SNC·LAVALIN	TECHNICAL NOTE Adaptive Water Management Strategy at Lake A53	Prepared by: D. Chen / H. Tellez Reviewed by: A.L. Nguyen		
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Client: **AGNICO-EAGLE MINES**

Project: **DETAILED ENGINEERING OF WATER MANAGEMENT AND GEOTECHNICAL INFRASTRUCTURE AT AMARUQ**

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REVISION INDEX

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1.0 Introduction

Agnico Eagle Mines Limited, Meadowbank Division ("Agnico Eagle") is developing the Whale Tail Pit, a satellite gold deposit on the Amaruq Whale Tail property, as a continuation of current mine operations and milling at the Meadowbank Mine. The Amaruq Whale Tail property is a 408 km² site located on Inuit Owned Land, approximately 150 km north of the Hamlet of Baker Lake and approximately 50 km northwest of the Meadowbank Mine in the Kivalliq region of Nunavut. The Meadowbank Mine is an approved mining operation and Agnico Eagle will extend the life of the mine by constructing and operating the Whale Tail Pit.

Currently, water flows naturally from the Lake A53 to the Whale Tail Lake, as shown in Figure 1-1. As part of the Amaruq project, a Whale Tail Dike will be built in Whale Tail Lake, separating the lake into the north and south lake. The North Whale Tail Lake will be dewatered to allow for the construction of the open pit and the future Whale Tail Attenuation Pond. The discharge from Lake A53 is planned to be diverted to the South Whale Tail Lake via a new diversion channel called the East Channel (refer to the Design Report of East Diversion Channel, 6118-E-132-002-TCR-018, for details).

Figure 1-1: Whale Tail Lake and Lake A53

However, the East Channel will not be constructed prior to the 2019 freshet. An adaptive water management strategy at Lake A53 was developed to manage the water from this lake prior to the East Channel construction during the spring melt and summer period with the following objectives:

- Prevent fish migration from Lake A53 toward Whale Tail North Basin during the dewatering operations;
- Maintain a dry East Channel construction area.

The adaptive water management strategy at Lake A53 consists of maintaining a lower water level by pumping the water from this lake toward Whale Tail Attenuation Pond via an above-ground pipeline.

The following technical note presents the hydrological analysis used to assess the pumping requirements to manage the water level in Lake A53 and provides a description of the required pumping and piping infrastructure.

2.0 Hydrological Analysis

2.1 Background Information

To carry out the hydrological analysis for this mandate, data from a previous hydrological assessment conducted by SNC in 2018 at the Amaruq site-location were used. This hydrological analysis is fully described in SNC (2018). Table 2-1, 2-2 and 2-3 summarize the data obtained from this study with return periods from 1:2 years to 1:100 years, in 72 hr.

Table 2-1: Spring Rainfalls (1950-2016)

Return Period [year]	72- hour Spring Rainfall [mm]
2	12.9
5	20.5
10	25.5
25	30.5
50	37.0
100	41.9

Table 2-2: Summer-Fall Rainfalls (1950-2016)

Return Period [year]	72- hour Summer - Fall Rainfall [mm]
2	30.8
5	43.0
10	51.2
25	59.0
50	69.2
100	76.8

Table 2-3: Maximum Annual Statistical Snowpack

Return Period [year]	Maximum Annual Snowpack [mm water-eq]
2	105
5	142
10	165
25	185
50	209
100	226

As previously established in the hydrological model (SNC, 2018), hyetographs for the present analysis were based on a 25-day snowmelt with peaks obtained using the “Alternating Block Method”.

2.2 Physical Characteristics

Figure 2-1 shows the general location of Lake A53 and its corresponding sub-drainage area which was obtained to be approximately 146.5 ha.

