Appendix 14

Whale Tail MDRB Report No 25B

December 15th, 2019

Mr. Martin Plante
General Manager
Agnico–Eagle Mines, Meadowbank Division
Baker Lake Office

Email: martin.plante@agnicoeagle.com

Dear Mr. Plante,

Report No 25B, Amaruq
Meadowbank Mine Dike Review Board
Meetings September 9-11 and November 27, 2019

1.0 INTRODUCTION

The annual meeting of the Dike Review Board was held on site from September 9th to 11th followed by a session in Montréal on November 27th. The Board is now comprised of two members, Mr. D. W. Hayley and Mr. D. A. Rattue. Both members attended these meetings.

The objectives were to review the status of the operation of water and tailings retention structures at Meadowbank and the construction and operation of the dikes at Amaruq. In September, the time was spent primarily on the site visits. The formal presentations were given at the November meeting. This report covers the discussions and observations relating to a site visit of the Amaruq facilities and the subsequent presentations. The contents of the preliminary report transmitted in September have been incorporated into this document. A companion report presents the observations pertaining to the Meadowbank site.

The agenda for the November meeting and the list of participants are included in Attachments A and B respectively.

The Board made a field visit in September by helicopter, by vehicle and on foot, to observe conditions at Amaruq primarily the Whale Tail Dike but also the North East (NE) Dike, the Waste Rock Storage Facility (WRSF) Dike and Mammoth Dike.

A selection of photographs taken during the visits has been included in Attachment C. One figure extracted from the pre-visit briefing is included in Attachment D.

In the report that follows, the subject matter is covered essentially in the same order as during the visits. The recommendations arising from the site visit and summarized briefly at the conclusion of the site visit are underlined in the text as are those derived from the November meeting.

2.0 WHALE TAIL DIKE

Aerial views of Whale Tail Dike are presented in Photos Nos 1 and 2. The downstream exposed lakebed has been drained by pumping, whereas the upstream (south) basin has filled due to run-off in the catchment and partly from water pumped back to the south basin. The water level had risen from 152.5 m to 155.7 m at the time of the site visit. Consequently, areas on the abutments have been submerged and a hydraulic gradient created across the Whale Tail Dike and its foundation.

Seepage has been observed since the creation of this hydraulic gradient. Turbid water was noted near the east abutment soon after the start of drawdown whereas water discharged at the downstream toe near the dam centre from Stn. 0+670 towards the west abutment is clear (Photo no. 3). Examination of the area near the east abutment shown in photo no. 4 shows clear water discharging at the toe of the dam and sediment laden water from the waste dump side. It appears that this dump, used for the disposal of cement-bentonite waste during construction, is the probable source of sediment in the discharge water. Although much of this material has subsequently been removed, disturbance due to excavation activities has released additional sediment. The flow of the turbidity laden water is captured separately (photo no. 5) and measured at the V-Notch weir shown in photo no. 6.

Several springs were noted over the remainder of the dike toe area but the water is clear. Temporary weirs were set up to measure the flow rates as shown in photos nos. 7 to 9. The western sector shown in photo no. 10 is not, as yet, instrumented. Small sand boils are also observed in this latter area (Photo no. 11).

Important questions were raised as to the source of the turbidity and the potential effect on the integrity of the dike cut-off. Cement-bentonite when cured has been demonstrated to be able to resist erosion under gradients similar to that at the Whale Tail Dike. The Board is of the opinion that the source of seepage water is more likely to be through discontinuities in the bedrock rather than windows in the cut-off wall.

The abutments and much of the eastern side of the lakebed (shallow water) were in a permafrost condition. The Board had previously cautioned that the foundation rock in a permafrost condition is not amenable to grouting and, indeed, non was attempted beyond Stn. 0+516. A section through the dike is shown in figure 1. Ice rich overburden was excavated in the central portion down to bedrock and was replaced by fine and coarse filter material prior to the construction of the cut-off wall. The presence of “warm” lake water, particularly with the raising of the south basin, has initiated thaw of the ice in rock discontinuities which developed into a continuous process whereby seepage flow and the attendant heat flux led to an extension of the area of thawed foundation rock through which flow can take place.

