Indian and Northern Affairs Canada / Affaires indiennes et du Nord Canada

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Via Email

Richard Dwyer
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Nunavut Water Board
P.O. Box 119
Gjoa Haven, NU X0E 1J0

Subject: Water License #2AM-MEA0815, Agnico-Eagle Mines Ltd., Meadowbank Gold Project, Kivalliq Region, Submission of Report on *Tailings Storage Facility Dike Design, Meadowbank Gold Project, Nunavut* (Golder Associates, Dec. 17/08)

Dear Richard,

Please be advised that Indian and Northern Affairs Canada has completed a review of the Golder Associates Dec. 17/08 Tailings Storage Facility Dike Design Report submitted by Agnico-Eagle Mines Ltd. This report is subject to the Nunavut Water Board's approval as per Part G, Item # 1 and Part D, Item #2 of Water License #2AM-MEA0815.

A Technical Review Memorandum (attached) is provided for the Board's consideration.

Should you have any questions regarding this submission, feel free to contact me at 867-975-4555 or David.Abernethy@inac-ainc.gc.ca.

Regards,

David W. Abernethy
Regional Coordinator

Cc. Kevin Buck, Water Resources Division Manager
Michael Nadler, Regional Director General, Director of Operations – Acting

Canada

Technical Review Memorandum

Date: Apr. 7/09

To: Richard Dwyer, Nunavut Water Board

From: David Abernethy, Indian and Northern Affairs Canada

Re: Technical Review, *Tailings Storage Facility Dike Design, Meadowbank Gold Project, Nunavut* (Golder Associates, Dec. 17/08)

1. Description

On Feb. 16/09 Agnico-Eagle Mines Ltd. (AEM) provided the above referenced document to the Nunavut Water Board (NWB or Board) and Indian and Northern Affairs Canada (INAC) Water Resources Division. This “Report” is subject to the Board’s approval pursuant to Part G, Item #1 and Part D, Item #2 of Water License #2AM-MEA0815.

The following additional reports were included in this technical review:

- Meadowbank Dike Review Board. *Report No. 2*, Feb. 10/09
- Meadowbank Dike Review Board. *Trip Report – Dr. Andrew M. Robertson – October 31, 2008*, Nov. 4/08
- Meadowbank Dike Review Board. *Report No. 1*, Sept. 29/08

It is noted that the NWB has not, to date, distributed this Report to interested parties for review.

2. Results of Review

The following comments / recommendations are provided to the Board for consideration in the approval of the proposed tailings storage facility dike design report. Where appropriate, similar comments that were made by the Meadowbank Dike Review Board (MDRB) in either their Sept. 29/08 Report No. 1 (MDRB #1) or Feb. 10/09 Report No. 2 (MDRB #2) are indicated.

1. Generally, the Report is well presented and follows a logical sequence, with many cross references to the Canadian Dam Association Dam Safety Guideline 2007. However, in INAC’s opinion, the Report appears to lack an upfront, high level overview of the design intent, some project

background history, a site plan showing all important infrastructure, and an appreciation of the construction schedule.

2. There is a clear deficiency in information regarding the geotechnical conditions beneath the footprint of the proposed dike structures, and this has been correctly identified in the Report. Additional geotechnical drilling will be required before final design and construction (see also MDRB#2, Section 7.0); however, it is not clear when this drilling work will be complete and how it will affect the final design. Continuing construction without detailed geotechnical information and possible design revisions could pose a serious risk to the project.

3. The site investigation required to complete the detailed design of the structures should pay particular attention to defining the ice content in the foundation overburden materials because it is to be removed if encountered. The contractor should be given some indication of the volume of this material.

