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Project No. 08-1428-0028
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RESPONSE TO INAC
SUBJECT: MEADOWBANK BAY-GOOSE DIKE REVIEW COMMENTS

Dear Mr. Robert,

On March 27, 2009, Indian and Northern Affairs Canada (INAC) interveners provided a technical review memorandum following their review of the design report, drawings and specifications for the Bay Goose Dike and South Camp Dike designs as well as based on the Meadowbank Dike Review Board (MDRB) reports. This letter provides Golder Associates Ltd. (Golder's) response to INAC questions and comments which is being submitted on behalf of AEM.

1.0 BACKGROUND

Golder on behalf of Agnico-Eagle Mines Ltd. (AEM) prepared and submitted the Bay Goose Dike and South Camp Dike Designs (Doc. 802 Ver. 0), consistent with the Water License #2AM-MEA0815 application, to the Nunavut Water Board (NWB). The NWB received the reports and placed them on their public registry. NWB requested written representations from various parties, including INAC. The response to INAC review comments is presented below.

2.0 RESULTS OF REVIEW

Comment 1:

The revised alignment is an improvement over the original as it generally puts the dike in shallower water and therefore should make construction of the cut-off easier (see also MDRB#1, Section 5.0).

Response 1:

The results of the site investigation performed during the spring of 2009 have provided additional information that has been used to further optimize the alignment. The northern portion of the Bay-Goose Dike will be constructed in 2009. A supplemental investigation program is being planned for the winter of 2009 – 2010. It will further investigate the foundation conditions for the southern portion of the dike which is scheduled to be constructed in 2010. The results of this pending investigation may result in further modifications to the alignment.

Comment 2:

A comprehensive site investigation certainly needs to be carried out. It is understood that the site investigation was expected to start this month. The following should be considered during this site investigation:

- a) *Target some boreholes in the fault zone.*

Response 2a:

As part of the 2009 spring geotechnical investigation, two inclined boreholes were drilled with attempting to intersect the fault. However, the fault was not intersected in either borehole. A supplemental investigation program is planned for winter 2009 - 2010 to further investigate the southern portion of the dike alignment, including the interpreted fault zone.

- b) *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).*

Response 2b:

The 2009 investigation included 2 inclined boreholes as mentioned above. Oriented coring was not conducted as part of the investigation nor borehole camera surveys conducted. Although this could be considered as part of the next investigation, exfoliation joints tend to be parallel or sub-parallel to topography, as encountered typically during the 2009 investigation. In addition, none of the interpreted near vertical to steeply dipping fault/shear zones were intersected during the 2009 drilling investigation program. Thus, the use of vertical grout holes is considered appropriate. Additional angled grout holes could be drilled along an upstream line, to intersect any near vertical fault zones if grout takes in tertiary and higher order grout holes do not achieve closure.

- c) *A drilling procedure that allows the amount of cobbles and boulders in the till to be quantified. A large diameter sonic drilling program was successful in quantifying the cobble and boulder content in the similar till materials found on the lakebed at the Diavik mine (see also MDRB#2, Section 5.0).*

Response 2c:

The spring 2009 drilling investigation program utilized available equipment on site, including an air track drill rig and diamond drill rig. Relative information about presence of cobbles and boulders and their size along the majority of the alignment has been obtained. As mentioned above, a supplemental investigation program is planned for winter 2009 - 2010 to further investigate the southern portion of the dike alignment, however; the drilling investigation method has yet to be selected.

- d) *Drilling or probing techniques that will define the thickness of the lacustrine sediment and its variation in the footprint of the dike should be employed (see also MDRB#1, Section 3.3 and 5.0).*

Response 2d:

The spring 2009 drilling investigation program has provided a good indication of the thickness of the lake bed soils at approximately 50 m intervals along the proposed cutoff wall centerline. The inferred presence of lakebed sediments was found at several locations. Further investigation to characterize the thickness of lacustrine sediments will be performed during the winter of 2009 - 2010 for the southern portion of the Bay Goose Dike.

Comment 3:

It is unclear why the Bay-Goose dike was given a High dam classification but the South Camp Dike was given a Significant dam classification (CDA 2007, Table 2-1). A failure of either dike floods the same area, and hence, the same number of people will potentially be at risk. The High classification is based on loss of life of 10 people or fewer. We would anticipate that more than 10 people would be in the pits at any one time, so a classification of Very High is felt to be more appropriate for both dikes.

