# ATTACHMENT 14

## LTWP Preliminary Design Report – Appendix E – Pump Calculations

ARCADIS

PROJECT City of Iqaluit - Raw Water Pumping Station

PROJECT NO. 144081

DATE August 28, 2024

COMPUTED BY Paul Dagenais

CHECKED BY

**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 additiona **1,824,500** $m^3$ 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

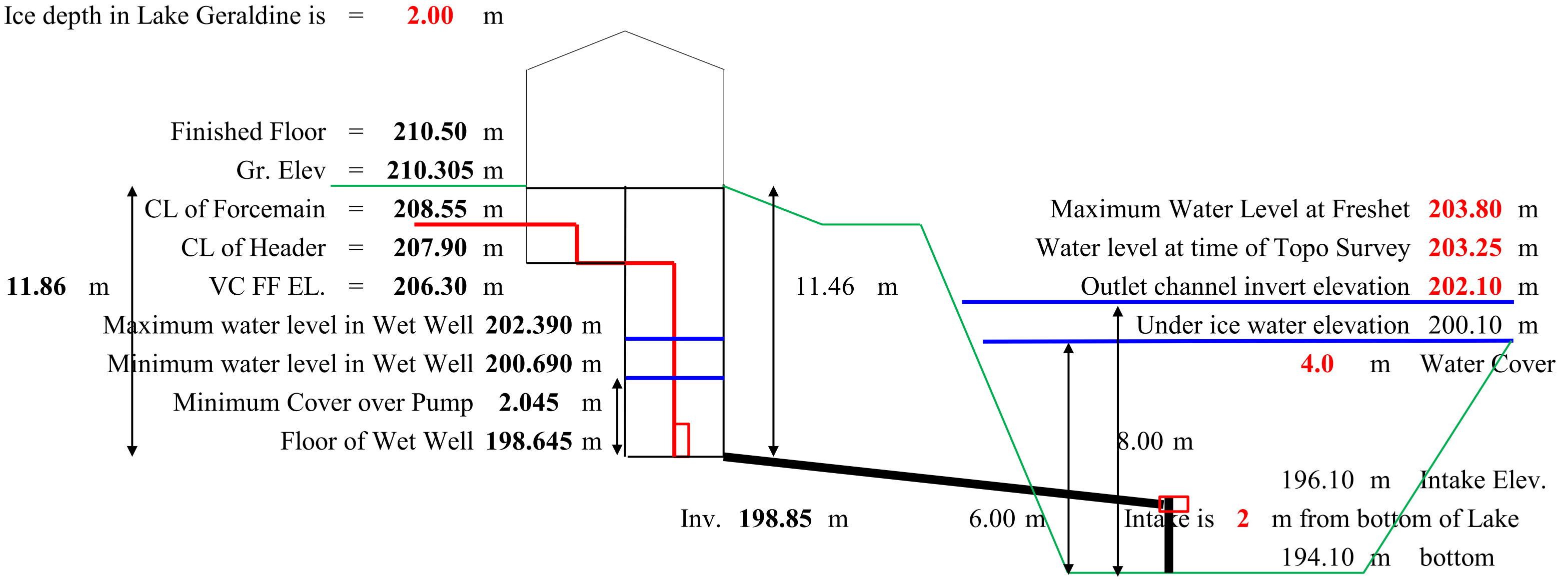
At a pump rate of 556 L/s the volume of water that can be pumped in 30 days = 1,441,152 $m^3$

The remaining volume of water required = 1,824,500 $m^3$ - 1,441,152 $m^3$ = 383,348 $m^3$