4. The Report appears to pay limited attention to the thermal regime beneath the new structures to maintain or at least improve (aggrade) the permafrost. This is most pertinent to the Central Dike seepage cut-off system, which involves a liner system above bedrock elevation and grouting below bedrock elevation. This is a result of not being able to grout in either frozen soils or rock. There is concern that degradation of the permafrost after construction could lead to uncontrolled seepage through non-grout-filled zones beneath the dike structures. It is suggested that additional thermal modelling and review be undertaken on all dike structures to confirm that the proposed seepage cut-off systems will meet their proposed design intent and no unmanageable loss of this frozen seepage barrier will occur (see also MDRB#2, Section 6.3).

5. The Report contains limited information on what INAC considers to be important construction activities and infrastructural components. For example:

    - Dewatering of the lake in terms of discharge location and requirements for water treatment and release.
    - Defining disposal location for excavated lakebed sediments, till, and other natural materials.
    - Details of proposed additional geotechnical borehole locations and drilling schedule.
    - Water management and water discharge location during construction works.
    - Design and stability of the upstream seepage cut-off trench excavations for the dike structures.

- Design of the water management structures and collection systems downstream of the dike structures.
- Source of rock fill and filter material. There is a requirement for approximately 4 million m^3 of rock fill material. Where is this coming from and how does the production schedule fit with the mine schedule?
- General construction schedule and a Tailings Storage Facility operating schedule showing dike raises, etc. (see also MDRB#2, Section 6.4) and (see also MDRB#2, Section 7.0).

6. The construction specifications are not clear about who is responsible for different construction activities. The specifications should be reviewed, revised, and expanded to clearly identify the Owner's, Contractor's, and Engineer's responsibility and duties (see also MDRB#2, Section 9.0). In some instances, the Owner or the Contractor is required to design and accept responsibility for major infrastructure components (e.g., cut-off trench: quote from Specification S3.5.3 "Method of excavation and stability of the excavation shall be the responsibility of the Contractor, with method reviewed by the Engineer"). Some of these excavations could be 18 m deep, which is no trivial excavation; therefore, these excavations warrant a justifiable level of engineering design and attention to construction detail. Accordingly, in our opinion, this is best designed, specified, and certified by the Engineer and not by the Contractor working for the Owner. The downstream water collections systems should also be designed by the Engineer.

7. The designer should determine whether vertical grout holes are going to be the most effective. When conducting the additional geotechnical investigation, a significant number of the boreholes should be inclined and cores in the bedrock should be oriented to allow the preferential fracture direction to be determined. This information will help determine whether the proposed vertical grouting approach is appropriate or if angled grout holes would be more effective (see also MDRB#1, Section 3.9.1).

3. Specific Issues

The following comments / recommendations make reference to specific sections of the Report's text, drawing, and construction specifications.

A. Report's Text

1. *Section: 1.0, Paragraph: 3, Line 3* – "first three years" should read "first three years and six months," according to Figure VI-7.

2. *Section: 1.0, Paragraph: 4, Line: 1* – "Construction materials are primarily generated from on site materials" – Where are these materials being sourced? Is there a schedule for construction material production?

3. *Section: 1.0, Table: 1.1* – For the South Cell, the Central Dike crest elevation increases 135, 145, 150 masl – Why does the maximum height at the rock fill crest not increase in similar increments?

4. *Section: 2.1, Paragraph: 2, Bullet: 5* – "possible dredge spoils" – where are the dredged spoils coming from?

5. *Section: 2.2, Paragraph: 2, Line: 2* – "The Central Dike and Saddle Dams are 'High' consequence of failure structures" – It is our opinion that the Central Dike should receive a "Very High" classification as a consequence of Central Dike failure in terms of the adjacent open pit operations would probably results in a loss of life greater than 10.

6. *Section: 2.4, Paragraph: 3, Bullet: 1* – "Freeboard should be sufficient to prevent heave of the crest due to frost action" - This statement is somewhat out of place for the Central Dike, which is predominately constructed with granular material. It is INAC's understanding that this statement is really related to finer-grained soils in more southern climates with harsh winters.

7. *Section: 2.4, Paragraph: 5, Line: 1* – "The minimum freeboard between the tailings and the liner crest" – Should "tailings" read "tailings or supernatant water"?