An exposure of Greywacke rock in the mine pit (Photo no. 12) may be illustrative of the fractured rock probably present below the eastern abutment of the Whale Tail Dike. Preliminary results of a “Willowstick” geophysical survey, released at the time of the Board visit, would tend to lend additional credence to the hypothesis of seepage flow through fractured and recently thawed rock. AEM is currently assessing the potential of achieving a reduction of flow by grouting. The Board endorses this work and sees the Willowstick survey results as enabling the exploratory drilling and grouting to be more focused.

The Board also sees merit in enhancing the potential for freeze back to contribute to seepage reduction. Areas such as the submerged upstream east abutment, shown in photo no. 13, could

be covered with low permeability, well graded granular fill (esker sand and gravel rather than rockfill) to minimize water heat flux and augment the surface area exposed to cold air temperatures in the upcoming winter season. A similar approach is suggested for the downstream side of the dike, both at the abutment and on the lakebed.

Seepage reduction is desirable in the medium to long term to minimize water handling issues particularly in winter. However, in the short term (winter-spring 2020), a contingency plan should be made to ensure that water accumulation in the northern basin of Whale Tail Lake does not jeopardize mine pit operations. It is recommended that the minimum elevation of the rock plug at the pit crest be verified by soundings. Furthermore, the foundation topography of the dike should be examined, together with the Willowstick data, to determine strategic points for water collection and pumping. Activities described at the November meeting suggest this exercise is well advanced and the sump pumps are now available for water control.

The cracks that have been observed on the dike crest (Photo no. 14) are also believed to be the result of thaw settlement in the overburden which remained below the upstream and downstream shells (see figure 1). Deformation of the dike has been noted in the results of the inclinometer measurements. This is likely also related to thaw settlement under the shells and to the application on the cut-off wall of hydrostatic thrust. The addition of a few survey monuments would permit monitoring of future movement on the outer edges of the crest.

The presentations, made to the Board at the November meeting, provide data that indicates the Whale Tail dike is stable in spite of the underflow within the fractured bedrock foundation. Nevertheless, the quantity of seepage flow will be an issue in water management and the Board concurs with the continuing efforts to reduce this flow rate. The work will include supplementary instrumentation and additional fill strategically placed to encourage freeze back.

The Board is pleased to note that plans have been made to carry out remedial grouting. There is currently some debate concerning the most appropriate sequence for the execution of the grouting. This will require continuous assessment of results in order to optimize the process. The systematic grouting of primary holes at 12 m centre to centre may serve as a first exploratory stage, and permit a more focused programme for areas that appear to include the primary conductors. The overall objective is a reduction of seepage flow rates to a manageable quantity without necessarily treating the entire foundation. The Board expects that most benefit will be derived from grouting in sectors not previously treated by the grouting carried out as part of the initial construction.

The Board wishes to reiterate its recommendation to add granular material or fine rockfill in the area at the east abutment on the upstream side where excavations have exposed the foundation to the water of the south Whale Tail lake. The fill should be placed to an elevation above the maximum estimated full head in the lake such that the fill surface is exposed to winter conditions that will encourage re-establishment of permafrost.

3.0 NORTH EAST DIKE

The North East (NE) dike was constructed to capture flows from a catchment to the north-east of the Whale Tail Pit and permit evacuation by pumping of this water before its entry to the pit area. Heavy rain during the 2019 season and slower than anticipated mobilization of pumping capacity led to encroachment on the freeboard during freshet. Seepage was noted downstream of the eastern sector of the dike. A pond still abuts against the upstream toe berm as shown in photo

no. 16. Photos nos.17 and 18 show the flow pipe currently monitoring the ongoing seepage. There are no other instruments in this structure and therefore, the permafrost condition of the foundation cannot be verified. However, the presence of flow indicates the potential for permafrost degradation. This dike will have a short life-span (intent 2 years) and monitoring, together with enhanced pumping capacity for the 2020 freshet, may suffice. No additional information provided at the November meeting changes this view.