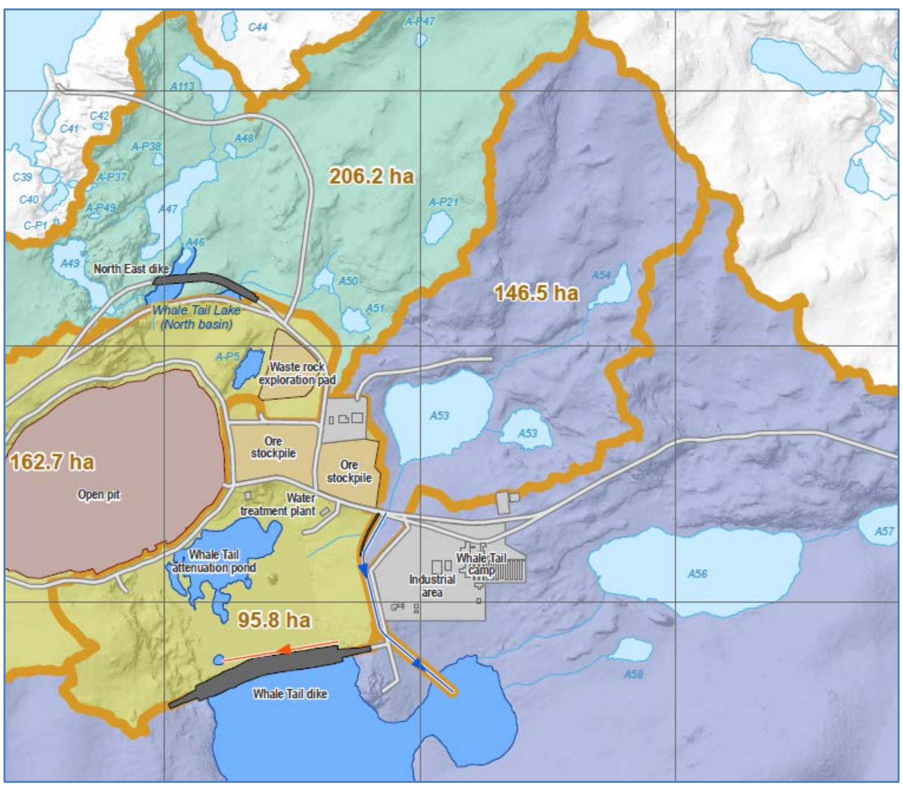


Figure 2-1: General Location of Lake A53

2.3 Assumptions and Considerations

The principal purpose of this hydrological analysis was to evaluate if a pumping capacity of 1,000 m^3/h would be sufficient to maintain the water level at El.160.93 m during the spring freshet. This elevation was determined to be 0.8 m below the normal water level (El. 161.73 m) in the lake (Lake A53). For this analysis, pumping requirements during following flood scenarios were evaluated:

- 1:100-Year Event,
- 1:10-Year Event, and
- 1:2-Year Event

The following assumptions were taken into consideration:

- A runoff coefficient of 1.0 was adopted due to permafrost conditions;
- Maximum pumping flow 1,000 m^3/h;
- Total drainage area 148.3 ha;
- Starting Lake A53 Elevation 160.93 m (El. 161.73 – 0.8 m); and
- Maximum allowed water elevation 161.33 m.

2.4 Level Pool Routing

Level-pool-routings were conducted to verify if the water levels described in Section 2.3 could be maintained during the indicated scenarios. Table 2-4 summarizes the results obtained during this assessment.

Table 2-4: Level Pool Routing Results

Return Period (Yr)	Starting Date	Minimum Required Pumping Rate (m^3/h)	WL* (m)	Max WL** (m)	(WL)-(Max WL) (m)
1:2-Yr	3 days > Spring	230	161.33	161.33	0.00
1:10-Yr	3 days > Spring	400	161.33	161.33	0.00
1:100-Yr	3 days > Spring	1,000	161.36	161.33	-0.03

*Highest Water Level (WL) obtained during the routing analysis.
*Maximum Water Level (Max WL) allowed in the analysis.

Based on the results shown in Table 2-4, it can be concluded:

- For an event with return period of 1:2 years, a pump with a minimum pumping capacity of 230 m^3/h would be sufficient to maintain the water level below or equal to the maximum-allowed-water-level;
- For the 1:10-Year event, the minimum pumping capacity would be 400 m^3/h;
- For the 1:100-Year event the maximum pumping capacity of 1,000 m^3/h would be able to keep the water level slightly higher (0.03 m) above the Max WL (El. 161.33 m).

Another simulation was carried out to verify the highest water level that could be reached by varying the pumping rate with flood return period of 1:100 -Year and a 3-day pumping delay after spring freshet. It was concluded that the same highest water level was observed when the pumping rate used was over 570 m^3/h. In other word, for events equal or lesser than the 1:100-Year, Lake A53 can be managed by pumping operations using a pump that can deliver between 570 to 1,000 m^3/h. As a contingency plan to reduce the risk that the water level could reach a higher elevation than 161.33 m at design flood with return period of 1:100 Year, the starting date of the pumping can occur as soon as spring melt starts (less than 3 days).