8. *Section: 2.4, Paragraph: 5* – What is the justification for reducing the operating freeboard from 2.0 m during operations to 1.0 m for closure?

9. *Section: 2.5, Paragraph: 2* – The downstream dike slopes are steep 1.5H:1V. How will the crest widths be widened and have the proposed designs taken into consideration all anticipated vehicular traffic that will have to travel along the dike crest together with the relevant safety requirements?

10. *Section: 2.5, Paragraph: 3* – According to Table 1.1, all dike crest widths are defined as 10 m, and therefore, is it understood that these design crests widths will not be wide enough to accommodate a Caterpillar 777. According to the Mine Health and Safety Regulations, N.W.T. Reg. 125-95, Section 1.143, a Caterpillar 777 will require 12.1 m plus a shoulder barrier height of at least three-quarters of the height of the tire. Therefore, a dike crest width of roughly 19.6 m would be required for a Caterpillar 777.

11. *Section: 2.7, Paragraph: 1* – Design values may require revision pending response to Comment 5 above.

12. *Section: 2.8, Paragraph: 4* – “Bedrock…” – How will grouting guard against seepage due to potential loss of ground ice as a result of changes in thermal regime (potential warming)? Has maintenance of thermal conditions been supported by thermal modelling? The main concern really relates to thermal degradation of the underlying materials in areas where ponded water abuts against either the dike structure or the natural ground surrounding the abutments. Figure VI-8 shows an initial pond adjacent to the upstream face of the Central Dike. There are documented experiences where mining operations underestimate the volume of water that accumulates and needs to be stored during operations. Often, the first choice for additional water storage is the tailings storage facility. Has the site-wide water balance taken into account the possible requirement for additional water storage in the tailings storage facility area? If so, have these elevated water levels been allowed for in the thermal design of the water and tailings containment structure?

13. *Section: 4.4.1, Paragraph: 1, Line: 1* – The lack of lakebed sediment (lacustrine sediment) thickness and characterization along the proposed dike alignments is a shortcoming of the fieldwork and should be addressed before dewatering for and construction of the proposed dikes.

14. *Section: 4.4.1, Table 4.1* – The tabulated lakebed (lacustrine) sediment thicknesses relate to the East Dike which is located in shallow water and is outside the containment area being considered here. However, the tabulated thicknesses are surprisingly thin given past experience at Diavik and Ekati. Much thicker lakebed sediments should be expected at the deepwater location of the Central Dike. The test locations from Table 4.1 should also be plotted on a drawing for ease of reference.

15. *Section: 4.4.2, Figure 4.3* – Cobbles and boulders in the till have not been characterized and the till gradations presented in Figure 4.3 appear to be scalped (cobbles removed) samples. The bidding contractor(s) could potentially be misled by this. It is recommended that the till gradations indicate that they have been determined on materials with the over-sized material removed. Considerable amounts of till have been excavated on site, and it would be appropriate to use this experience to define typical percentages of oversize material that can be expected in the lakebed tills.

16. *Section: 4.4.2, Table 4.4* – These SPT test results only relate to the Divider Dike. What about the boreholes drilled for the Central Dike (03GT-TD-2, 03GT-TD-6, 03GT-TD-6, etc.)? Overall, there is little testing or sampling of the lacustrine sediments or till overlying the bedrock. These deposits along the route of the Central Dike were found to be a maximum

of 18.13 m thick (ref. Table I-2); why was there no sampling or in situ testing of these materials?

17. *Section: 4.4.2, Table 4.5* – Was the coarser material removed from these samples prior to testing? This table should have a description of the material tested because some of the borehole logs are absent from the Report (see Comment 15 above).

18. *Section: 5.1.1, Paragraph: 2, Line: 2* – “High Consequence” – the Central Dike should be classified as a “Very High” consequence dike as previously discussed in Comment 5.

19. *Section: 5.1.1, Paragraph: 4, Line 2* – The Report has very little information or discussion regarding the lake dewatering, and INAC assumes that the planning, sequencing, deposition, treatment, and discharge of this water has been adequately dealt with in other documents.