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




Intake Length **157.5** m

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NUNAMI STANTEC LIMITED

**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

TETRA TECH

**Unnamed Lake Water Balance for Withdrawals Interim Report**

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

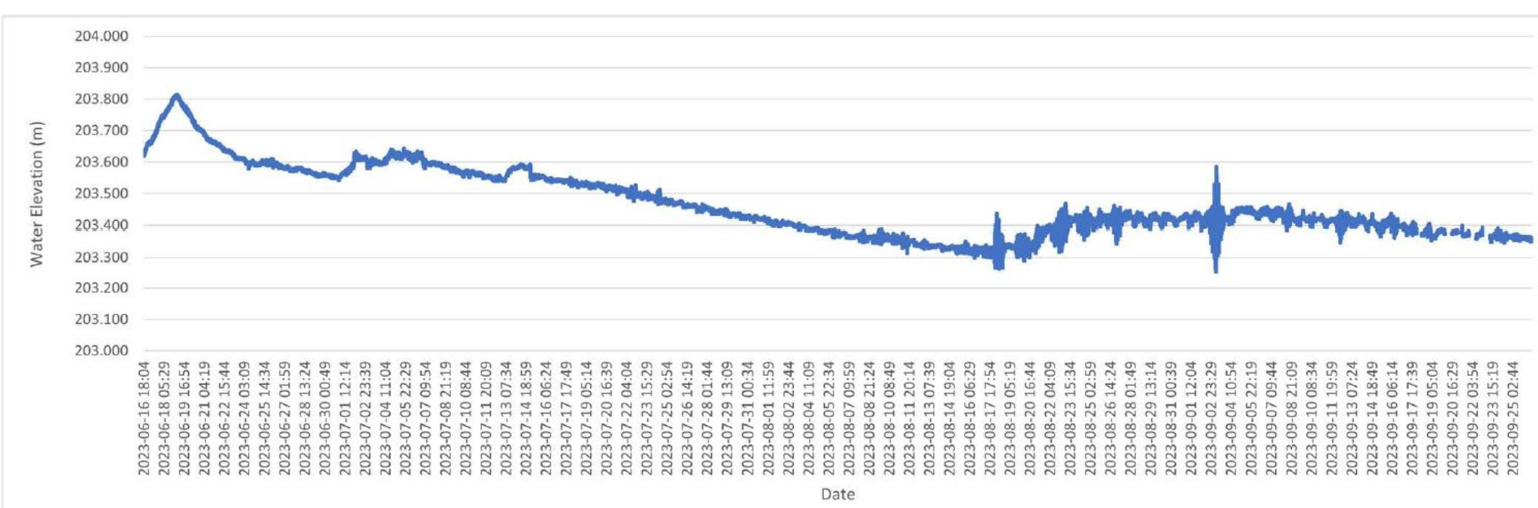


**Figure 5-10: OTTLK Water Elevations (Unnamed Lake Water Levels)**

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## 2.0 Intake

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

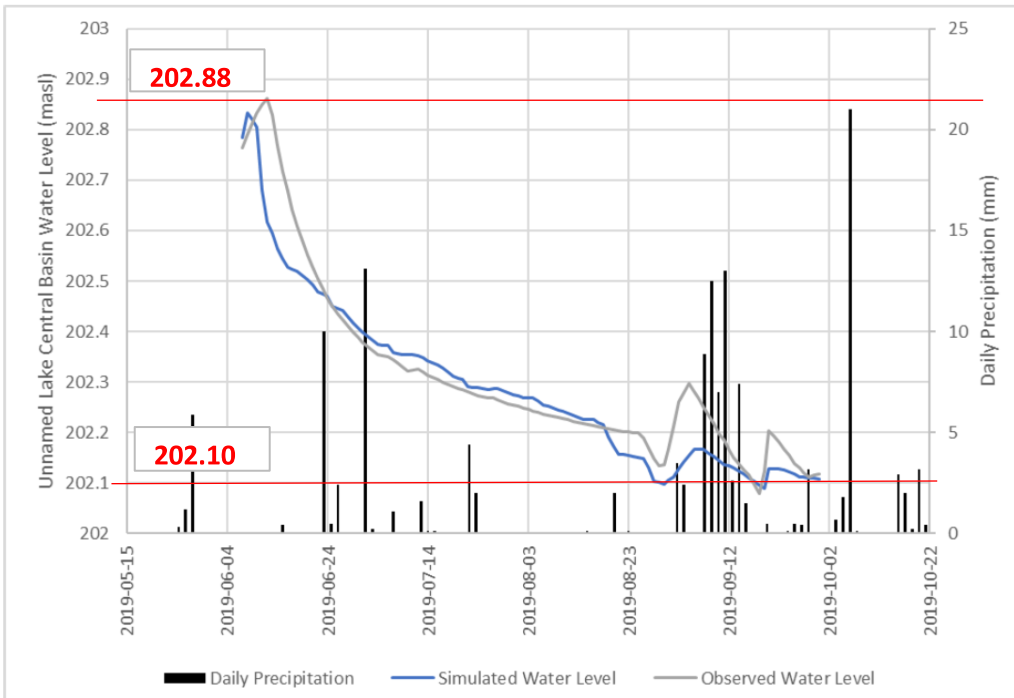
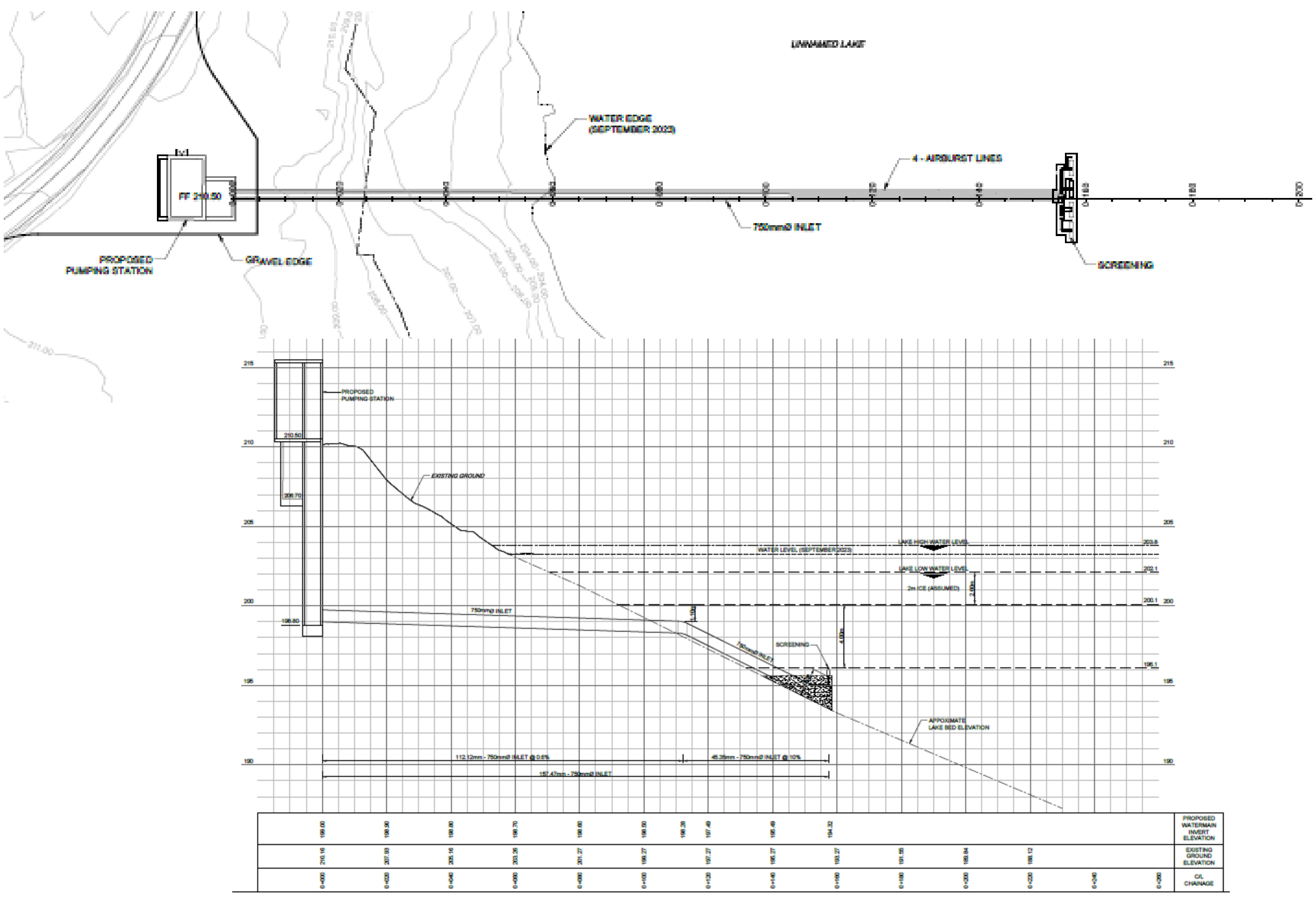



**Figure 8: Comparison of Simulated Water Levels Versus Measured Following 2019 Spring Freshet**



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***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 $m^2$ $A = \frac{pi*D^2}{4.00}$ **D= 0.84 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 x A = 1.00 m/s x 0.2972 $m^2$ = 0.2972 $m^3/s$ = **297.2 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 :

$h_m = k*(v^2/2g)$

k = 1.30

v = 1.87 m/s

g = 9.81 $m^2/s$

$\mathbf{h_m}$= **0.240 m**

Flow in pipe = **0.5560** $m^3/s$

Friction losses in piping:

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

L= **157.5** m

D= 0.6151 m

Q= 0.556 $m^3/s$

C= **120**

$\mathbf{h_f}$= **0.860 m**

$h_t$ = Minor losses + Friction losses

$\mathbf{h_t}$ = **1.100 m = 1.564 psi = 3.609 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 m - 1.41 m
= 200.69 m

Maximum water level in the Wet Well = High Lake Level - Losses in the Intake and Pipe
= 203.80 m - 1.41 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

Open Screen Area = Flow / Approach Velocity

= 0.5560 $m^3/s$ / 0.11 m/s

= 5.050 $m^2$

**Freshwater Intake End-of-Pipe Fish Screen Guideline**

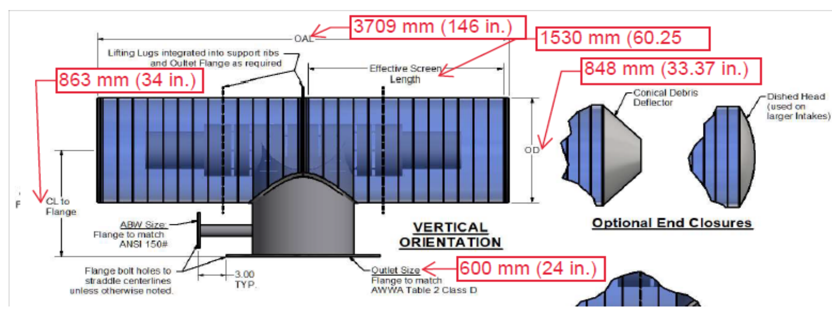
**Table 3 Examples of Screen Material**

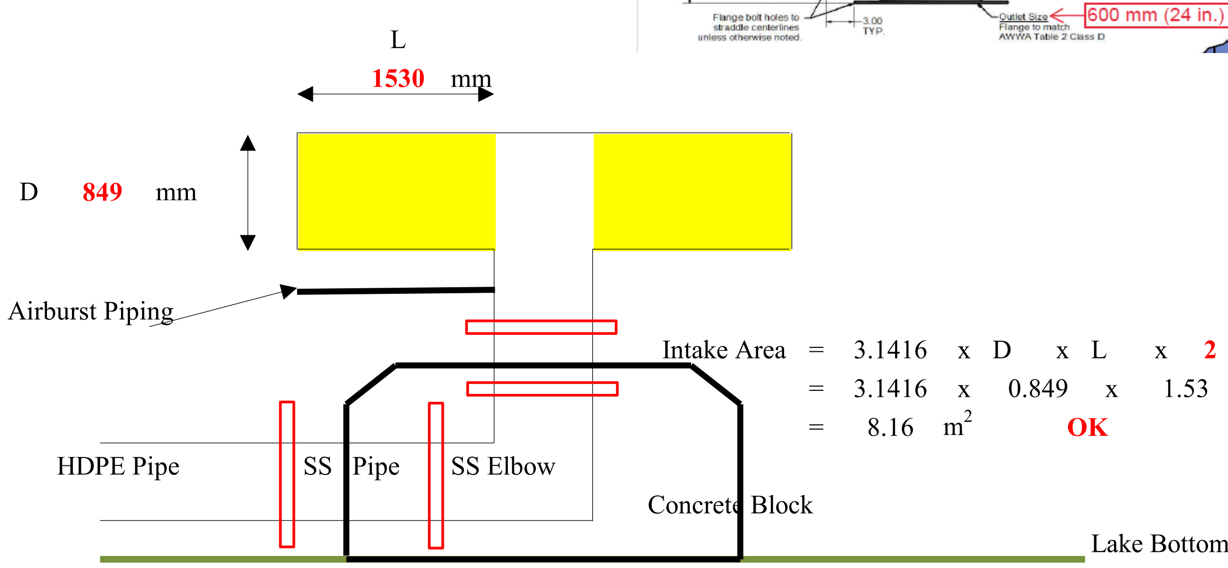
| Material | Wire Thickness | Opening Width | % Open Area |
|---|---|---|---|
| 8 x 8 Stainless Steel Alloy Mesh | 0.711 mm (0.028") | 2.44 mm (0.096") | 60 |
| #7 Mesh Wire Cloth | 1.025 mm (0.041") | 2.54 mm (0.100") | 51 |
| #8 Mesh Wire Cloth | 0.875 mm (0.035") | 2.25 mm (0.089") | 52 |
| #8 Mesh 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 |