Response 3:

The dam classification for the Bay Goose Dike was classified as “High” due to the risk to workers and to economic loss. The South Camp Dike was classified with a slightly lower risk as the rate of inflow from a failure in this structure is anticipated to be less, thereby giving more time for people to be evacuated. In addition it is anticipated that repairs for the structure could be done more readily minimizing the financial impact. The quantity of people working within both pits will vary and may exceed 10, however; we have considered that it is likely that some employees could be evacuated. These ratings are consistent with the classification for the East Dike. It should be noted that if the classification of the Bay Goose were changed to very high no design change would be required.

Comment 4:

Relevant ground temperature data is lacking; therefore, the permafrost distribution along the dikes (in particular at the abutments) is not well understood. There are 23 ground temperature cables at site, but permafrost temperatures and distribution provided in this design report are based on the CALM site at Baker Lake for some reason. There is a comment that the active layer is typically deeper near the shoreline, which seems odd. Extensive ground temperature instrumentation at other mines in similar climatic and soil/rock conditions have indicated that frozen ground is typically found offshore into water depths of up to 1 to 1.5 m (the water depth where the ice freezes to the bottom during the winter). The active layer immediately onshore (at the water's edge) is generally roughly the same as is found further inland unless there is exposed bedrock. The boundary between frozen and unfrozen ground found offshore at the 1.0 m to 1.5 m water depth is typically near vertical.

Response 4:

As part of the 2009 investigation program temporary thermistor strings were installed and monitored until they became inaccessible due to the ice thickness. Frozen ground was located in areas of the lake where the ice was frozen to the top of the lakebed soils, approximately in 1.5 m of water. Additional information to better define the transition between frozen and unfrozen ground will be sought during the winter 2009 – 2010 investigation.

Comment 5:

It will be difficult or impossible to grout in frozen soil or rock because the voids or fractures will be filled with ice. Therefore, the abutments and offshore in areas with water depths up to 1.0 m to 1.5 m cannot be effectively grouted. If seepage happens through the unfrozen soils/rock found immediately offshore of the near vertical frozen/unfrozen boundary noted in point 4 above, the boundary will potentially degrade, moving it towards the abutment into the previously frozen rock or soils. It is for this reason that active/passive thermal siphons were installed near the abutments of the dikes at the Diavik mine. Accordingly, the permafrost conditions at the abutments should be better defined and understood with respect to the current and future thermal and seepage regimes. This should include an evaluation of how seepage through the grouted zone could affect the frozen/unfrozen boundary and what measures may be required to control seepage and mitigate thaw.

Response 5:

Further consideration of other methods to reduce / control seepage near the abutments due to the presence of frozen ground may be considered, pending the results of the East Dike construction, dewatering, and ongoing seepage monitoring. It should be noted that heads (and thus gradients) on the abutments will be low (1.0 m to 1.5 m). As such, should dewatering activities show that leakage is occurring through/around the abutments, remedial grouting efforts could be undertaken to minimize this leakage. Thermistor strings will be installed to monitor the thermal conditions at the abutments.

Comment 6:

There is potential for frozen ground at depth (a closed talik) in shallow water areas, like the South Camp dike area. Again, the frozen soil/rock will not be able to be grouted, and the originally frozen, impermeable soil/rock could thaw if seepage occurs in the unfrozen overlying materials. This could lead to increased seepage with time;

Response 6:

As part of the spring 2009 investigation program 9 boreholes were drilled and one temporary thermistor string was installed in the area of South Camp Dike. The thickness of till was greater than anticipated (up to 25 m) which was frozen to depth. As a result of the change in conditions, the design for the South Camp Dike was modified and this structure has subsequently been constructed. Grouting is not currently planned beneath this dike. Monitoring of thermal regime beneath the dike will be implemented. Upon completion of dewatering, seepage will be collected on the downstream side and monitored.

Comment 7:

There is considerable potential for the lacustrine sediment found above the till on the lakebed to be mobilized into the water column during dike construction. It is stated that a sediment control curtain will be used to control release into the environment. A specification and design for the sediment control system should be included in the design and specification documents (see also MDRB#1, Section 3.3). The documents should include a performance specification for evaluating the effectiveness of the system.

Response 7:

A specification and design for the sediment control is included in the report *Control of Suspended Solids at Second and Third Portage Lakes – Construction of East, South Camp and Bay-Goose Dikes*, March 10, 2009. This report is included in the annual report submitted to INAC in April 2009.

Comment 8:

The thickness of the lacustrine sediment along the dike alignment is not well understood. If it is very thick, it will settle and could put significant down drag forces on the wall (see also MDRB#1, Section 5.0).