20. *Section: 5.1.3, Table 5.6* – The referenced Figures V-2 to V-8 have difference minimum factor of safety values as summarized in table 5.6. What is the reason for the differences?

21. *Section: 5.5.1, Paragraph: 5, Line 4* – The statement “a trench is excavated along the upstream toe of the rockfill through the foundation soils to bedrock and an impermeable liner is installed” does not convey the possible complexity of this excavation.

    In some places the bedrock is approximately 18 m below the lakebed, so this will potentially be a massive excavation in water-saturated material. The trench will require substantial dewatering as it will act as a sink and water will inflow from the permeable saturated surrounding lacustrine sediments and till. The water pumped from the trench will contain a substantial portion of suspended solids and will require storage, treatment, and possible discharge. Inflowing groundwater will probably result in unstable trench sideslopes due to seepage erosion that will necessitate flatter trench sideslopes to maintain adequate stability, particularly where the lacustrine sediments are thick.

    INAC has a concern regarding the practicality of installing the proposed liner cutoff system in largely unknown ground conditions (see also MDRB#2, Section 7.0). Accordingly, the following questions should be raised:

    - Who is designing the stability of the trench?
    - Who is designing the trench dewatering system?
    - Where will the trench dewatering system discharge to?

- When will additional geotechnical drilling be completed to assess the geotechnical conditions along the alignment of the trench?
- What is the construction staging for this work?

According to the Report it appears that these responsibilities have been delegated to the Contractor, is it realistic to expect the Contractor to bid and mobilize appropriate equipment to undertake this project with such limited geotechnical information?

22. *Section: 5.1.1, Paragraph: 6* – The tie in of the liner to the bedrock is one of the key components to control seepage under the dike. This will be achieved by cleaning the bedrock, casting a concrete slab, and attaching the liner to the concrete slab using a primer and adhesive. Drawing 4100-15 shows a horizontal and flat surface; however, in reality, this will not be the case along the cutoff trench alignment, and some sections of bedrock may even be steeply inclined with possible vertical faces. There has been documented similar experience related to the difficulties of such a liner tie in. Therefore, it is recommended that the specifications and drawings should be expanded to detail the construction methods required for these more difficult cutoff sections.

23. *Section: 5.1.3, Paragraph: 12, Line: 2* – “equal to a two thirds peak ground acceleration” – INAC has referenced the quoted reference (US Corps of Engineers 1984) and can find no reference for the two thirds reduction factor. It would be appreciated if the relevant section of the reference document could be identified.

24. *Section: 5.1.3, Table 5.6* – Upstream stability with cutoff trench excavation needs to be a considered case and should include possible seepage forces. This has been discussed in greater detail in Comment 21.

25. *Section: 5.1.3, Paragraph: 16, Line 2* – It is understood from the Report that no design work for the cutoff trench excavation has been undertaken; therefore, the statement “further design of the excavation may be required….” should be changed to reflect the actual work completed and that future detailed design work is still required. This has been discussed in greater detail in Comment 21.

26. *Section: 5.1.3, Table 5.7, Note B* – The quoted rate of seepage through a liner of 100 L/ha/day – Does this quoted value account for the design hydraulic gradient across the liner? This should not be a constant number and there is a need to account for the expected hydraulic gradient across the liner in calculating the expected seepage.

27. *Section: 5.1.4* – A general comment to this section relates to the possibility of increased seepage due to thaw of existing frozen soils and rock. It is

understood that the grout curtain will control the seepage under the dam in unfrozen materials; however, grout will have limited or no penetration into the frozen materials because the pores or fractures will be filled with ice. What analytical work has been undertaken to evaluate the possible degradation of the permafrost due to the change of the thermal boundary conditions as a result of the construction of the dike and raising of the lake elevation? This could be most apparent beneath the dike abutments at the edge of the talik where the zero degree isotherm is near vertical and is often known to be unstable and prone to degradation. Accordingly, permafrost degradation (loss of frozen water as a seepage barrier) of the dike founding soils and rocks could result in increased seepage flow, which may require additional downstream collection and management.