The following figures present the results of the hydrological analysis:

- Figure 2-3 shows the results of the 1:100-Year Event
- Figure 2-4 shows the results of the 1:10-Year Event
- Figure 2-5 shows the results of the 1:2-Year Event

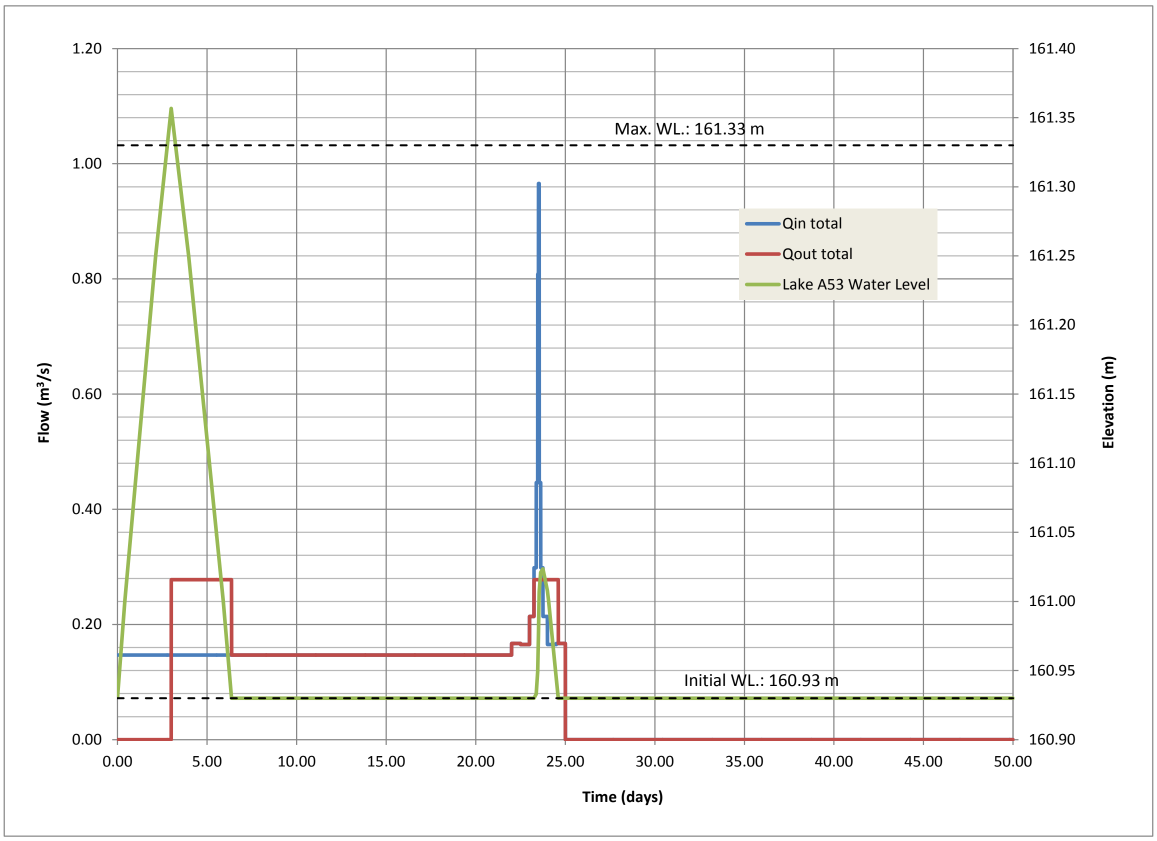


Figure 2-2: Level Pool Routing - 1:100-Year Event

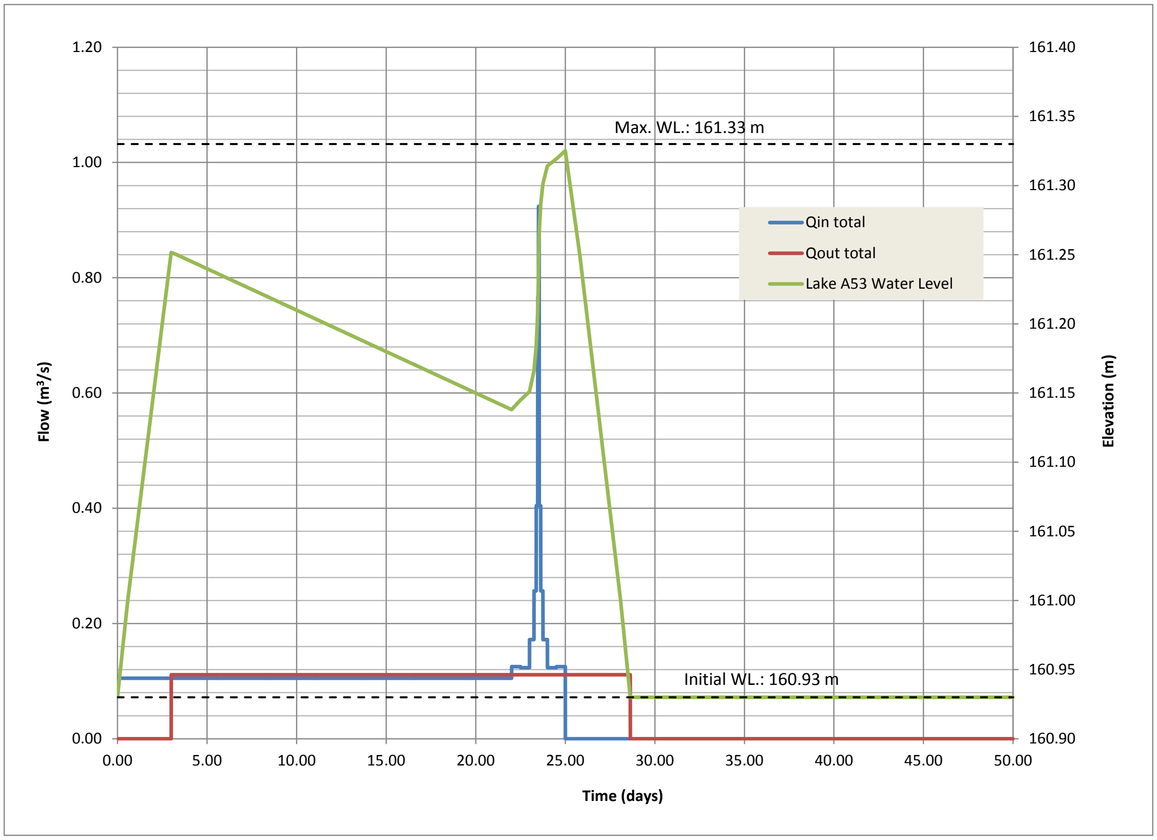


Figure 2-3: Level Pool Routing - 1:10-Year Event

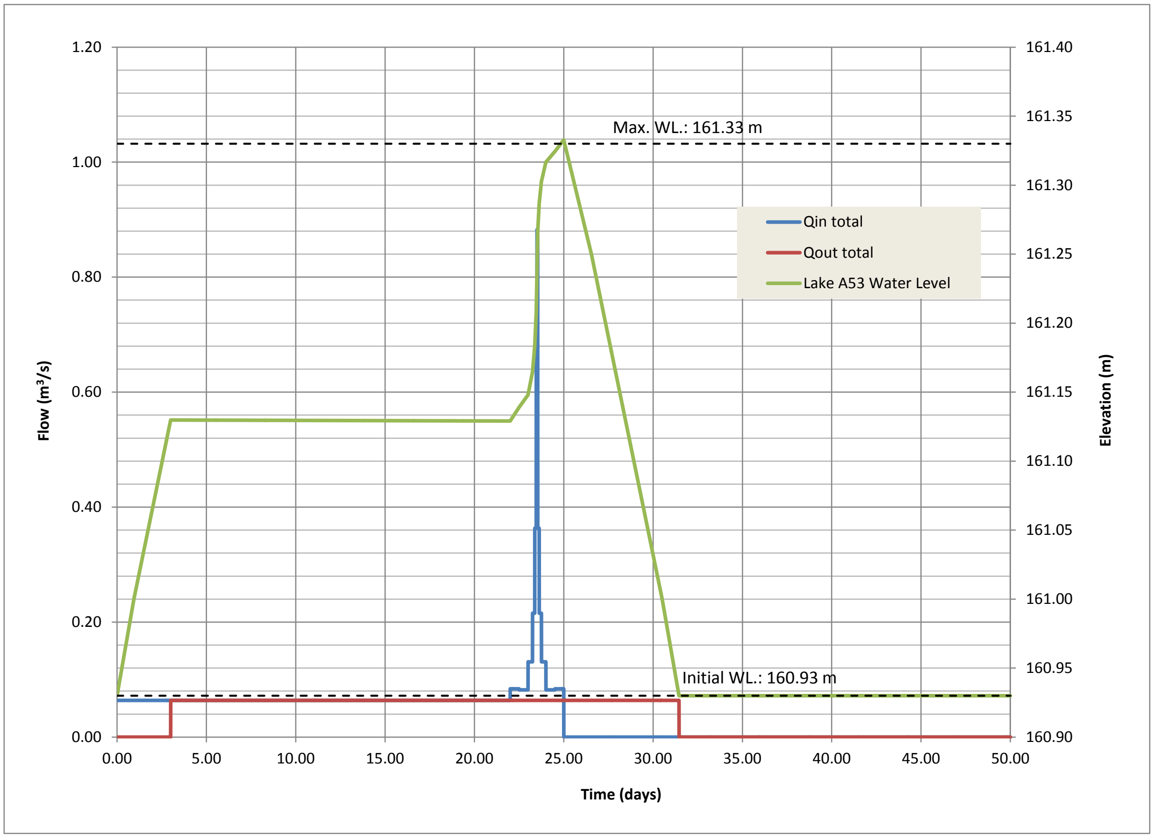


Figure 2-4: Level Pool Routing - 1:2-Year Event

3.0 Pump Station and Piping

According to the hydrological analysis, the conservative scenario with a 1 in 100 year spring freshet requires a minimum pumping rate of 570 m^3/h in order to maintain the maximum water level in Lake A53 at 161.33 m. Agnico Eagle is planning to use a **Godwin HL250M** pump with a diesel engine, currently available on the site to provide the pumping rate required.