Response 8:

Results from the 2009 drilling program indicated limited pockets of softer/lower density soils along the dike alignment which are interpreted to be lacustrine sediments. During dike construction in these areas, rockfill placement will proceed along the dike centerline, followed by placement laterally to displace outward as much of the softer sediments as possible. In the northern portion of the dike, excavation through rockfill will be to bedrock and the cutoff wall will be founded on bedrock. The cutoff wall will be supported laterally by compacted core backfill. Stability of the wall is not anticipated to be impacted by the presence of lacustrine sediment beneath the rockfill. Stability of the rockfill embankment will be monitored and adjusted, if necessary during construction. Stability of the downstream toe of the rockfill embankment will also be monitored following dewatering.

Comment 9:

Cobbles and boulders in the till have not been characterized and the till gradations presented in the report are on scalped (cobbles removed) samples. The bidding contractor(s) could potentially be misled by this. It is strongly 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. It will likely be the cobbles and boulders in the till that determine how deep the cut-off wall can be excavated into the lakebed tills (see also MDRB#1, Sections 3.5 and 3.8). Therefore, the contractor should be well aware of the amount of cobbles and boulders in the till in order to bid appropriately and eventually to have the correct equipment available at site to handle these materials;

Response 9:

Characteristics of the till and the presence of cobbles and boulders within the till was discussed with the potential contractors during the site visit held as part of the bid process. In addition, borehole records from the 2009 investigation program were supplied to the contractors during the bid period. During the construction kick-off meeting held with the selected contractor, the presence of boulders within the till was discussed and the contractor confirmed that they are aware of their presence and that they will have appropriate equipment for the excavation.

In addition, the base width of excavation for the Bay-Goose dike has been increased in comparison to that for the East Dike to aid in the removal of boulders. The side slopes of the excavation have also been reduced to reduce the possibility of cobbles or boulders rolling back down into the base of the excavation. As the excavation through the rockfill and lakebed soils will be extended to bedrock for the northern portion of the Bay-Goose Dike, the potential for encountering large boulders during cutoff wall excavation is reduced. The geotechnical investigation program provided information on the bedrock elevation at approximately a 50 m spacing along the dike centerline which will assist in targeting excavation depths.

Comment 10:

There is no design for the seepage collection system, perhaps because it is noted to be the owner's responsibility. The design and specification should include designs and specifications for the seepage collection system. Consideration should be given in this design with respect to how it will function during the winter.

Response 10:

Design of the seepage collection ditches will be prepared by the engineer and construction will be by the Owner. Therefore details regarding the construction of the seepage collection ditches are not contained in the specifications or drawings for the contractor's construction component of the Bay-Goose Dike.

Comment 11:

The design report does not address the procedure to be employed for dewatering the area inside of the dike. Depending on the procedure used and the weather conditions during pumping, it is expected that between 50% and 60% of the water may be discharged directly to the environment (see also MDRB#1, Section 3.11). It is unclear where and how the remainder of the water will be handled. The design and specifications should indicate how this water will be handled unless this is specified in another document.

Response 11:

The Updated Water Management Plan for the Project (Doc. 833) provides further details regarding dewatering. This document has been submitted to INAC.

Comment 12:

There is a question in our minds regarding whether the site investigation will be complete and design finalized in time for contractor bids, contractor selection, and subsequent equipment mobilization. It will be very difficult for the contractors to bid accurately and mobilize the appropriate equipment fleet until the design is finalized and quantities are available. This raises questions with respect to what might be done if the contractor does not have the correct equipment available to undertake the work (see also MDRB#1, Section 6.0).

Response 12:

The selected contractor is required to construct the northern portion of the Bay-Goose Dike during the 2009 construction season. The geotechnical investigation program for the northern portion of the Bay-Goose Dike has been completed, the design finalized, bids received, and the contract awarded.

Information from the geotechnical investigation program and the final design was provided to the bidding contractors prior to submission of their bids. A kickoff meeting with the selected contractor has been held to review methods of construction, equipment, health and safety, schedule, and other aspects of the work. The contractor is preparing to mobilize appropriate staff and equipment to complete the work planned for 2009.

The results of the 2009 geotechnical investigation were presented to the MDRB during a meeting on June 12, 2009, and the MDRB supported the level of detail that was achieved for the northern portion of the dike (MDRB#3). A supplemental investigation program will be conducted during the winter of 2009 - 2010 for the southern portion of the dike. Following completion of the investigation program the alignment and final design for this portion of the dike will be established. If the design differs from the current, the Owner will undergo negotiations with the contractor to come to an agreement on adjustments if required. If necessary, the contractor will mobilize additional equipment to construct the southern portion of the dike in 2010.