4.0 WASTE ROCK STORAGE FACILITY DIKE

This structure's main purpose is to ensure that there will be no flow of potentially contaminated contact water from the Waste Rock Storage Facility (WRSF) into Mammoth Lake. In an analogous situation to the NE Dike, water levels during the 2019 freshet were accompanied by seepage observations at the downstream toe. There was some controversy on site as to whether the seepage path is through or beneath the bituminous liner on the upstream surface of the dike. The detailed ground temperature data, presented at the November meeting, shows that thaw had not progressed below the liner at the location of the thermistor cable in the cut-off trench however, substantial warming had occurred by early June according to the thermistors located beneath the body of the embankment.

The extent of upstream toe submergence can be appreciated from photos nos. 19 and 20. What is also noticeable in the lower photo is the irregular surface that indicates where thaw settlement has occurred. The instrumented section (photo no. 19) may not be fully representative of the condition beneath the dike. The Board concurred with the suggestion to add thermistor strings to the east and the west of this point. The Board also suggested that the upstream berm be widened and thickened with granular material (sand and gravel) which would have three benefits:

1. Facilitate snow removal and enhance aggradation of ground freezing;
2. Reduce exposure to "warm" water during freshet; and
3. Reduce seepage rates in the event of the presence of a window.

AEM has prepared plans to add a zone of low permeability fill to the upstream berm as discussed with the Board at the November meeting. The Board emphasized the need to construct the fill of homogeneous well graded material and that the upper finished surface should be thick enough to remain well above the maximum potential water level and should be sloped into the reservoir. There will also be a need to adequately protect the existing instrument installations during this construction activity.

The excavation of a small sump on the downstream side has also been suggested as a desirable addition.

5.0 MAMMOTH DIKE

The Mammoth Dike design is essentially the same design as that constructed for the WRSF dike. An upstream sloping surface supports a bituminous membrane liner that terminates about 3 m below original ground on a horizontal pad about 1.5 m wide. The geomembrane is protected above and below with a thin layer of fine-grained filter. Discussion at the meeting in November was brief as the system had not been tested. However, on December 9th the board received an e-mail from Mr. Clark advising that the water elevation in Mammoth Lake had increased substantially over the past few weeks. Recent data indicated that the water level is at elevation 152.66 m (and rising) which is 0.16 m above the design basis lake elevation. This has been

attributed to ice formation in the channel that drains the lake. Given the uncertainties associated with winter freeze-up, the risk of surface water entering the open pit has resulted in an increase in the Trigger Action Response Plan (TARP) level.

The Board recommends that it continue to be advised on performance of the Mammoth Dike and that upgrades recommended for the WRSF Dike be considered for the Mammoth Dike.

6.0 NEW WATER MANAGEMENT INFRASTRUCTURE

With the addition of the proposed IVR pit, some new structures will be required. Discussion ensued on the design concepts and on the design criteria. The Canadian Dam Association (CDA) dam safety guidelines are a reference for the establishment of such criteria. Often the design parameters are related to the consequence category of a given structure. This is based on the incremental consequence of uncontrolled release of stored water above and beyond the damage that would be caused by the event (flood, seismic or other) if the dam did not exist. The consequences fall into groups such as loss of human life, economic loss, and environmental impact. However, consequences such as interruption to mine operations and the reputation of the company should be included.

Before design can commence, there should be an agreement with the owner on the perceived risk and the design criteria to be adopted. These may well be more severe than the criteria suggested by CDA which are primarily oriented to the protection of human life.

The establishment of such criteria is particularly relevant for some of the structures in question, where pumping (an active intervention) is required as part of the water management instead of simply spilling water in a passive (no human intervention required) mode. Some form of contingency plan or, at least, the recognition of the impact of the failure to intervene in a timely manner is included. The basic design may revolve around the 1:100 yr. inflow design flood which would be typical for a small structure, but the potential consequences of a more severe condition such as 1:1000 yr. event, with contingency plans as appropriate, should be evaluated.