The proposed pipe routing is presented in Figure 3-1 and the details are presented in Appendix 1. The discharge pipe will follow a new service road from Lake A53 until the Road #1, where it will then pass through an existing 900 mm culvert. Finally, the pipe will discharge into the existing stream from where water will flow to the Whale Tail Attenuation Pond by gravity. The profile of the pipe is also presented in Appendix 1.

Figure 3-1: Proposed pipe routing from Lake A53 to Attenuation Pond

Section 3.1 presents the hydraulic calculation to verify if the current HL250 pump can fulfill the pumping requirements and section 3.2 presents a review of the pumping suction cage.

3.1 Hydraulic Calculation

Table 3-1 presents the hydraulic calculation parameters used to evaluate the headloss at 1000 m^3/h when transferring water from Lake A53 to the intermittent stream.

Table 3-1: Hydraulic Calculation Parameters

Parameter	Value	Unit
Minimum water level	160.93	m
Pump skid elevation	162.90	m
Maximum water level	161.33	m
Maximum pumping rate of the pump (note 1)	1000	m^3/h
Nominal pipe diameter	14	inch
Pipe internal diameter (I.D.)	12.25	inch
Pipe HDPE material	PE4710	
Pipe pressure rating (DR17)	125	psi
Pipe length (suction)	20	m
Pipe length (discharge)	510	m

Note 1: maximum flowrate according to the pump curves.

Two scenarios with fully open and partially-closed discharge valve were evaluated in order to verify if the operating point of the pump falls within the operating range of the Godwin HL250M diesel pump.

Scenario 1: valve fully open

As shown on Figure 3-2, the pump operating points are outside of the maximum capacity limitation of the pump. Thus, the pump will not work properly with these operating conditions.

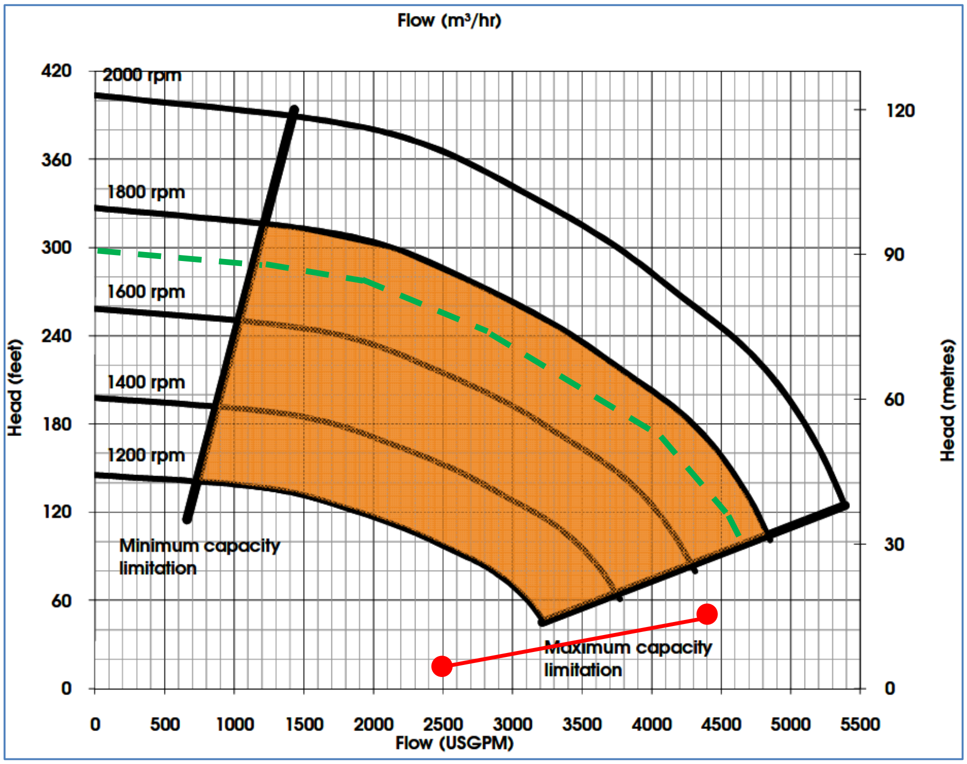


Figure 3-2: Operating Points of Scenario 1 (valve fully open)