Effective Screen Area = Open Screen Area / % Open Area/100

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

= 5.05 $m^2$ / 0.63 = 8.02 $m^2$




Intake Area = 3.1416 x D x L x **2**

= 3.1416 x 0.849 x 1.53 x 2.0

= 8.16 $m^2$ **OK**

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## 3.0 Pumping Station Design

### *3.01 Pump Discharge Piping*

***Ultimate Design*** **Q = 278.0 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 = 0.17 $m^2$ $A = \frac{pi*D^2}{4.00}$ **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** 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 0.15 $m^2$ = 0.12 $m^3/s$ = **120.65 L/s**

### *3.02 Pump Header Piping* 1 *Pump Running*

***Ultimate Design*** **Q = 278.0 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 = 0.12 $m^2$ $A = \frac{pi*D^2}{4.00}$ **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** 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 0.15 $m^2$ = 0.12 $m^3/s$ = **120.65 L/s**

### *3.03* **Pump Header Piping 1 Pumps Running**

***Ultimate Design*** **Q = 278.0 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 = 0.12 $m^2$ $A = \frac{pi*D^2}{4.00}$ **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** 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 0.27 $m^2$ = 0.22 $m^3/s$ = **219.16 L/s**

### *3.04* **Pump Header Piping 2 Pumps Running**

***Ultimate Design*** **Q = 556.0 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 = 0.23 $m^2$ $A = \frac{pi*D^2}{4.00}$ **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** 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 0.27 $m^2$ = 0.22 $m^3/s$ = **219.16 L/s**

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### *3.05 Forcemain Sizing*

***Ultimate Design*** **Q = 556.0 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 $A = Q/V$ $A = 0.2926$ $m^2$ $A = \frac{pi*D^2}{4.00}$ **D= 0.61 m**

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

| | | | | | | |
|---|---|---|---|---|---|---|
| Presure 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 |

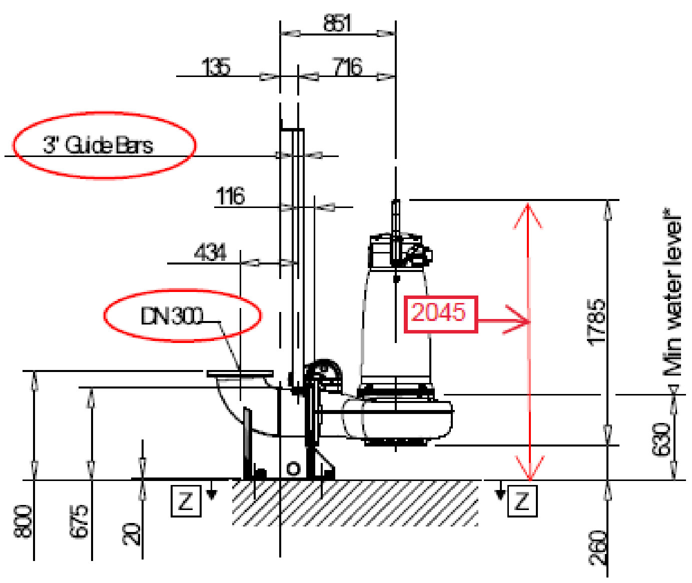
Actual Velocity = Q/A = **2.92** m/s **OK**

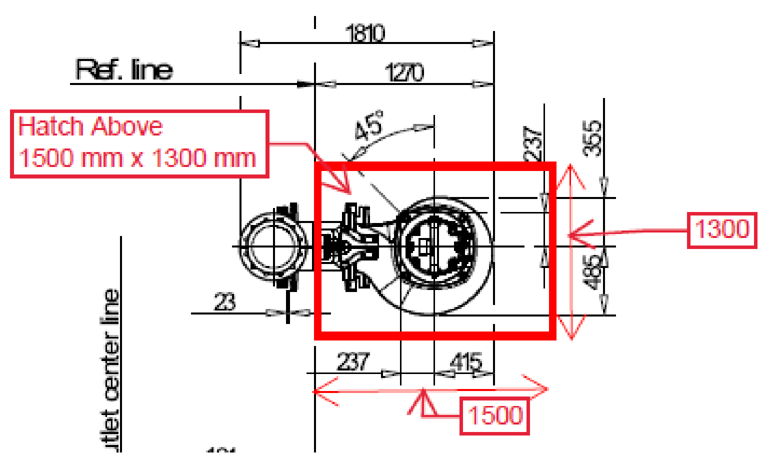
Minimum flow (scouring velocity) = **1.00** m/s = 3.28 ft/s

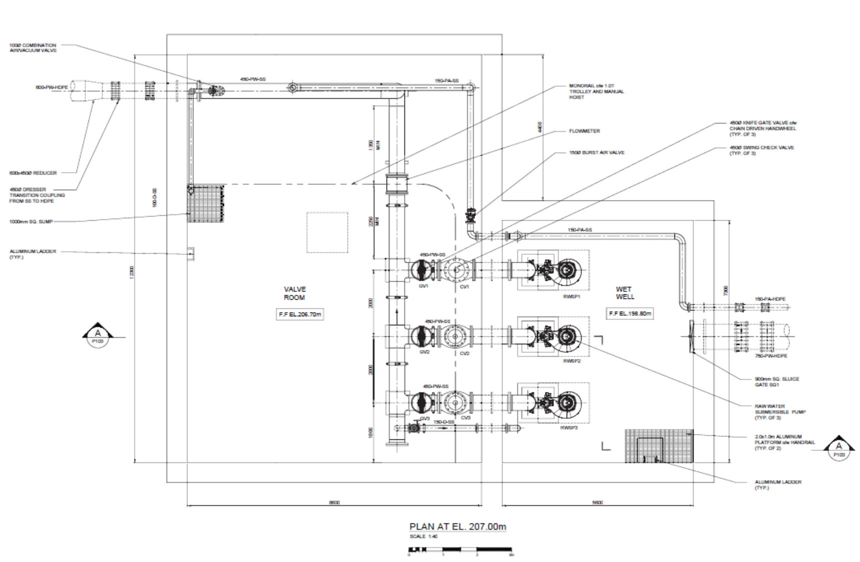
Minimum scouring flow for each pipe $Q_p$ = V x A = 1.00 m/s x 0.1902 $m^2$ = 0.1902 $m^3/s$ = **190.2 L/s**

