A = Q/V A = 0.08 m² A = $\frac{\pi D^2}{4.00}$ D = 0.33 m

Use - 450 mm (18 in.) diameter
Pipe ID = 17.624 in. 447.6 mm
Actual Velocity = Q/A = 1.27 m/s OK
Minimum flow (scouring velocity) = 0.80 m/s = 2.62 ft/s
Minimum scouring flow for each pipe Q_p = V x A = 0.80 m/s x 0.16 m² = 0.13 m³/s = 125.88 L/s

3.04 Pump Header Piping 2 Pumps Running

Ultimate Design Q = 400.0 L/s

Estimate Required Diameter of the Discharge Piping.

Set outlet piping velocities between 0.80 and 4.00 m/s
Set velocity at 2.40 m/s A = Q/V A = 0.17 m² A = $\frac{\pi D^2}{4.00}$ D = 0.46 m

Use - 450 mm (18 in.) diameter
Pipe ID = 17.624 in. 447.6 mm
Actual Velocity = Q/A = 2.54 m/s OK
Minimum flow (scouring velocity) = 0.80 m/s = 2.62 ft/s
Minimum scouring flow for each pipe Q_p = V x A = 0.80 m/s x 0.16 m² = 0.13 m³/s = 125.88 L/s

3.05 Twin Forcemain Sizing

Ultimate Design Q = 200.0 L/s

Estimate Required Diameter of the Forcemain Piping.

Set outlet piping velocities between 0.80 and 3.00 m/s
Set velocity at 1.90 m/s A = Q/V A = 0.1053 m² A = $\frac{\pi D^2}{4.00}$ D = 0.37 m

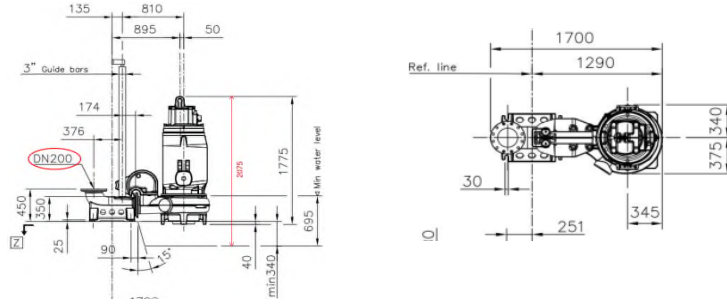
Use - 400 mm (16 in.) diameter HDPE DR 11
Pressure Rating = 200.0 psi 1379.0 kPa 140.6 m
Pipe OD = 17.21 in. 437.1 mm
Pipe Thickness = 1.582 in. 40.20 mm
Pipe ID = 14.046 in. 356.80 mm
Operating pressure + surge pressure rating = 400.00 psi 281.2 m

Actual Velocity = Q/A = 2.00 m/s OK
Minimum flow (scouring velocity) = 1.00 m/s = 3.28 ft/s
Minimum scouring flow for each pipe Q_p = V x A = 1.00 m/s x 0.1000 m² = 0.1000 m³/s = 100.0 L/s