7.0 DIKE CROSS-SECTIONS

The Board provided some information on typical dike cross-sections commonly used in the western Arctic. Locating the key trench beneath the embankment rather than at the upstream toe, can result in benefits by encouraging and maintaining the foundation in a frozen condition. The configuration adopting the upstream toe location has had mixed results at Amaruq. It requires a substantial thickness of extra fill cover to ensure that the granular protection pad is always above water. This should be adopted as a fundamental design objective that will maintain frozen conditions and encourage permafrost stability in both the fill structure and the underlying foundation.

8.0 NEXT MEETINGS

No dates have been set for future visits but early September is viewed as an appropriate time. The Board awaits instruction from AEM in this regard.

9.0 ACKNOWLEDGMENTS

The Board wishes to thank the personnel of AEM for the organization of logistics and for their participation and that of SNC-Lavalin (SLI) in the site visits and meetings.

Signed:

Don W. Hayley, P. Eng D. Anthony Rattue, P. Eng.

ATTACHMENT A

AGENDA FOR BOARD MEETING NO. 25B

November 26th and 27th, 2019

Agnico Eagle Mines - Meadowbank Division
Meadowbank Dike Review Board
Meeting # 25 - November 26 to 27, 2019
Meeting Location : Fairfield Inn & Suites by Marriott Montreal Airport
AGENDA

DAY 1 - November 26	**Time allocated**	**Start**	**End**
P1 - Welcome, Review of the Agenda [AEM]	0:30	8:00	8:30
Review of Answers to MDRB Report #24	0:30	8:30	9:00
P2 - Overview of Meadowbank Dewatering Dike Performance [AEM]	1:00	9:00	10:00
Break	0:15	10:00	10:15
P3 - Tailings Management - Operations [AEM]	1:00	10:15	11:15
P4 - Closure Update TSF/WRSF [AEM]	0:45	11:15	12:00
Lunch	1:00	12:00	13:00
P5 - Tailings Management - Dike Performance and Instrumentation - North Cell / SWD [AEM]	1:30	13:00	14:30
P6 - Tailings Management - Dike Performance and Instrumentation - South Cell [AEM]	1:30	14:30	16:00
Break	0:15	16:00	16:15
Deliberation by Board Member (Day 1)	0:30	16:15	16:45
DAY 2 - November 27			
P7 - Summary of Whale Tail Project 2018-2019 Construction Season (WTD,WRSF,NE,MammothI) [SNC]	1:00	8:00	9:00
P8 - Whale Tail Dike Performance [AEM]	2:00	9:00	11:00
P9 - Performance of WRSF Dike [AEM]	1:00	11:00	12:00
Lunch	1:00	12:00	13:00
P10 - Performance of Mammoth and NE Dike [AEM]	1:00	13:00	14:00
P11 - Pre-Feasibility Study for Water Management Infra - Amaruq Phase 2 [SNC]	1:00	14:00	15:00
Break	0:15	15:00	15:15
Deliberation by the Board Members	0:45	15:15	16:00
Preliminary Report by the Board Members	1:00	16:00	17:00
Meeting Closure			

ATTACHMENT B

ATTENDANCE AT NOVEMBER 2019 MEETING
Held at the Fairfield Marriott Hotel, Dorval, Québec

Attendance		
Fredérick L. Bolduc	AEM	Geotechnical Coordinator
Jesse Clark	AEM	Geotechnical Coordinator
Yan Coté	AEM	Engineering Manager
Rebecca Cousineau	AEM	Geotechnical Engineer
Patrice Gagnon	AEM	Geotechnical Engineer
Éric Haley	AEM	Water & Tailings EIT
Michel Julien	AEM	V.P Environment
Alexandre Lavallée	AEM	Geotechnical Coordinator
Thomas Lepine	AEM	EoR – Technical Specialist, Env. Management
Bruno Lessard	AEM	Instrumentation Specialist
Pier-Eric McDonald	AEM	Geotechnical Engineer
Pascal Poirier	AEM	Water & Tailings Engineer
Christian Tremblay	AEM	Geotechnical Engineer
Yohan Jalbert	SLI	Geotechnical Engineer
Don Hayley		Dike Review Board
Anthony Rattue		Dike Review Board