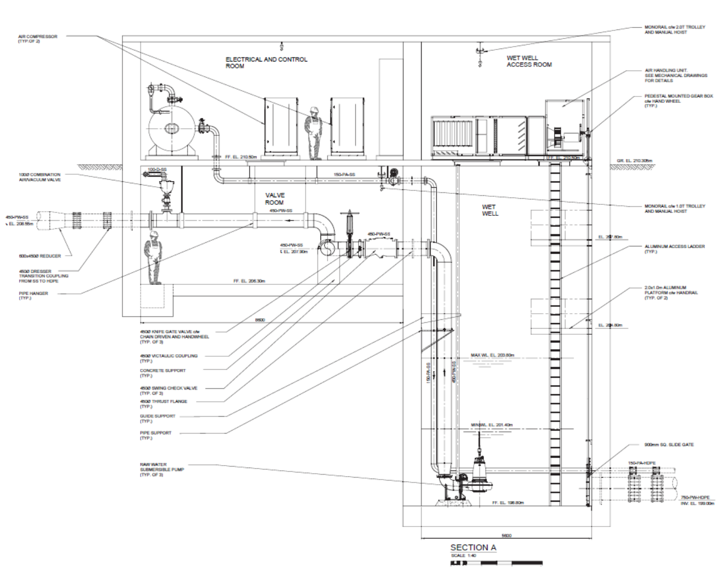
### 4.0 Pump Sizing

**NP 3315 LT 3~ 627**



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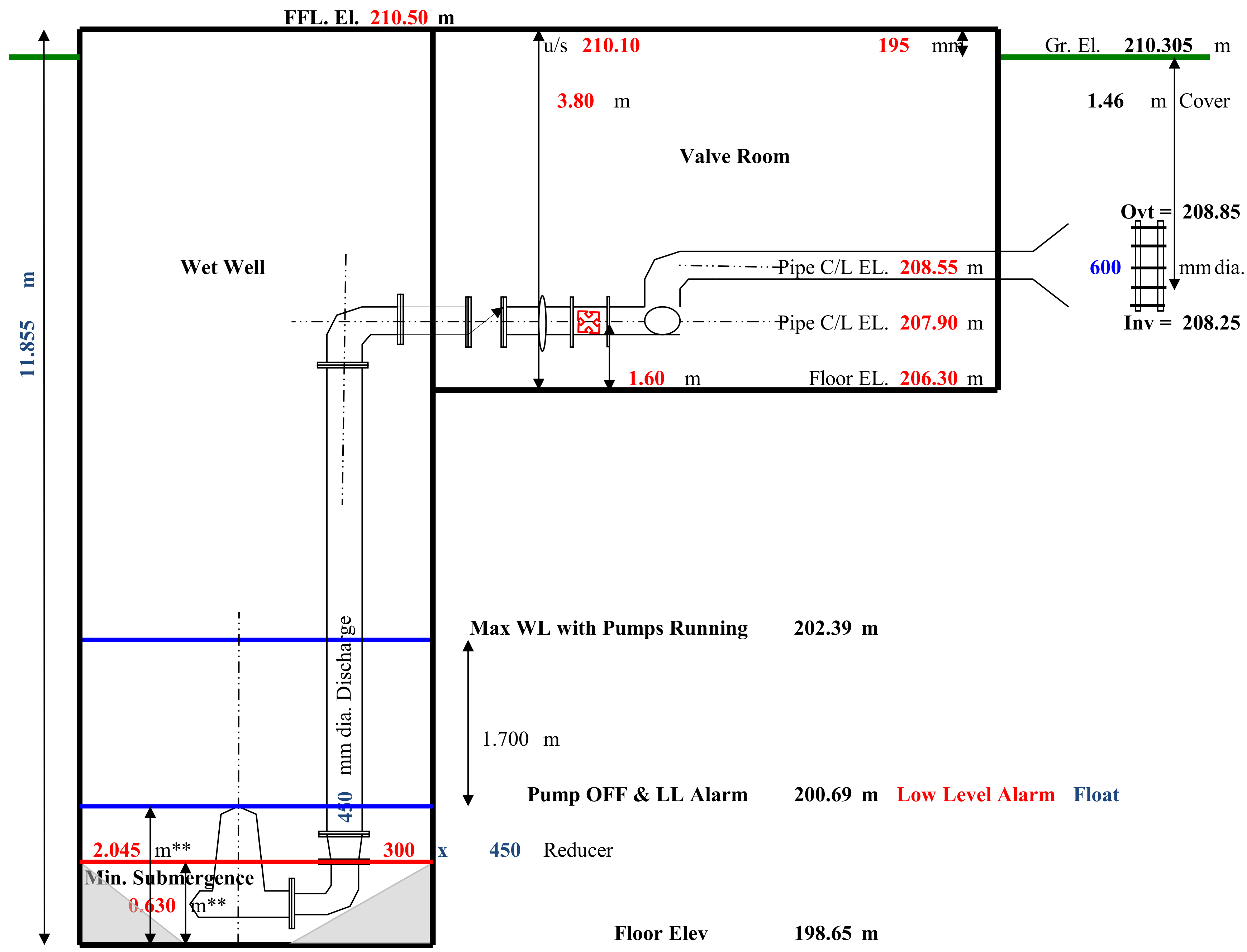


*4.01 TDH on Pumps*

**Losses in Pump Discharge Elbow**

Inside Dia. of pipe = **0.300** m

Minor losses in piping :

$h_m = k*(v^2/2g)$

k = 0.55

v = 3.93 m/s

g = 9.81 $m^2/s$

$h_m$ = **0.440 m**

Flow in pipe = **0.2780** $m^3/s$

Friction losses in piping:

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

L= 0.0 m

D= 0.300 m

Q= 0.2780 $m^3/s$

C= 150

$h_f$ = **0.000 m**

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

$h_s$ = **198.65** - **198.65** = **0.00 m**

$h_t$ = Minor losses + Friction losses + Static Difference

$h_t$ = **0.440 m = 0.626 psi = 1.444 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 |

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### Losses from Pump (P3) to Discharge Header in the Valve Chamber

Inside Dia. of pipe = **0.438** m

Flow in pipe = **0.2780** $m^3/s$

Minor losses in piping :

$h_m = k*(v^2/2g)$

k = 4.79

v = 1.84 m/s

g = 9.81 $m^2/s$

**$h_m$ = 0.830 m**

Friction losses in piping:

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

L= 10.3 m

D= 0.438 m

Q= 0.2780 $m^3/s$

C= **150**

**$h_f$ = 0.060 m**

Static difference = Elev. @ Header Centerline - Maximum Water Level in Wet Well

**$h_s$ = 207.900 - 202.390 = 5.510 m**

$h_t$ = Minor losses + Friction losses + Static Difference

**$h_t$ = 6.400 m = 9.101 psi = 20.997 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 |
| 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 | 1 | 1.80 |
| 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 | 0 | 0.00 |
| | **Total** | | **4.79** |

### Losses from TEE (P3) toTEE (P2) on Discharge Header

Inside Dia. of pipe = **0.438** m 304L Stainles

Flow in pipe = **0.2780** $m^3/s$

Minor losses in piping :

$h_m = k*(v^2/2g)$

k = 0.85

v = 1.84 m/s

g = 9.81 $m^2/s$

**$h_m$ = 0.150 m**

Friction losses in piping:

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

L= 2.00 m

D= 0.438 m

Q= 0.2780 $m^3/s$

C= **150**

**$h_f$ = 0.020 m**

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

**$h_s$ = 207.90 - 207.90 = 0.000 m**

$h_t$ = Minor losses + Friction losses + Static Difference

**$h_t$ = 0.170 m = 0.242 psi = 0.558 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 | 0 | 0.00 |
| Wye | 1.00 | 0 | 0.00 |
| 90 deg - Tee | 1.80 | 0 | 0.00 |
| 180 deg - Tee | 0.60 | 1 | 0.60 |
| Reducer / Increase | 0.25 | 1 | 0.25 |
| Bell Mouth Inlet | 0.04 | 0 | 0.00 |
| Exit | 1.00 | 0 | 0.00 |
| | **Total** | | **0.85** |

### Losses from TEE (P2) on Discharge Header to Reducer Outside of Valve Room

Inside Dia. of pipe = **0.591** m 304L Stainles

Flow in pipe = **0.5560** $m^3/s$

Minor losses in piping :

$h_m = k*(v^2/2g)$

k = 1.45

v = 2.03 m/s

g = 9.81 $m^2/s$

**$h_m$ = 0.310 m**

Friction losses in piping:

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

L= 14.85 m

D= 0.591 m

Q= 0.5560 $m^3/s$

C= **150**

**$h_f$ = 0.070 m**

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

**$h_s$ = 208.55 - 207.90 = 0.650 m**

$h_t$ = Minor losses + Friction losses + Static Difference

**$h_t$ = 1.030 m = 1.465 psi = 3.379 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 | 2 | 0.60 |
| Wye | 1.00 | 0 | 0.00 |
| 90 deg - Tee | 1.80 | 0 | 0.00 |
| 180 deg - Tee | 0.60 | 1 | 0.60 |
| Reducer / Increase | 0.25 | 1 | 0.25 |
| Bell Mouth Inlet | 0.04 | 0 | 0.00 |
| Exit | 1.00 | 0 | 0.00 |
| | **Total** | | **1.45** |