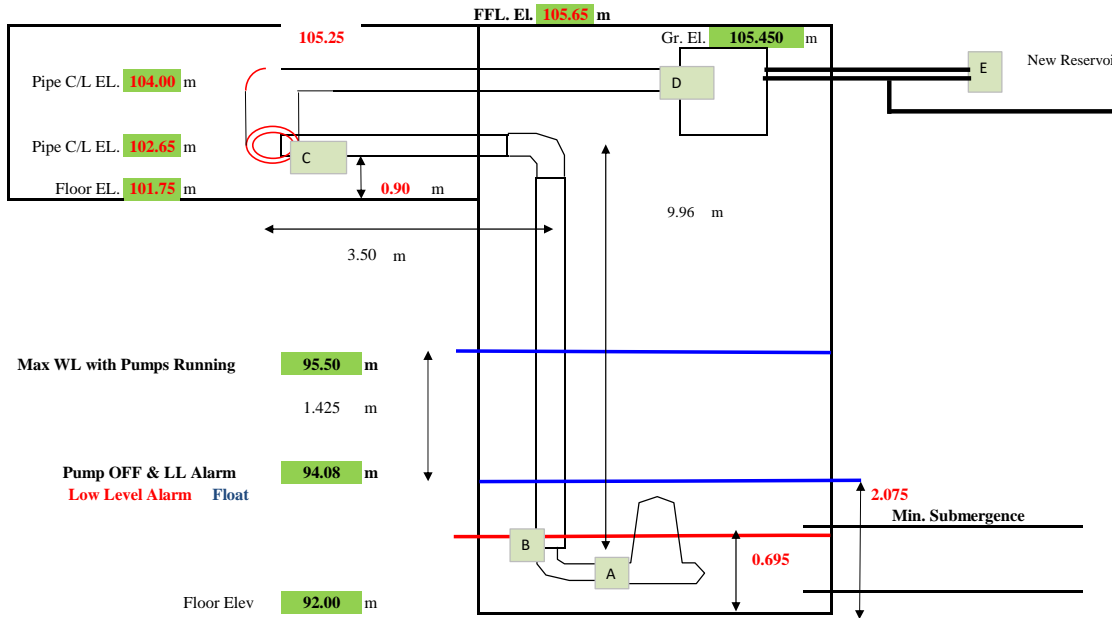
SIZING SUMMARY

3.01	350.00 mm	14.00 in.
3.02	350.00 mm	14.00 in.
3.03	450.00 mm	18.00 in.
3.04	450.00 mm	18.00 in.
3.05	400.00 mm	16.00 in.

4.0 Pump Sizing



depth into page= 8.00 m 5.30 m



4.01 TDH on Pumps

Losses in Pump Discharge Elbow (P1, P2, P3) - A to B

Inside Dia. of pipe = 0.200 m
 Minor losses in piping:
 $h_m = k \cdot (v^2 / 2g)$
 $k = 0.55$
 $v = 6.37 \text{ m/s}$
 $g = 9.81 \text{ m/s}^2$
 $h_m = 1.140 \text{ m}$

Flow in pipe = 0.2000 m³/s
 Friction losses in piping:
 $h_f = (0.54rt(Q / (0.278 * C * D^{2.63}))) * L$
 $L = 0.0 \text{ m}$
 $D = 0.200 \text{ m}$
 $Q = 0.2000 \text{ m}^3/\text{s}$
 $C = 150$
 $h_f = 0.000 \text{ m}$

Static difference = Elev. @ Header Centerline - Elev. @ Header Centerline
 $h_s = 92.00 - 92.00 = 0.00 \text{ m}$

$h_t = \text{Minor losses} + \text{Friction losses} + \text{Static Difference}$
 $h_t = 1.140 \text{ m} = 1.621 \text{ psi} = 3.740 \text{ feet}$

Minor Losses - 'k' values			
	k	#	T
Swing Check	2.50	0	0.00
Gate Valve	0.19	0	0.00
Plug Valve	0.77	0	0.00
11.25 deg. Bend	0.15	0	0.00
22.5 deg. Bend	0.15	0	0.00
45 deg. Bend	0.20	0	0.00
90 deg. Bend	0.30	1	0.30
Wye	1.00	0	0.00
90 deg - Tee	1.80	0	0.00
180 deg - Tee	0.60	0	0.00
Reducer / Increase	0.25	1	0.25
Bell Mouth Inlet	0.04	0	0.00
Exit	1.00	0	0.00
Total			0.55

Losses in Forcemain from P/Stn to LG Discharge, D to F, Route 2, Long

Inside Dia. of pipe = **0.3568** m Flow in pipe = **0.2000** m³/s
 Minor losses in piping : Friction losses in piping:
 $h_m = k \cdot (v^2/2g)$ $hf = (0.54rt(Q/(0.278 \cdot C \cdot D^{2.63}))^2) \cdot L$
 k = 9.28 L = **1100.0** m
 v = 2.00 m/s D = 0.3568 m
 g = 9.81 m/s² Q = 0.200 m³/s
h_m = 1.900 m C = **150**
h_f = 8.450 m
 Static difference = MAX WATER LEVEL OF LG - CL OF PIPE LEAVING THE BUILDING
h_s = 111.30 - 104.00 = 7.300 m
 h_t = Minor losses + Friction losses + Static Difference
h_t = 17.650 m = **25,098** psi = **57.907** feet

Minor Losses - 'k' values			
	k	#	T
Swing Check	2.50	1	2.50
Gate Valve	0.19	1	0.19
Plug Valve	0.77	0	0.00
Ball Valve	0.04	1	0.04
11.25 deg. Bend	0.15	0	0.00
22.5 deg. Bend	0.15	0	0.00
45 deg. Bend	0.20	19	3.80
90 deg. Bend	0.30	1	0.30
Wye	1.00	0	0.00
90 deg - Tee	1.80	0	0.00
180 deg - Tee	0.60	2	1.20
Reducer / Increase	0.25	1	0.25
Bell Mouth Inlet	0.04	0	0.00
Exit	1.00	1	1.00
Total			9.28

Head Loss Summary

	minor	friction	static	total	
A to B	1.140	0.000	0.000	1.140	m
B to C	0.850	0.150	8.575	9.575	m
C to D	0.590	0.140	1.350	2.080	m
D to E	1.820	3.810	28.000	33.630	m Route 1
D to E	1.910	3.840	28.000	33.750	m Route 2, short
E to F	1.900	8.450	7.300	17.650	m Route 2, long

For 2 Intake(s) :