Scenario 2: valve partially closed

One solution with regard to the scenario 1 is to partially close a valve installed on the discharge of the pump in order to create additional head loss. For simulation purpose, a 14-in butterfly valve was used and the opening was set to 40%. The calculation results are shown in Figure 3-3. The pump HL250M will be able to transfer water from Lake A53 to Whale Tail Attenuation Pond with a pumping rate between approx. 710 and 1000 m^3/h (refer to the red line in Figure 3-3 for the operating range). It is to be noted that the pump speed should be limited to a maximum of 1700 RPM in order to protect the piping system due to high discharge pressure that could develop in the event of possible blockage (i.e. dead head operation).

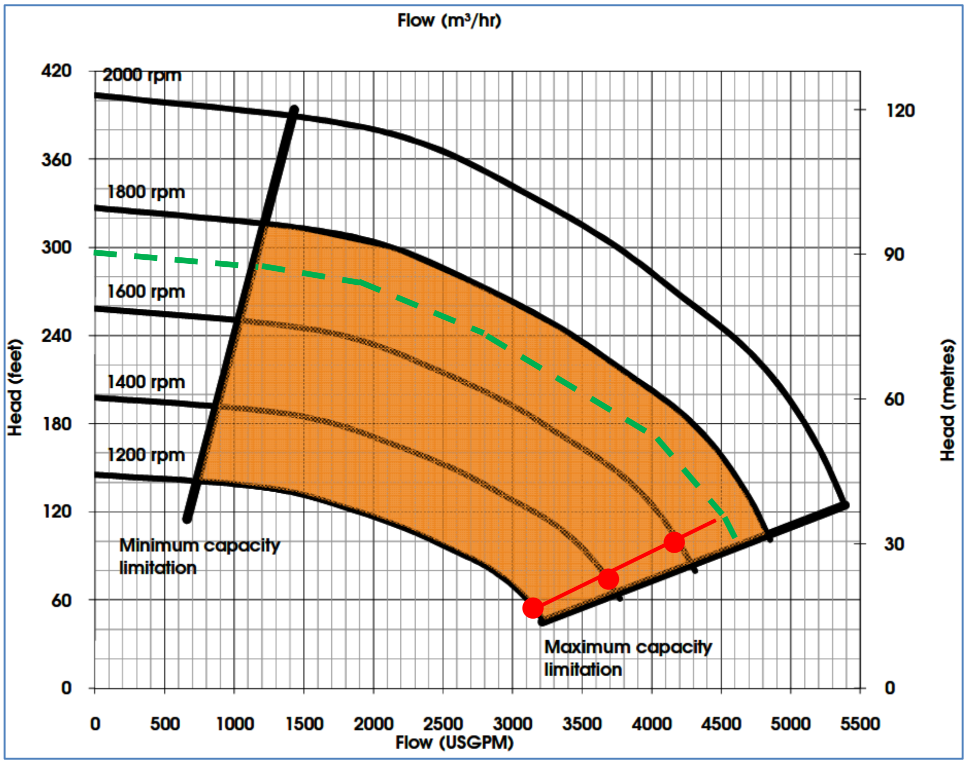


Figure 3-3: Operating Points of Scenario 2 (valve partially closed)

3.2 Pump Suction Cage Design

It is known that arctic char and lake trout can be found in Lake A53. According to the Freshwater Intake End-of-Pipe Fish Screen Guideline (DFO, 1995), these species belong to the subcarangi form category in terms of the swimming mode and the approach velocity at the pump water intake should be limited to 0.11 m/s in order to avoid losses of fish due to entrainment or impingement. The Guideline considers that most eggs and fish larvae remain in bottom substrates until they reach the fry stage (i.e., 25 mm fork length). Thus, the maximum design opening for a fish of 25 mm fork length is estimated at 2.54 mm (0.1 inches).

The pump suction cage from Vault Lake was validated to be adequate for pumping maximum 1000 m^3/h from Lake A53. Table 3-2 summarizes the design of the existing pump suction cage that will be used for this application. The suction cage is equipped with a metallic screen with openings of 2.5 mm (0.1 inch). Based on the surface area and type of the fish screen installed on the suction cage, the expected approach velocity at 1000 m^3/h is evaluated to be 0.083 m/s, lower than the guideline value specified by DFO.