Comment 13:

The design of and specifications for the instrumentation is not at all detailed. The instruments should adequately record conditions in the dike and allow appropriate warning of any undesirable or potentially unsafe conditions; it is therefore important that the instrumentation is properly installed and monitored. The reviewers recommend that additional detail be included in the drawings and specifications for the instrumentation system.

Response 13:

The specifications and drawings issued to potential contractors along with addenda issued during the bid process provided additional details to the contractors regarding the required instrumentation, including: number, types, depths of installation, and installation methods.

3.0 SPECIFIC ISSUES ANSWERS

a) Design Report

Comment 1:

Section 3.3 – Freeboard notes a 1.0 m freeboard, which is seems appropriate. However, no provision (overbuild) seems to exist in the design to account for settlements that could reduce the freeboard with time.

Response 1:

The cutoff wall, due to constructability issues, will actually be built 1.5 to 2 m (elevation 136.1 m) above the water level in Third Portage Lake (elevation 134.1 m). It is felt that this provides adequate freeboard and allowance for potential settlements.

Comment 2:

Section 4.1 – Shallow Depth Design indicates that dynamic compaction will be carried out to densify the backfill. The specifications do not indicate the procedures, criteria, etc., for dynamic compaction.

Response 2:

This component of the specification is based on performance (*i.e.*, performance specification) and therefore no minimum density is specified. The specifications state that sufficient compaction is required to permit construction of the slurry trench with stable side slopes for the continuous excavation depth and length.

The subcontractor who will perform the densification for the Bay-Goose Dike is the same subcontractor who performed the densification for the East Dike. For the shallow depth sections, which are comparable to the depths to which densification was performed for construction of the East Dike, the subcontractor plans to use a similar approach for the dynamic compaction, including: dropping the same mass, from a similar height, using a similar pattern for densification, and similar number of passes.

Comment 3:

Section 4.2 – Medium Depth Design identifies that thermal siphons could be considered if additional treatment of the foundation tills is required. This technique might indeed be suitable; however, the need for a minimum one full winter of freezing must be considered in the construction timeline (see also MDRB#1, Section 5.0).

Seepage evaluations have been carried for the dike, with a range of hydraulic conductivities for the lakebed soils and these have indicated seepage volumes of between 85 and 1500 m³/day for a 300 m long section. It is expected that the final design will use the results from the latest site investigations and experience with the construction of the East Dike to determine an expected range of inflows for the entire length of the dike. Foundation conditions and the effectiveness of the grouting will be highly variable and therefore it will be difficult to predict inflows accurately. However, it is recommended that a parametric seepage analysis be carried out to estimate the range of expected inflows to be able to design the seepage collection system appropriately (see also MDRB#1, Section 3.8).

Response 3:

Thermo siphons are no longer being considered for the medium depth section.

For the medium depth sections of the Bay-Goose Dike, below an elevation of 126 m cement soil bentonite (CSB) will be used for construction of the lower portion of the cutoff wall and soil-bentonite (SB) for the upper portion.

The proof of grouting effectiveness will be monitored during dewatering and following dewatering through the piezometers and thermistors installed within the dike and as measured in the seepage reporting to the downstream collection system. Information from the East Dike will be used to assist in the design of the seepage collection system for the Bay Goose Dike. Modifications to the collection system can be made, if warranted based on changes in seepage rates.

b) Drawing

Comment 1:

Drawing 4200-06 – The 0.75H:1V slope on the Core Backfill seems optimistic particularly when it is specified that the core backfill must precede placement of the Coarse Filter “wings” (Specification S5.9.4, page 47).

Response 1:

As indicated in the notes (Note 5) on the drawing 4200-06, all slopes shown are nominal values. As part of the quality control and quality assurance program, the quantity of core backfill will be monitored to ensure that the slurry trench will be excavated within this material.

Comment 2:

Drawing 4200-11 – This drawing does not show the piezometer installation locations. Additionally, the details for wiring the instruments into the proposed data acquisition “cabins” noted in the specifications are not shown.

Response 2:

As part of an addendum issued to the contractors during the bid process the approximate locations of piezometers to be installed has been indicated. The final location will be selected following dike construction. The specifics for wiring and connection to the cabins will be finalized with the contractor, depending on the specific models of instruments selected and also data acquisition systems supplied.