APPENDIX C

PHOTOGRAPHS TAKEN DURING THE VISIT

September 10th, 2019

Photo No. 1 Whale Tail Dike viewed from the East (Decreasing station)

Photo No. 2 Whale Tail Dike viewed from the West (Increasing station)

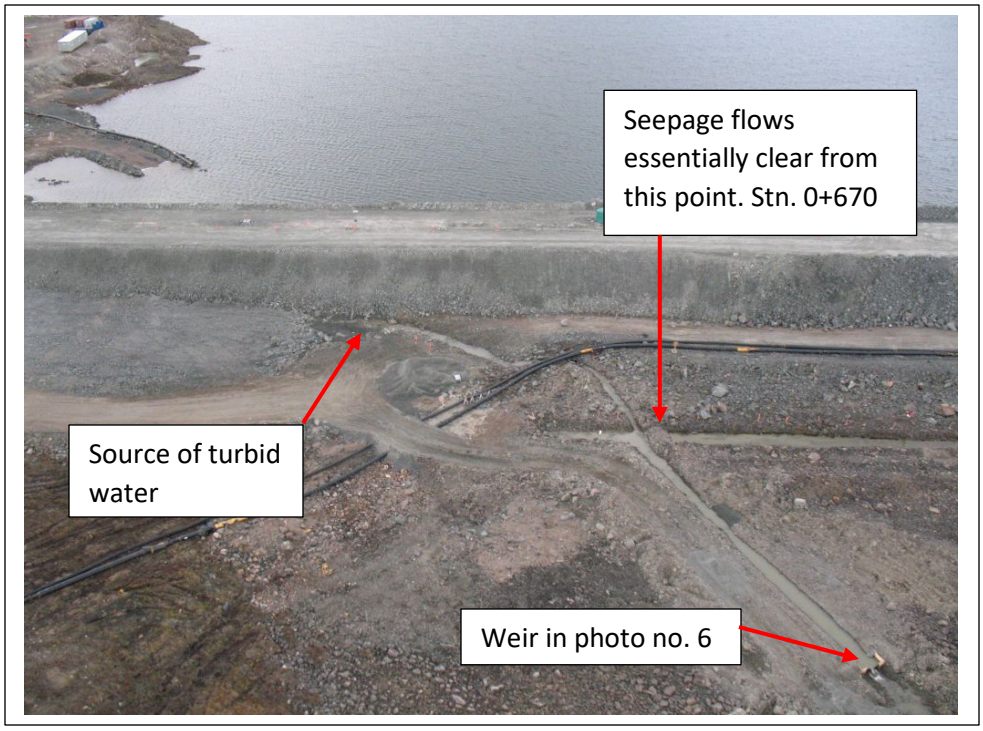

Photo No. 3 East sector of Whale Tail Dike

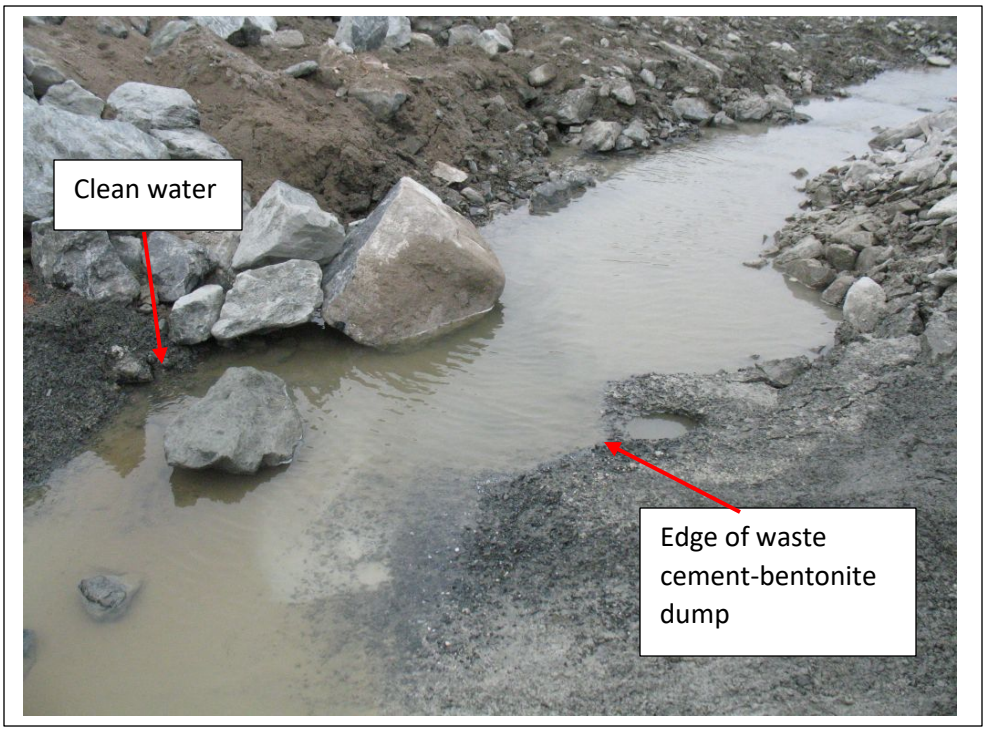

Photo No. 4 Source of turbid water