28. *Section: 5.1.5, Paragraph: 2, Bullet: 4* – Should ensure that all ice-rich foundation soils are removed beneath the entire footprint of the dam, not just beneath the rock fill footprint.

29. *Section: 5.2.1, Paragraph: 3* – This paragraph clearly states and is concerned that a Divider Dike failure could affect the Portage Pit. Given this statement, the Divider Dike should be designed as a "Very High" consequence structure as failure could result in a loss of life of greater than 10 people working in the Portage Pit. Is there a situation during the life of mine where the Divider Dike is the sole containment structure between it and the Portage Pit (i.e., without the Central Dike)? If this is the case, then the Divider Dike should be designed as a "Very High" classification structure.

30. *Section: 5.2.1, Paragraph: 4* – If seepage through the divider dike becomes an issue, where will the collected seepage water be directed? Will the seepage water be allowed to pond against the upstream face of the Central Dike?

31. *Section: 5.2.2, Paragraph: 3* – Why is only a single liner bedding layer employed for this structure, whereas all the other dikes have a two layer filter system (see also mdrb#2, Section 6.3)?

32. *Section: 5.2.3, Table 5.18* – It is interesting to note that an upstream stability analysis for the Divider Dike was undertaken for the cutoff trench excavation, but a similar analysis was not undertaken for the higher dam classification Central Dike. Concerns regarding the cutoff trench excavations for the dike structure have already been noted under Comment 21.

33. *Section: 5.5.2, Line 1* – Should "freezing" read "temperature"? Ground temperature cables measure temperature only. Whether the ground is

frozen depends on many factors, including material type, porewater characteristics, etc.

34. *Section: 5.5.5, Paragraph 1* – How have blast vibrations been included in the seismic slope stability analyses for the Central Dike?

35. *Section: 5.6* – INAC agrees that additional geotechnical drilling is necessary before construction of the dike structures.

36. *Section: 6.1, Table 6.1* – For the dewatering program, where will the approximately 15 million m^3 of water be discharged? Is there a plan for direct discharge to the environment, and what percentage will be directly discharged? Where will the balance of the water be discharged and how will it be treated?

37. *Section: 6.2* – INAC agrees that more tailings planning work needs to be undertaken once the tailings depositional characteristics are better verified and understood. It is also recommended that this work be undertaken in conjunction with a site-wide water balance to ensure adequate solids and water handling capacity throughout the life of mine.

38. *Section: 6.3* – The rockfill roads (RF1 and RF2) receive very little attention in the Report text and are shown on some of the drawings. What is the purpose and design intent of these structures?

B. Report Drawings

1. Drawing 4100-04 – It would be useful to link the various stages of construction to a timeline. It should also be noted that very large volumes of rock fill are required for construction of the dikes. Where will this material be sourced?

2. *Drawing 4100-04* – The drawing indicates the projected fault line. Is any drilling proposed to define more clearly the extent of the fault zone together with grouting requirements?

3. *Drawing 4100-06* – The southwest upstream junction between the Central Dike and Saddle Dike is a possible zone for permafrost degradation. Consideration should be given for a thermal cover in this area to protect the underlying permafrost.

4. *Drawing 4100-07* – The cutoff trench shows typical slopes. If an 18 m excavation is required in this area, these slopes will require more detailed design work.

5. *Drawing 4100-07* – Notes 1), 3), and 4) are considered as inappropriate for the Contractor to deal with and should be designed by the Engineer because an excavation of 18 m (equivalent to a six-storey building) upstream of the dike is a serious undertaking.

6. *Drawing 4100-12* – Notes 2) and 3) are considered as inappropriate for the Contractor to deal with and should be designed by the Engineer.