Table 3-2: Dimension of the Pump Suction Cage

Dimension	Value	Unit
Length	1.57	m
Width	1.07	m
Height	1.07	m
Opening	2.5	m
Open area percentage	69%	
Safe factor related to dead area related to the structural frame of the cage and potential partial clogging	15%	
Total open area	3.3	m^2
Maximum flowrate	1000	m^3/h
Approach velocity at maximum flowrate	0.083	m/s

3.3 Piping

As noted in Table 3-1, 14-in DR17 HDPE piping will be used to transfer the water from Lake A53 to Attenuation Pond. The piping will be installed directly on the ground and will follow the routing as detailed in the drawing in Appendix 1. The pipeline will end after passing through an existing culvert under Road #1. Water will then flow by gravity to the Attenuation Pond following the existing stream.

3.4 Installation Methodology

An access road will be built from the Road #1 toward Lake A53. The HDPE pipe will be installed directly on the ground and follow along side of the access road. At the end of the access road, a pad will be built where the pump container will be placed on. The suction cage and suction pipeline will be placed in the lake using a crane.

3.5 Installation and Operating Schedule

The schedule for the management strategy is proposed as follows:

- 2019 before freshet (May and beginning of June): construction of the service road and a pad close to Lake A53 for the pumping station and installation of the suction cage, pipeline and pump
- 2019 freshet (June) throughout to Fall (September): active pumping of water from Lake A53 to North Whale Tail Lake via a pipe

The water level will be surveyed on a regular basis and the pump will manually be started based on the measurement.

3.6 Impact Mitigation of Active Pumping of Lake A53

The active pumping of Lake A53 will take place during summer/fall 2019 in order to prevent water from flowing through Road #1 prior to the construction of the East Diversion Channel. Once the East Diversion Channel will be constructed, the water level in Lake A53 will rise to its natural level.

During the active pumping season, the water level in the lake will fluctuate between elevations 160.93 to as high as 161.33. The fluctuation in water level in the lake will be limited to at most +/-0.4 m. This small variation is not expected to cause any erosion issue on the lake embankment.

Regular survey of Lake A53 will be performed to monitor and control the water level. Degradation of permafrost is not expected due to the short pumping season.

The pump suction cage will also prevent fish from being trapped by the pump suction pump and thus no damage is expected to the fish habitat since it is designed per DFO requirements.

4.0 References

Baseline Hydrology – SNC Report 651298-2600-4HER-0001, Johnson Liu, 2018

Freshwater Intake End-of-Pipe Fish Screen Guideline, Department of Fisheries and Oceans, 1995

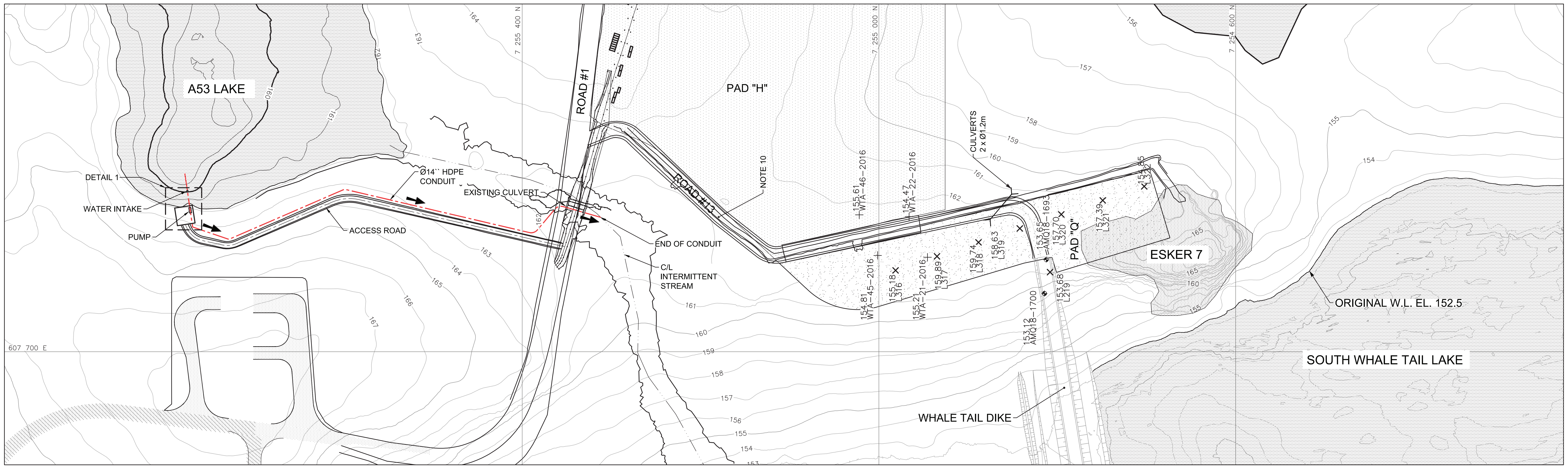
Thermal Analysis at the WRSF Dike – SNC report 651298-6000-4GER-0001, M. Durand-Jézéquel, 2018