TDH on Pumps = In-Station Losses + Out of Station Losses
 To New Reservoir, Route 1 = 12.795 m + 33.63 m = **46.425** m = **66.016** psi = **152.313** feet
 To New Reservoir, Route 2 short = 12.795 m + 33.75 m = **46.545** m = **66.187** psi = **152.707** feet
 To Lake Geraldine, Route 2 Long = 12.795 m + 17.65 m = **30.445** m = **43.293** psi = **99.885** feet

Static Lift at near zero flow = Discharge Elevation - Low Water Level
 To New Reservoir = 132 m - **94.075** m = **37.925** m = **53.929** psi = **124.426** feet
 To Lake Geraldine = 111.30 m - **94.075** m = **17.225** m = **24.494** psi = **56.512** feet

3 Three pumps, each with a capacity of 200.0 L/s @ 46.55 m TDH

Three pumps each with a capacity of **3168** USGPM @ **152.7** ft TDH (**66.19** psi)

4.02 Hydraulic Horsepower = $\frac{Q \text{ (L/s)} \times \text{TDH (m)}}{102}$ = 91.3 kW = 122.4 hp

4.03 Brake Horsepower = $\frac{\text{Hydraulic Horsepower}}{\text{pump efficiency (\%)}}$ Eff = **73%** say 138.0 kW
 = 125.0 kW = 167.6 hp **185.0** hp **OK**
138.0 kW

TO NEW RESERVOIR

DESIGN SUBJECT	UNIT	C = 130	C = 140	C = 150	
PUMP DESIGN FLOW	L/s	400.0	400.0	400.0	
FORCEMAIN DIAMETER	mm	400	400	400	Twin FM
VELOCITY	m/s	2.00	2.00	2.00	
FORCEMAIN LENGTH	m	495.0	495.0	495.0	
FORCEMAIN HEAD LOSS	m	1.55	1.43	5.63	
SUCTION LINE HEAD LOSS	m	N/A	N/A	N/A	
DISCHARGE LINE HEAD LOSS, NR	m	1.76	1.74	2.87	
TOTAL HEAD LOSS, NR	m	3.31	3.17	8.50	
LOW WATER LEVEL WET WELL	m	94.09	94.09	94.09	
HIGH WATER LEVEL WET WELL	m	95.50	95.50	95.50	
FORCEMAIN END C/L ELEVATION	m	132.00	132.00	132.00	
STATIC HEAD	MAX.	37.91	37.91	37.91	
	MIN.	36.50	36.50	36.50	
TOTAL DYNAMIC HEAD	MAX.	41.22	41.08	46.41	
	MIN.	39.81	39.67	45.00	

4.04 Surge Pressure on Forcemain

The following calculations are performed to determine the transient pressures likely with instantaneous pump stoppage.

$$\text{Maximum Water Hammer Pressure (m)} = P = \frac{a * V}{g}$$

where:

$$a = \text{Wave velocity} = \text{sqrt} \left(\frac{K}{\rho \left(1 + \frac{K}{E} * \psi \right)} \right) \quad \text{m/s}$$

- V = velocity of water stopped = 2.00 m/s
- ρ = Density of fluid being conveyed = 998 kg/m³
- K = Bulk modulus of elasticity of fluid = 2.15E+09 N/m²
- E = Young's modulus of elasticity of pipe material; approx. = 1.00E+09 Pa (HDPE)
- μ = Poisson's ratio for the pipe material = 0.40 dimensionless
- R₀ = pipe external radius = 0.219 m
- R_i = pipe internal radius = 0.178 m
- d = inside diameter of pipe = 0.357 m
- e = thickness of pipe wall = 0.0402 m
- g = acceleration caused by gravity = 9.806 m/s²
- Q = maximum flow in the conduit = 0.4000 m³/s
- C = 1-μ² = 0.84

a) Rigid Conduits

$$\psi = 0.00 \quad a = 1468 \quad P = 299.36 \text{ m} = 425.69 \text{ psi} \quad \text{Not Applicable}$$

b) Thick Walled Elastic Conduits Anchored Against Longitudinal Movement Throughout its Length

$$\psi = 2 * (1-\mu) * \left(\frac{R_0^2 + R_i^2}{R_0^2 - R_i^2} - \frac{2\mu R_i^2}{R_0^2 - R_i^2} \right) = 4.40$$

$$a = 454 \quad P = 92.61 \text{ m} = 131.69 \text{ psi} \quad \text{Not Applicable}$$

c) Thick Walled Elastic Conduits Anchored Against Longitudinal Movement at the Upper End

$$\psi = 2.00 * \left(\frac{1 + 1.5 R_i^2}{R_0^2 - R_i^2} + \frac{\mu(R_0^2 + 3R_i^2)}{R_0^2 - R_i^2} \right) = 9.59$$