Photo No. 5 Dike to separate clean flow from turbid flow

Photo No. 6 V-Notch weir for turbid flow

Photo No. 7 V-Notch weir for clean water flow at Stn. 0+560

Photo No. 8 Central sector of Whale Tail Dike

Photo No. 9 V-Notch weir for clean water flow at Stn. 0+430

Photo No. 10 Western sector of Whale Tail Dike

Photo No. 11 Sand boils in western sector

Photo No. 12 Exposure of greywacke in Whale Tail Pit

Photo No. 13 South Whale Tail Pond in vicinity of east abutment

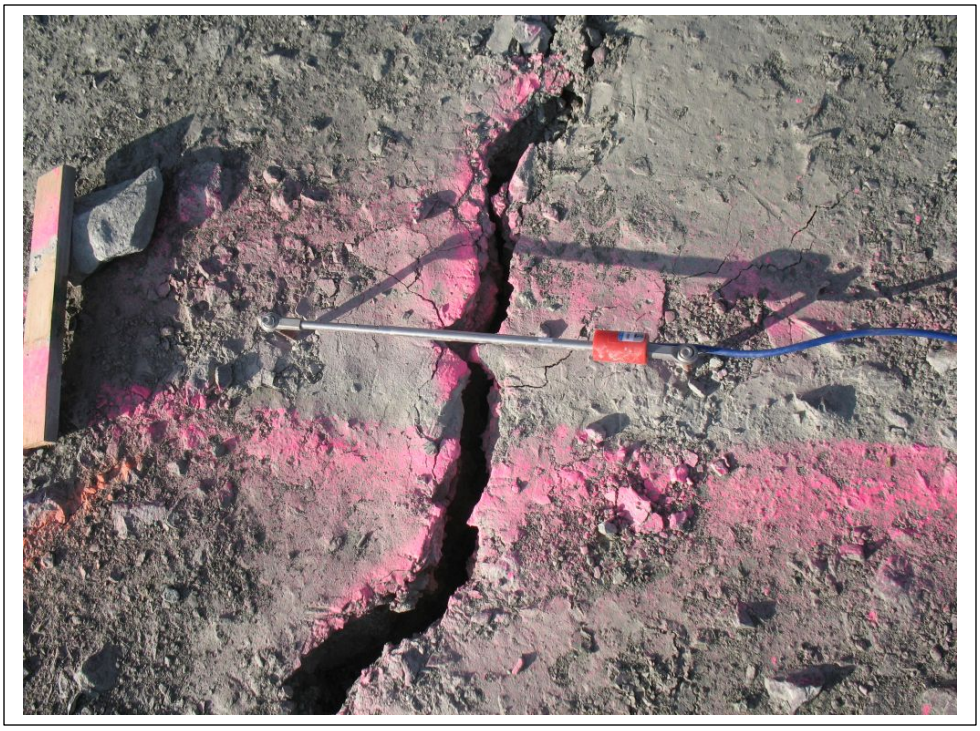

Photo No. 14 Crackmeter at Stn. 0+715

Photo No. 15 North East Dike from west abutment

Photo No. 16 Pond upstream of eastern sector of North East Dike

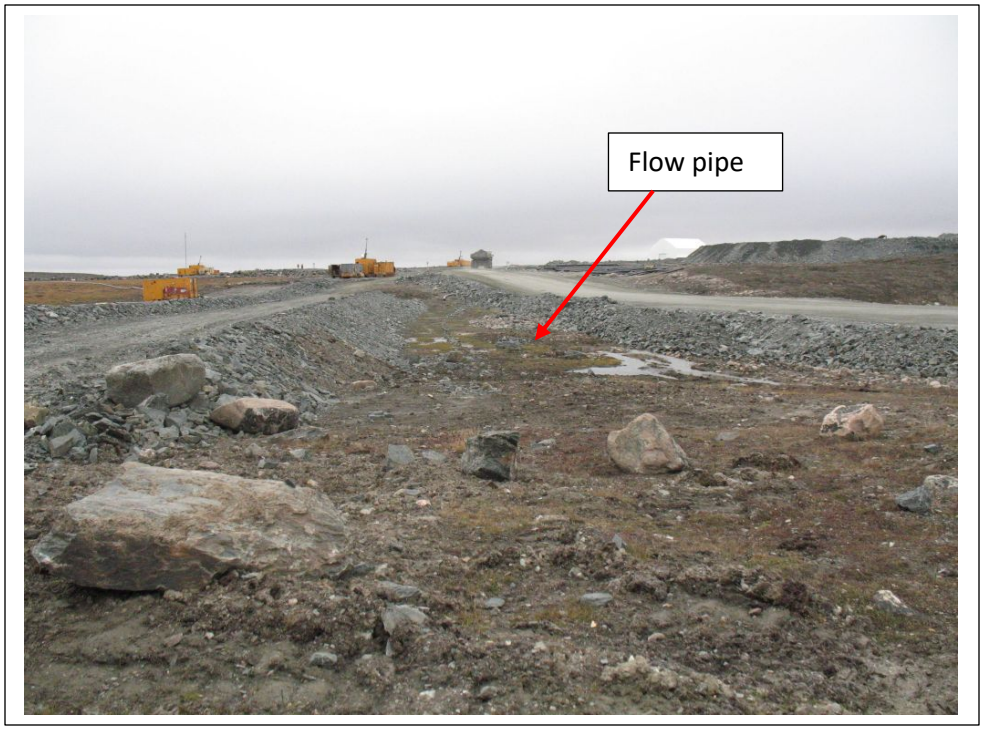