7. *Drawing 4100-13* – Notes 2) and 3) are considered as inappropriate for the Contractor to deal with and should be designed by the Engineer. The drawing fails to represent the possible magnitude of the cutoff trench excavation.

8. *Drawing 4100-14* – Notes 1), 2), and 3) are considered as inappropriate for the Contractor to deal with and should be investigated further before start of construction.

9. *Drawing 4100-15* – This drawing only addresses a level working surface. This will not be the case for most of the cutoff trench; therefore, additional drawings should address casting of the lean concrete mat and adhesion of the liner on inclined surfaces.

10. *Drawing 4100-16* – Suggest that additional lines of thermistor strings be considered for the north and south abutments of the Central Dike.

11. *Drawing 4100-33* – What is the rationale for not using a two-stage filter liner bedding for this structure when it has been used for all other dike structures. It is assumed to be related to the working life of the structure being only temporary. Given that assumption, will the proposed liner bedding for the Divider Dike perform as intended during the life of the structure?

12. *Drawing 4100-33* – Again, the final depth of the cutoff trench for the Divider Dike will be in the range of 8 m. It is not felt to be appropriate to have the Contractor accept responsibility for the excavation stability, as per Drawing Note 4).

13. *Drawing 4100-50 to 59* – Again, the final depths of the cutoff trench for the Saddle Dam structures are not known, but they are expected to be much shallower than for the Divider and Central dikes. Where the cutoff trench is shallower than the active zone, consideration should be given to installing a thermal cover comprising till or other locally available material.

14. *Drawing 4100-70 to 72* – The rock fill roads receive very little attention in the Report, and it is not clear on their purpose and design intent.

C. Report Specifications

The following general comments relate to the Construction Specifications.

1. The roles and the responsibilities of the Owner, Contractor, and Engineer need to be clearly and consistently defined throughout the specification document. This poor differentiation could lead to future dispute between the Client and the Contractor. Table 1-3 of Appendix VII clearly differentiates between the responsibilities of the Owner and Contractor; however, the detailed specification sections are less descriptive. For example, S3 Foundation Preparation is an Owner's responsibility according to Table 1-3; however, Section S3.5, Paragraph 1, states "the Contractor shall lay out each excavation…"

2. With the limited geotechnical information, it is unfair to expect the contractor to "make his own interpretations of geologic conditions" as stated in S1.2.1.

3. Where possible, the Standards and Regulations should include and adopt the local Canadian standards, i.e., CSA.

4. The construction specification and construction responsibility should be supported with a detailed construction schedule. This is considered necessary given the close proximity of site activities. In addition, the schedule will allow for timely equipment selection and mobilization to site.

5. S2 Care of Water
   - Where will the collected water be pumped to?
   - How will the excavations on land be dewatered given the bouldery nature of the lacustrine sediments?

6. S3 Foundation Preparation
   - The waste soil and rock dump should be identified on a drawing by the Engineer so it does not affect any future tailings disposal plan.

7. S4 Lean Concrete Mat
   - How will the lean concrete mat be cast on steeply sloping surfaces along the alignment of the cutoff trench?

8. S5 Fill Placement
   - S5.6 suggests that there will be no winter placement and compaction. Is this realistic for the proposed construction schedule? If winter placement is necessary, the specifications should also address winter placement and compaction.

4. Conclusion

Indian and Northern Affairs Canada is of the opinion that AEM should implement these comments / recommendations into the design of the Meadowbank Gold Project's Tailings Storage Facility.

Generally, the Report is well prepared with an abundance of detailed factual information and test work. However, some of the fundamental, high level design aspects of the project have been omitted from the Design Report — e.g., the construction schedule, clearly defined roles and responsibilities, adequately detailed geotechnical information for the design of significant dike structures, practicality of constructing the proposed designs, and protecting the local ground thermal regime as one of the barriers to under-dike seepage control. Therefore it is recommended that AEM consider and/or incorporate the findings of this review into the construction and design aspects of the Meadowbank Gold Project's Tailings Storage Facility.