| | | | |
|---|---|---|---|
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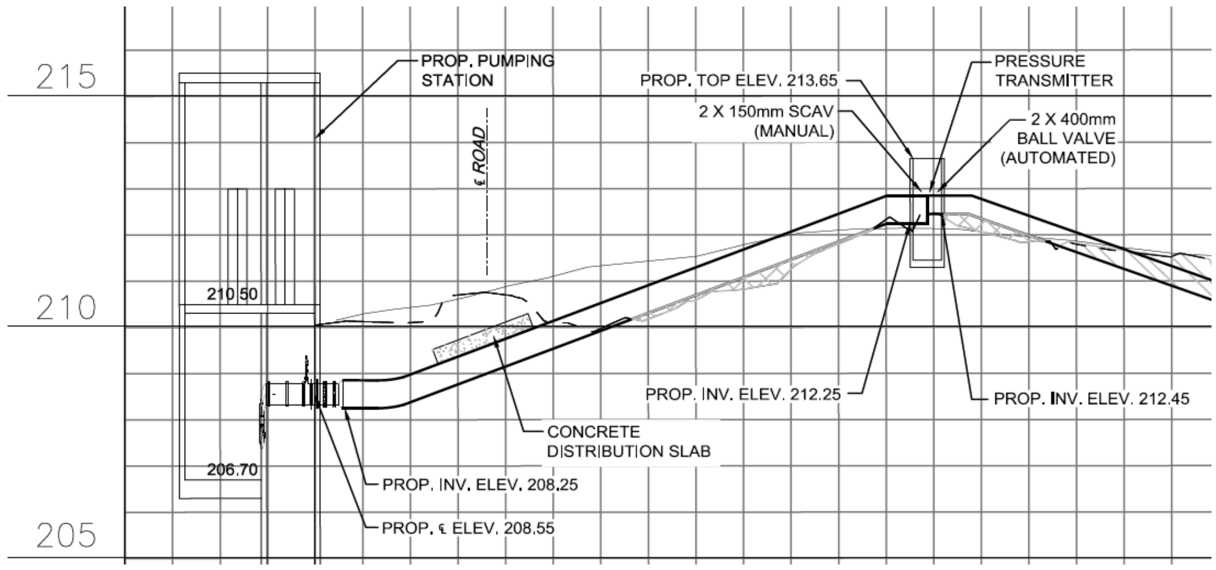
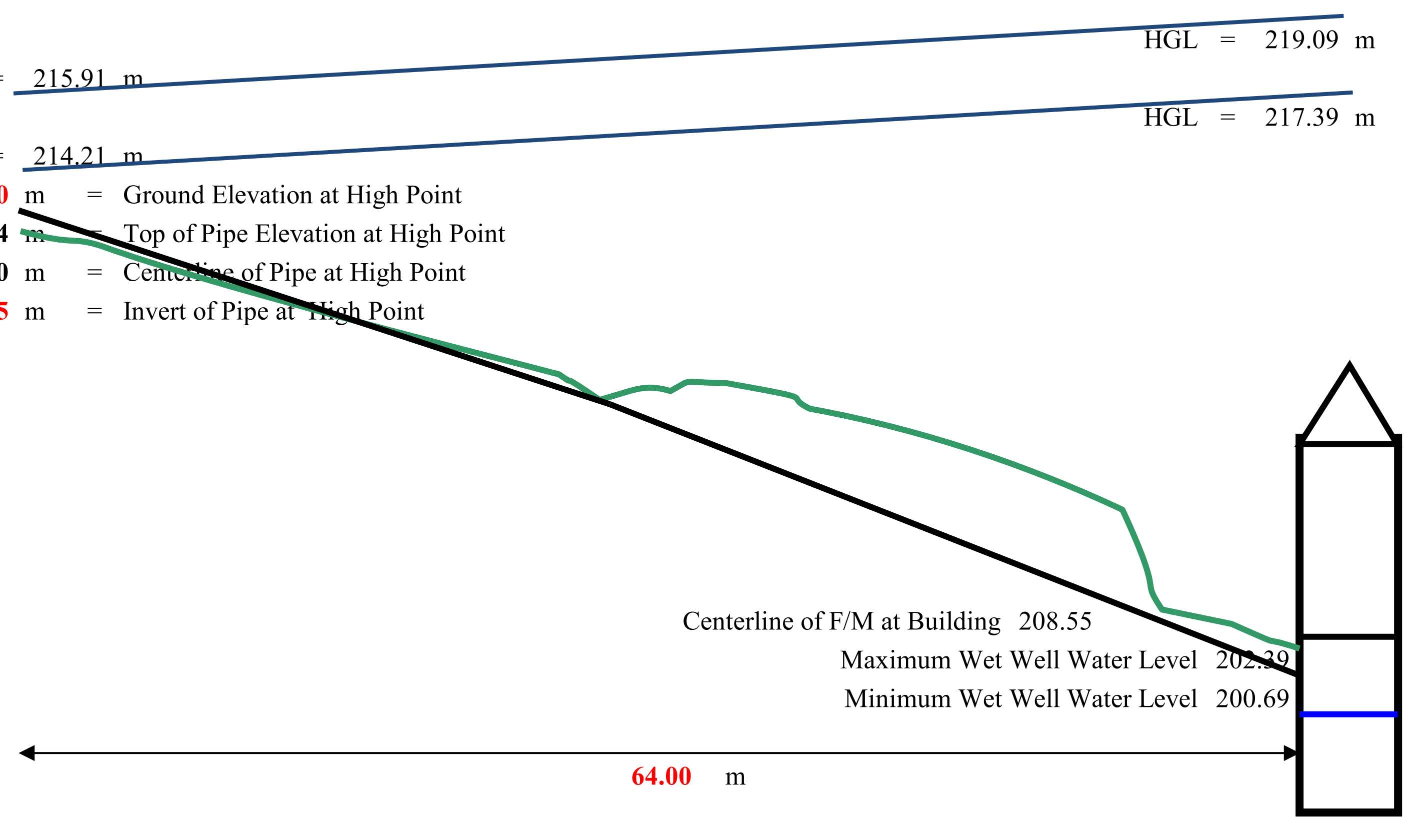



**Losses in Forcemain from P/Stn to High Point**

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

Flow in pipe = **0.5560** $m^3/s$

Minor losses in piping:

$h_m = k*(v^2/2g)$

k = 1.40

v = 2.92 m/s

g = 9.81 $m^2/s$

**$h_m$ = 0.610 m**

Friction losses in piping:

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

L = 64.0 m

D = 0.4921 m

Q = 0.556 $m^3/s$

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 m**

$h_t$ = Minor losses + Friction losses + Static Difference

**$h_t$ = 5.246 m = 7.460 psi = 17.211 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** |

ARCADIS

| | | | |
|---|---|---|---|
| PROJECT | City of Iqaluit - Raw Water Pumping Station | PROJECT NO. | 144081 |
| | | DATE | August 28, 2024 |
| COMPUTED BY | Paul Dagenais | CHECKED BY | |

***4.02 Conveyance Pipe Sizing***

***Ultimate Design*** **Q = 278.0 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 $m^2$  $A = \frac{pi*D^2}{4.00}$  **D= 0.43 m**

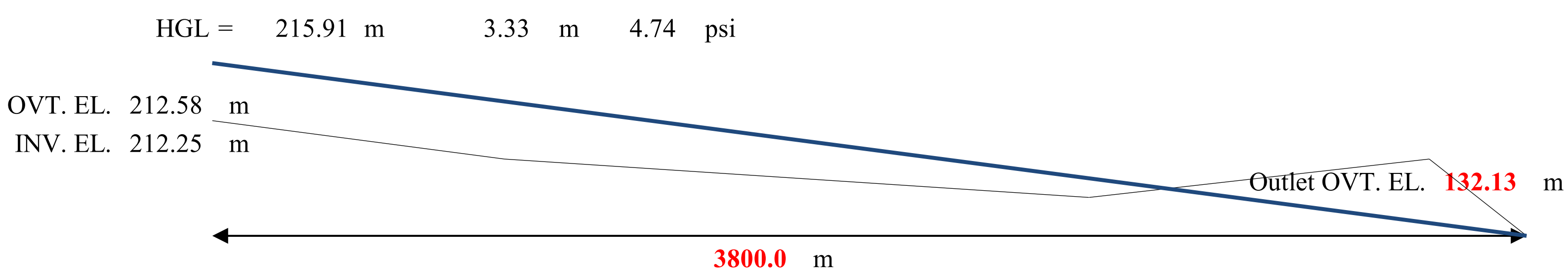
**Use 2 - 400 mm** ( 16 in.) **diameter HDPE DR 11**

| | | | | | | |
|---|---|---|---|---|---|---|
| Presure 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 x A = 1.00 m/s x 0.0845 $m^2$ = 0.0845 $m^3/s$ = **84.5 L/s**

**LOSSES IN CONVEYANCE PIPE to OUTFALL**




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

Minor losses in piping :

$h_m = k*(v^2/2g)$

k = 5.45

v = 3.29 m/s

g = 9.81 $m^2/s$

$h_m$ = **3.010 m**

Flow in pipe = **0.278** $m^3/s$

Friction losses in piping:

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

L= **3800.0** m

D= 0.328 m

Q= 0.2780 $m^3/s$

C= **150**

$h_f$ = **80.770 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 | 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** |

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

**$h_s$ = 132.13 - 212.58 = -80.450 m**

$h_t$ = Minor losses + Friction losses + Static Difference

**$h_t$ = 3.330 m = 4.735 psi = 10.925 feet**

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| **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*** $= \frac{Q\ (L/s)\ x\ TDH\ (m)}{102}$ = 45.5 kW = 61.0 hp

***4.03 Brake Horsepower*** $= \frac{\text{Hydraulic Horsepower}}{\text{pump efficiency (\%)}}$ = 60.7 kW = 81.4 hp

Eff = **75%** at runout say 82.1 kW

**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 | 11.81 |
| | MIN. | m | 10.11 | 10.11 | 10.11 |
| TOTAL DYNAMIC HEAD | MAX. | m | 15.12 | 14.98 | 14.99 |
| | MIN. | m | 13.42 | 13.28 | 13.29 |

### *4.04 Surge Pressure on Forcemain*

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

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

where:

a = Wave velocity = $\text{sqrt}\left( \frac{K}{\rho \left( 1 + \frac{K}{E} \times \psi \right)} \right)$ 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 | = | $1-\mu^2$ | = | 0.84 | |

*h) Alternate Method*

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

**a = 323 P = 96.15 m = 136.73 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: $h_f$ = $({}_{0.54}rt(Q/(0.278*C*D^{2.63}))*L)$

L = **611.09 m**

Where: $h_f$ = 6.510 m

D = 0.4921 m

Q = 0.5560 $m^3/s$

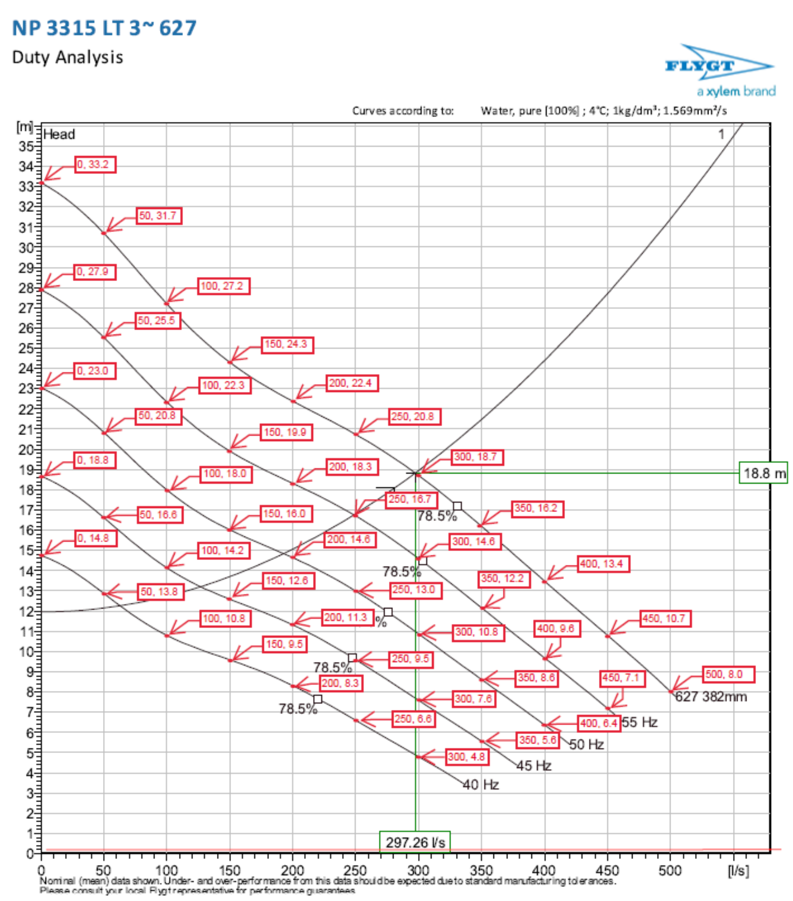
C = **150**

| | | | | | |
|---|---|---|---|---|---|
| Length of Forcemain | = | **611.09** | m | HLL = | **202.39** m |
| Forcemain Discharge Elevation | = | **212.74** | m | MLL = | **201.54** m |
| | | | | LLL = | **200.69** m |

Pipe Area = **0.190** $m^2$

| | 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** | | |



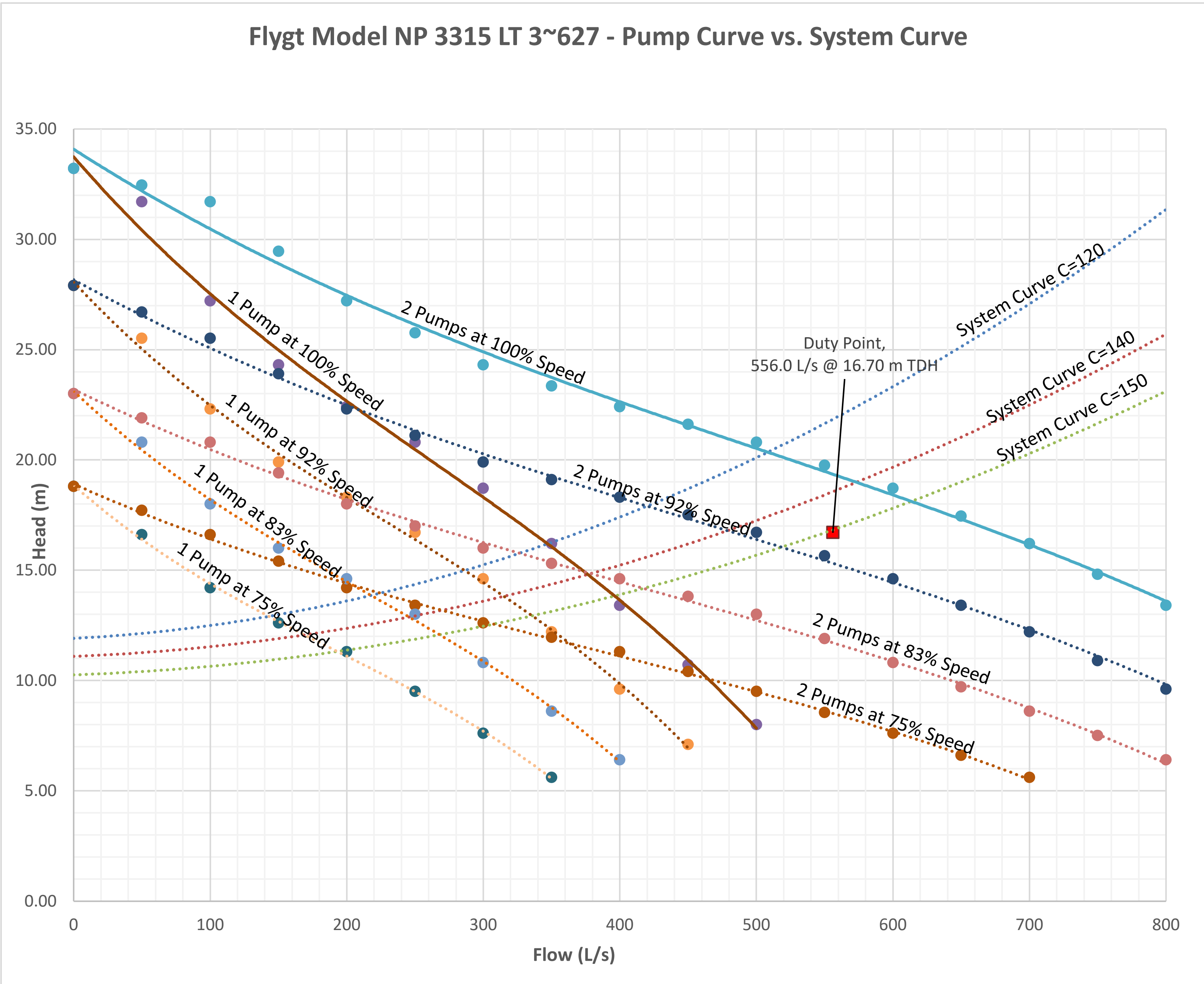
PROJECT City of Iqaluit - Raw Water Pumping Station