Appendix 1:

Plan and Profile View of the Pump and Pipeline for Adaptive Water Management Strategy at Lake A53

NO. DESSIN / DRAWING NO. 61-648-270-200

FORMAT ARCHD



PLAN VIEW

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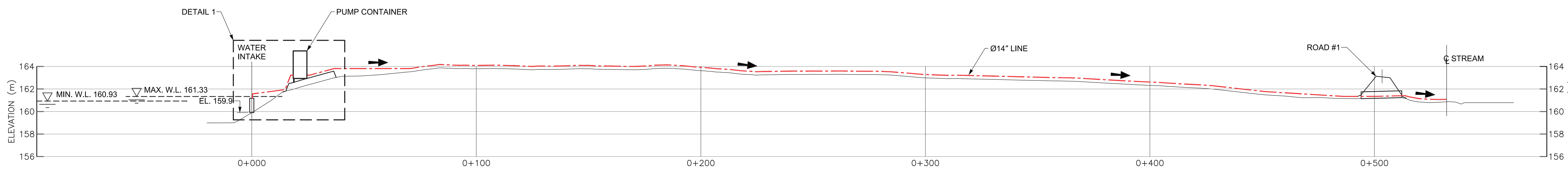
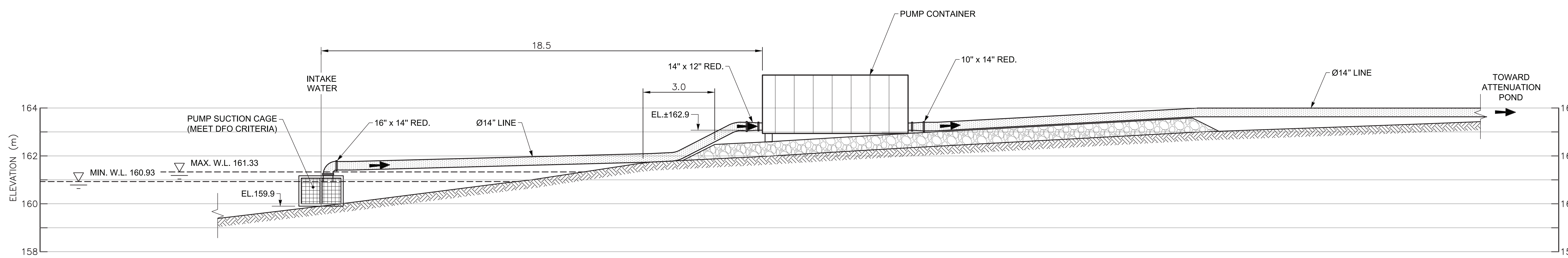


LONGITUDINAL PROFILE

SCALE: HOR. 1:1000
VER. 1:200



DETAIL 1: PUMP SUCTION CAGE & SUCTION LINE

SCALE: 1:100

PERMIT TO PRACTICE
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Signature ______ P.Eng.
Date 2019-01-31
PERMIT NUMBER: P 260
The Association of Professional Engineers, Geologists and Geophysicists of NWT/NU

PLAN CLÉ / KEY PLAN

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DESSINS EN RÉFÉRENCE / REFERENCE DRAWINGS

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AGNICO EAGLE

REV.	DATE	DESCRIPTION	PAR/BY	APP.	CLIENT
00	2019-01-30	ISSUED FOR CONSTRUCTION	C.B.	A.L.N.	
PB	2019-01-25	ISSUED FOR CLIENT COMMENTS	C.B.	A.L.N.	
PA	2019-01-15	ISSUED FOR INTERNAL COMMENTS	C.B.	A.L.N.	

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REGISTERED PROFESSIONAL ENGINEER, 2019-01-31, A.-L. NGUYEN, LICENSEE, NT/NU

TITRE / TITLE
AGNICO EAGLE - AMARUQ DIVISION
648 - DEWATERING
270 - PIPING
PLAN, LONGITUDINAL SECTION AND DETAIL PIPELINE PROFILE FOR ADAPDIVE WATER MANAGEMENT STRATEGY AT LAKE A53

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