$$a = 316 \quad P = 64.39 \text{ m} = 91.56 \text{ psi} \quad \text{Not Applicable}$$

d) Thick Walled Elastic Conduits with Frequent expansion Joints

$$\psi = 2.00 * \left(\frac{R_0^2 + R_i^2}{R_0^2 - R_i^2} + \mu \right) = 10.79$$

$$a = 298 \quad P = 60.86 \text{ m} = 86.54 \text{ psi} \quad \text{Not Applicable}$$

e) Thin Walled Elastic Conduits Anchored Against Longitudinal Movement Throughout its Length

$$\psi = \frac{d}{e} * (1 - \mu^2) = 7.46$$

$$a = 356 \quad P = 72.54 \text{ m} = 103.16 \text{ psi} \quad \text{Not Applicable}$$

f) Thin Walled Elastic Conduits Anchored Against Longitudinal Movement at the Upper End

$$\psi = \frac{d}{e} * (1.25 - \mu) = 8.89$$

$$a = 327 \quad P = 66.76 \text{ m} = 94.93 \text{ psi} \quad \text{Not Applicable}$$

g) Thin Walled Elastic Conduits with Frequent expansion Joints

$$\psi = \frac{d}{e} = 8.88$$

$$a = 328 \quad P = 66.80 \text{ m} = 94.99 \text{ psi} \quad \text{Not Applicable}$$

h) Alternate Method

$$a = \text{Wave velocity} = \text{sqrt} \left(\frac{K}{\rho \left(1 + C * \frac{K}{E} * \frac{d}{e} \right)} \right)$$

$$a = 356 \quad P = 72.54 \text{ m} = 103.16 \text{ psi}$$

Therefore, pipe must handle a total pressure (working + surge) of: 46.55 m + 72.54 m = 119.09 m = 169.34 psi

total pressure rating = 400 psi OK 2758.0 kPa No Surge Protection Needed

5.0 Pump Curves

Pumping Station Piping Losses

Headloss in forcemain (not including Static Losses) 8.62 m

Where: $h_f = 8.620$ m

Equivalent length of HDPE pipe (L) D = 0.3568 m

Q = 0.4000 m³/s

Friction losses in piping:

$$h_f = (0.54 \pi (Q / (0.278 * C * D^{2.63}))^2) * L$$

C = 150

L = 311.05 m

Pipe Area = 0.100 m²

Length of Forcemain = 311.05 m HRL = 95.50 m

Forcemain Discharge Elevation = 132.00 m MRL = 94.80 m

LRL = 94.09 m

System Curve at PUMP (TDH (m))

Flow (L/s)	0	50	100	150	200	250	300	350	400	450	500	550	600	650	700
C Factor															
100	37.91	38.30	39.31	40.88	42.97	45.56	48.63	52.17	56.17	60.63	65.52	70.85	76.61	82.79	89.39
120	37.91	38.19	38.91	40.03	41.52	43.37	45.56	48.09	50.94	54.12	57.61	61.41	65.52	69.93	74.64
140	37.21	37.41	37.96	38.80	39.92	41.31	42.95	44.85	47.00	49.39	52.01	54.87	57.96	61.27	64.81
150	36.50	36.68	37.16	37.90	38.89	40.11	41.56	43.23	45.12	47.22	49.53	52.05	54.76	57.68	60.80

Flygt Model NP 3231/706 3~480

Flow (L/s)	0	50	100	150	200	250	300	350	400	450	500	550	600	650	700
1 @ 100%	71.0	64.5	58.0	51.0	44.0	37.0	30.0								
2 @ 100%	71.0	68.0	65.0	61.5	58.0	54.5	51.0	47.5	44.0	41.0	38.0	34.0	30.0	25.0	20.0
3 @ 100%	71.0	69.0	67.0	65.0	63.0	60.5	58.0	56.0	54.0	51.8	49.5	46.9	44.3	42.1	40.0
1 @ 92%	59.5	53.8	48.0	42.0	36.0	28.0	20.0								
2 @ 92%	59.5	56.8	54.0	51.0	48.0	45.0	42.0	39.0	36.0	32.5	29.0	24.5	20.0		
1 @ 83%	49.0	43.5	38.0	33.0	28.0	21.0	14.0								
2 @ 83%	49.0	46.6	44.3	41.1	38.0	35.5	33.0	30.3	27.5	24.3	21.0	17.0	13.0		
1 @ 75%	40.0	35.0	30.0	25.0	20.0										
2 @ 75%	40.0	37.5	35.0	32.5	30.0	27.5	25.0	22.5	20.0	16.8	13.5				
1 @ 67%	31.5	26.8	22.0	17.5	13.0										
2 @ 67%	31.5	29.5	27.5	25.3	23.0	20.5	18.0	15.5	13.0	10.0	7.0				