PROJECT NO. 144081

DATE August 28, 2024

COMPUTED BY Paul Dagenais

CHECKED BY



| | | | |
|---|---|---|---|
| ARCADIS PROJECT | City of Iqaluit - Apex River Raw Water Pumping Station | PROJECT NO. | 30182375 |
| | | DATE | September 24, 2025 |
| COMPUTED BY | Mel Zhang | CHECKED BY | Kevin Celian |

**City of Iqaluit - Raw Water Pumping Station**

**1.0 Design Criteria**

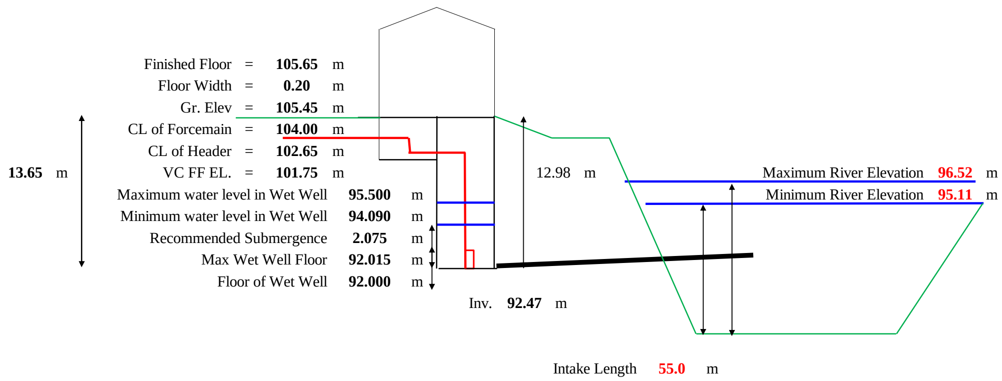
To meet 1,000,000 cubic meters of raw water ( PDR page 12)

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 a 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 $m^2$ $A = \frac{pi*D^2}{4.00}$ **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 x A = 1.00 m/s x 0.2199 $m^2$ = 0.2199 $m^3/s$ = **219.9 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 $m^2$ $A = \frac{pi*D^2}{4.00}$ **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 x A = 1.00 m/s x 0.2199 $m^2$ = 0.2199 $m^3/s$ = **219.9 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 :

$h_m = k*(v^2/2g)$

k = 2.19

v = 1.82 m/s

g = 9.81 $m^2/s$

**$h_m$= 0.370 m**

Flow in pipe = **0.400** $m^3/s$

Friction losses in piping:

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

L= **55.0** m

D= 0.5291 m

Q= 0.400 $m^3/s$

C= **120**

**$h_f$ = 0.340 m**

$h_t$ = Minor losses + Friction losses

**$h_t$ = 0.710 m = 1.010 psi = 2.329 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 |

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

**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

### *2.02 Intake Screen*

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

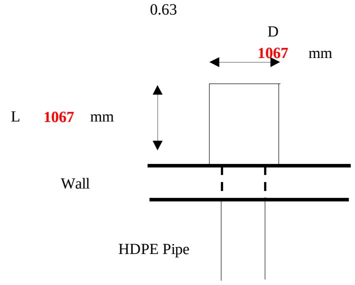
Screen approach velocity of approximately **0.11** m/s = 0.361 fps is required for the subcarangiform fish

Open Screen Area = Flow / Approach Velocity
= 0.4000 $m^3/s$ / 0.11 m/s
= 3.640 $m^2$

Effective Screen Area = $\frac{\text{Open Screen Area}}{\text{\% Open Area/100}}$

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

= $\frac{3.64 \ m^2}{0.63}$ = 5.78 $m^2$




Intake Area = 3.1416 x D/2 x L x **2**
= 3.1416 x 0.534 x 1.07 x 2.0
= 3.58 $m^2$

Two Intake Screens = 7.15 $m^2$ **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 $m^2$ 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 $m^2$ = 0.08 $m^3/s$ = **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 $m^2$ 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 $m^2$ = 0.08 $m^3/s$ = **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 $m^2$ 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 $m^2$ = 0.13 $m^3/s$ = **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 $m^2$ 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 $m^2$ = 0.13 $m^3/s$ = **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 $m^2$ A = $\frac{pi*D^2}{4.00}$ **D= 0.37 m**

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

Presure 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**

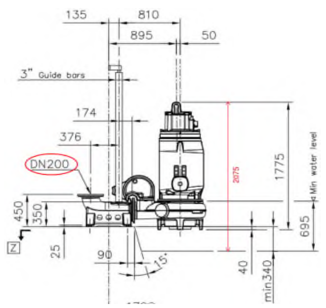
Minimum flow (scouring velocity) = **1.00** m/s = 3.28 ft/s

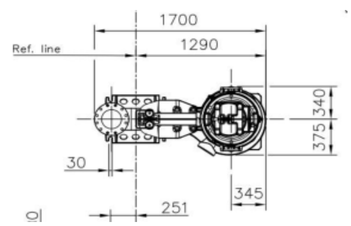
Minimum scouring flow for each pipe $Q_p$ = V x A = 1.00 m/s x 0.1000 $m^2$ = 0.1000 $m^3/s$ = **100.0 L/s**

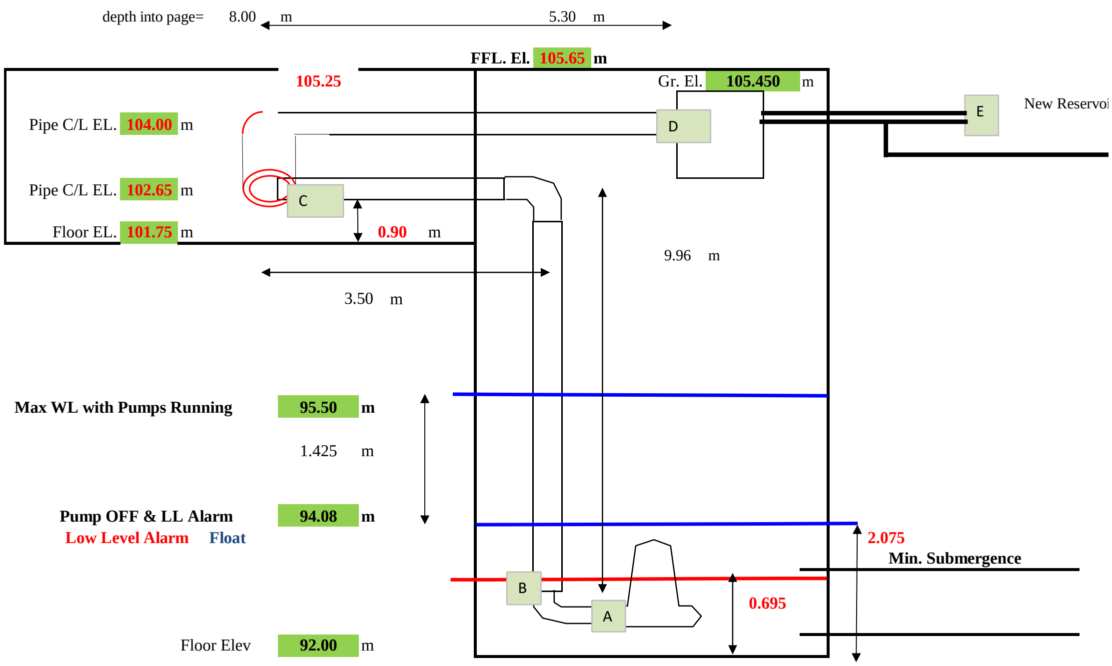
SIZING SUMMARY

| | | |
|---|---|---|
| 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**




***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 :

$h_m = k*(v^2/2g)$

k = 0.55

v = 6.37 m/s

g = 9.81 $m^2/s$

$\mathbf{h_m}$ = **1.140 m**

Flow in pipe = **0.2000** $m^3/s$

Friction losses in piping:

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

L= **0.0** m

D= 0.200 m

Q= 0.2000 $m^3/s$

C= **150**

$\mathbf{h_f}$ = **0.000 m**

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

$\mathbf{h_s}$ = **92.00** - **92.00** = **0.00 m**

$h_t$ = Minor losses + Friction losses + Static Difference

$\mathbf{h_t}$ = **1.140 m = 1.621 psi = 3.740 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** |

**Maximum Losses from Pumps to Discharge Header in the Valve Chamber B to C (from Pump 3; L of 2m = length of 350 mm section in pump header)**

Inside Dia. of pipe = **0.350** m

Flow in pipe = **0.2000** $m^3/s$

Minor losses in piping :