Photo No. 17 Location of flow pipe in photo no. 18

Photo No. 18 Seepage floe from NE Dike

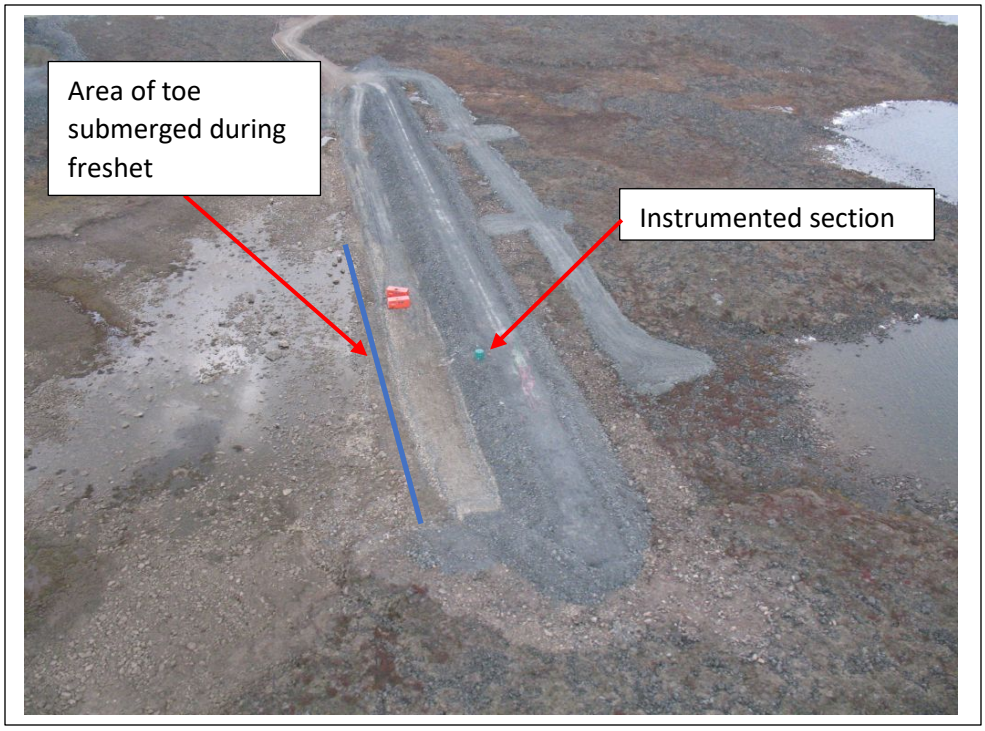

Photo No. 19 WRSF Dike

Photo No. 20 Upstream berm of WRSF Dike

Photo No. 21 Mammoth Dike

APPENDIX D

FIGURE

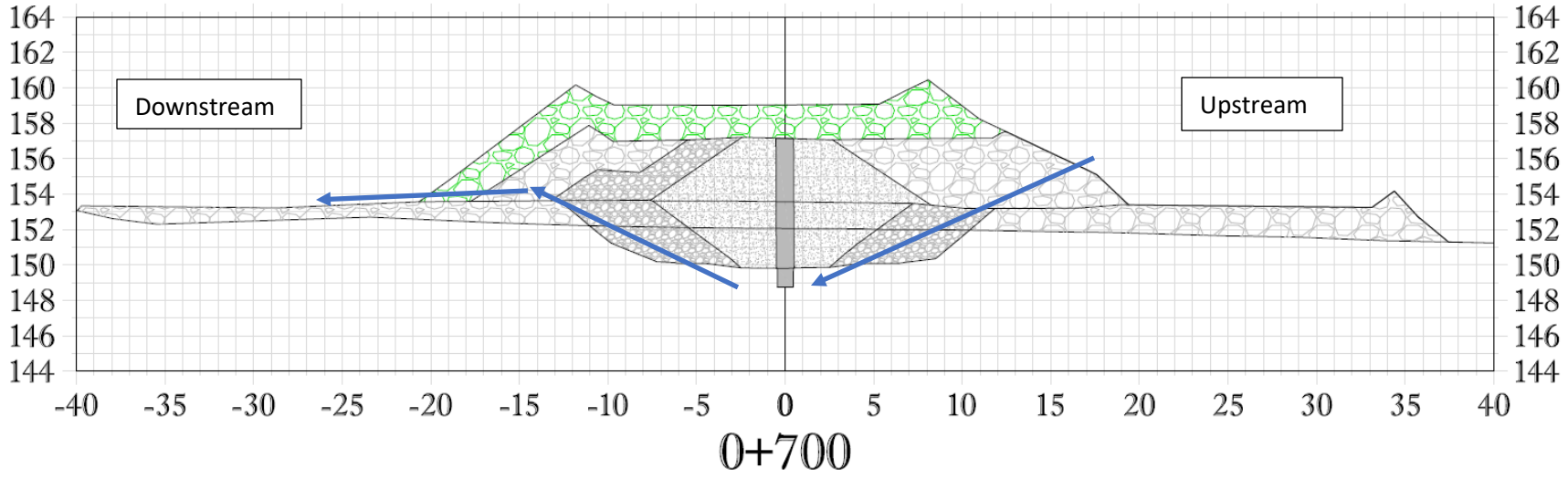

Figure 1 Cross-section of Whale Tail Dike at Stn. 0+700 showing potential seepage pathways