$h_m = k*(v^2/2g)$

k = 3.84

v = 2.08 m/s

g = 9.81 $m^2/s$

**$h_m$ = 0.850 m**

Friction losses in piping:

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

L= 16.8 m

D= 0.350 m

Q= 0.2000 $m^3/s$

C= 150

**$h_f$ = 0.150 m**

Static difference = Elev. @ Header Centerline - Minimum Water Level in Wet Well

**$h_s$ = 102.650 - 94.075 = 8.575 m**

$h_t$ = Minor losses + Friction losses + Static Difference

**$h_t$ = 9.575 m = 13.616 psi = 31.414 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 |
| 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 | 1 | 0.60 |
| Reducer / Increase | 0.25 | 1 | 0.25 |
| Bell Mouth Inlet | 0.04 | 0 | 0.00 |
| Exit | 1.00 | 0 | 0.00 |
| | **Total** | | **3.84** |

**Maximum Losses from tee (P2) on Discharge Header to end of SS pipe, C to D (2 pumps running)**

Inside Dia. of pipe = **0.450** m

Flow in pipe = **0.4000** $m^3/s$

Minor losses in piping :

$h_m = k*(v^2/2g)$

k = 1.80

v = 2.52 m/s

g = 9.81 $m^2/s$

**$h_m$ = 0.590 m**

Friction losses in piping:

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

L= 14.65 m

D= 0.450 m

Q= 0.4000 $m^3/s$

C= 150

**$h_f$ = 0.140 m**

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

**$h_s$ = 104.00 - 102.65 = 1.35 m**

$h_t$ = Minor losses + Friction losses + Static Difference

**$h_t$ = 2.080 m = 2.958 psi = 6.824 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 | 2 | 0.60 |
| 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 | 0 | 0.00 |
| Bell Mouth Inlet | 0.04 | 0 | 0.00 |
| Exit | 1.00 | 0 | 0.00 |
| | **Total** | | **1.80** |

**Losses in Forcemain from P/Stn to NR Discharge, D to E, Route 1**

Inside Dia. of pipe = **0.3568** m

Flow in pipe = **0.2000** $m^3/s$

Minor losses in piping :

$h_m = k*(v^2/2g)$

k = 8.88

v = 2.00 m/s

g = 9.81 $m^2/s$

**$h_m$ = 1.820 m**

Friction losses in piping:

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

L= 495.0 m

D= 0.3568 m

Q= 0.200 $m^3/s$

C= 150

**$h_f$ = 3.810 m**

Static difference = DISCHARGE TO NEW RESEVOIR - CL OF PIPE LEAVING THE BUILDING AND

**$h_s$ = 132.00 - 104.00 = 28.000 m**

$h_t$ = Minor losses + Friction losses + Static Difference

**$h_t$ = 33.630 m = 47.822 psi = 110.335 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 | 14 | 2.80 |
| 90 deg. Bend | 0.30 | 1 | 0.30 |
| Wye | 1.00 | 0 | 0.00 |
| 90 deg - Tee | 1.80 | 1 | 1.80 |
| 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 | 1 | 1.00 |
| | **Total** | | **8.88** |

**Losses in Forcemain from P/Stn to NR Discharge, D to E, Route 2, short**

Inside Dia. of pipe = **0.3568** m

Flow in pipe = **0.2000** $m^3/s$

Minor losses in piping :

$h_m = k*(v^2/2g)$

k = 9.32

v = 2.00 m/s

g = 9.81 $m^2/s$

**$h_m$ = 1.910 m**

Friction losses in piping:

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

L= 500.0 m

D= 0.3568 m

Q= 0.200 $m^3/s$

C= 150

**$h_f$ = 3.840 m**

Static difference = DISCHARGE TO NEW RESEVOIR - CL OF PIPE LEAVING THE BUILDING AND

**$h_s$ = 132.00 - 104.00 = 28.000 m**

$h_t$ = Minor losses + Friction losses + Static Difference

**$h_t$ = 33.75 m = 47.993 psi = 110.728 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 | 2 | 0.08 |
| 11.25 deg. Bend | 0.15 | 0 | 0.00 |
| 22.5 deg. Bend | 0.15 | 0 | 0.00 |
| 45 deg. Bend | 0.20 | 13 | 2.60 |
| 90 deg. Bend | 0.30 | 1 | 0.30 |
| Wye | 1.00 | 0 | 0.00 |
| 90 deg - Tee | 1.80 | 1 | 1.80 |
| 180 deg - Tee | 0.60 | 1 | 0.60 |
| Reducer / Increase | 0.25 | 1 | 0.25 |
| Bell Mouth Inlet | 0.04 | 0 | 0.00 |
| Exit | 1.00 | 1 | 1.00 |
| | **Total** | | **9.32** |

**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** $m^3/s$

Minor losses in piping :

$h_m = k^*(v^2/2g)$

k = 9.28

v = 2.00 m/s

g = 9.81 $m^2/s$

**$h_m$ = 1.900 m**

Friction losses in piping:

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

L= 1100.0 m

D= 0.3568 m

Q= 0.200 $m^3/s$

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 | = **53.929 psi** | = **124.426** | **feet** |
| To Lake Geraldine | = 111.30 **m** | - **94.075 m** | | |
| | = 17.225 | = **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*** = Q (L/s) x TDH (m) / 102 = 91.3 kW = 122.4 hp

***4.03 Brake Horsepower*** = Hydraulic Horsepower / pump efficiency (%) Eff = **73%** = 125.0 kW = 167.6 hp say 138.0 kW, **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. | m | 37.91 | 37.91 | 37.91 | |
| | MIN. | m | 36.50 | 36.50 | 36.50 | |
| TOTAL DYNAMIC HEAD | MAX. | m | 41.22 | 41.08 | 46.41 | |
| | MIN. | m | 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:

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

| | | | | | |
|---|---|---|---|---|---|
| V | = | velocity of water stopped | = | 2.00 | 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 | = | 0.219 | 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 | $m/s^2$ |
| Q | = | maximum flow in the conduit | = | 0.4000 | $m^3/s$ |
| C | = | $1-\mu^2$ | = | 0.84 | |

*a) Rigid Conduits* — **Not Applicable**

ψ = 0.00   a = 1468   P = 299.36 m = 425.69 psi

*b) Thick Walled Elastic Conduits Anchored Against Longitudinal Movement Throughout its Length* — **Not Applicable**

$$\psi = 2 \times (1-\mu) \times \frac{R_0^2 + R_i^2}{R_0^2 - R_i^2} - \frac{2\mu R_i^2}{R_0^2 - R_i^2}$$

= 4.40   a = 454   P = 92.61 m = 131.69 psi

*c) Thick Walled Elastic Conduits Anchored Against Longitudinal Movement at the Upper End* — **Not Applicable**

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

= 9.59   a = 316   P = 64.39 m = 91.56 psi

*d) Thick Walled Elastic Conduits with Frequent expansion Joints* — **Not Applicable**

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

= 10.79   a = 298   P = 60.86 m = 86.54 psi

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

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

= 7.46   a = 356   **P = 72.54 m = 103.16 psi**

*f) Thin Walled Elastic Conduits Anchored Against Longitudinal Movement at the Upper End* — **Not Applicable**

$$\psi = \frac{d}{e}\left(1.25 - \mu\right)$$

= 8.89   a = 327   P = 66.76 m = 94.93 psi

*g) Thin Walled Elastic Conduits with Frequent expansion Joints* — **Not Applicable**

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

= 8.88   a = 328   P = 66.80 m = 94.99 psi

*h) Alternate Method*

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

**a = 356   P = 72.54 m = 103.16 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**

| | | | |
|---|---|---|---|
| PROJECT | City of Iqaluit - Apex River Raw Water Pumping Station | PROJECT NO. | 30182375 |
| | | DATE | September 24, 2025 |
| COMPUTED BY | Mel Zhang | CHECKED BY | Kevin Celian |

## 5.0 Pump Curves

***Pumping Station Piping Losses***

Headloss in forcemain (not including Static Losses) 8.62 m

Equivalent length of HDPE pipe (L)

Friction losses in piping: $h_f$ = $(_{0.54}rt(Q/(0.278*C*D^{2.63}))*L)$

L = **311.05** **m**

Where: $h_f$ = 8.620 m

D = 0.3568 m

Q = 0.4000 $m^3/s$

C = **150**

Pipe Area = **0.100** $m^2$

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 | 7 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **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 | 9 |
| 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 | 7 |
| 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 | 6 |
| 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 | 6 |

**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** | | | | |