Comment 3:

Drawing 4200-12 - It appears that the typical section shows the wrong chainages: 30+235 should be 31+235 and 31+760 should be 30+760, if they are shown correctly on Drawing 4200-11.

Response 3:

Drawings have been revised.

Comment 4:

Drawing 4200-13 – Typical thermistor section does not show an installation detail for how the cables are to be installed (e.g., in a casing).

Response 4:

Installation will be directed by the Owner and will be in a casing.

Comment 5:

Drawing 4200-18 – The section generally shows a 2 m depth of lakebed soils. It is known that the soils will be of variable thickness; however, the depths from the existing boreholes indicate a simple average thickness of 3.2 m. Data will be available from the upcoming/ongoing site investigation, but the known information indicates that perhaps something greater than 2.0 m depth should have been considered.

Response 5:

Agreed, the results from the 2009 drilling investigation program have provided more detailed information (approximately 50 m centers) regarding the depth of lakebed soils beneath the cutoff wall and about the expected variation in these depths. The contractor is aware of this information and the drawings have been revised to reflect the new information. Further definition of the thickness of lakebed soils for the southern portion of the dike will be obtained during the upcoming winter 2009 – 2010 investigation and will be provided to the contractor prior to construction.

Comment 6:

Drawing 4200-19 – The section indicates that all grouting will be carried out in vertical holes. As noted in the Section 2.0, it is questioned whether vertical grout holes are the most appropriate orientation.

Response 6:

See response to comment 2b) in Section 2A note will be added to the drawings to indicate that additional angled grout holes may be required, depending on actual ground conditions encountered. Within the specifications, it is specified that drill rigs must be capable of installing casing and drilling grout holes at angles ranging from -90 to -45 degrees from the horizontal.

c) Specifications

Comment 1:

Section S1.2.3, Table 1-2 – All but one of the specifications are ASTM standards. It is suggested that CSA standards should be used for many of the required tests since this is a project in Canada and will probably use Canadian contractors.

Response 1:

ASTM is a recognized international standard.

Comment 2:

Section S1.4, Table 1-3 – Scope of Work – It is indicated that dewatering is to be carried out by the owner. It is recommended that the specifications include a section for dewatering.

Response 2:

See response to comment 11 in Section 2.

Comment 3:

Section S3 – Turbidity Barrier – This section indicates that specifications for the barrier (material, dimensions, etc.) will be provided under separate cover. The reviewers strongly recommend that the specifications for the turbidity barrier be included in this document (see also MDRB#1, Section 3.3).

Response 3:

See response to comment 7 in Section 2.

Comment 4:

Section S5.9.5 – Fill Compaction – It is indicated that procedures for densification of the Core Backfill will be trialed. Some methods may require specialized equipment, and unless it is planned for in advance, this equipment may not be available at site. It is suggested that the designers should indicate the expected methods to be employed (trialed) so the contractor has the appropriate equipment available.

Response 4:

The section of the specifications has been revised and is now “S5.6.4 “Compaction and Geotechnical Investigation”. The current specifications state the following:

“Compaction or densification of the Core Backfill and Coarse Filter “wings” shall be carried out to permit excavation of a slurry trench with stable side slopes throughout the trench in order to permit construction of the cutoff wall. The final acceptance of the compaction of the material is subject to the approval of the Slurry Trench Specialist and the Engineer. Methods for compaction or densification of the Core Backfill and Coarse Filter “wings” may be trialed during construction, and are subject to approval by the Engineer.

It shall be demonstrated to the satisfaction of the Slurry Trench Specialist that the backfill is sufficiently stable for slurry trench construction. A geotechnical investigation of the core materials shall be conducted at the discretion of and to the satisfaction of the Slurry Trench Specialist.”

See response to comment 2 in Section 3. The subcontractor recognizes that additional effort (energy) will be required for densification of the medium depth areas. The subcontractor is confident that by modifying the pattern and number of passes utilized that the required level of compaction will be achieved.

Comment 5:

Section S6.3.5 – SB Backfill – This section indicates that the slump of the SB Backfill shall be between 50 mm and 150 mm. Section S5.4.5 indicates that the till for this backfill can have particles up to 152.4 mm size. It is questioned how the slump of a material with very large aggregate could be measured. If it cannot be measured, is there an alternate test specification that is more appropriate for this material or is this till appropriate for making the SB Backfill? The QC and QA requirements (Table 9-2) also indicate that the permeability of this material will be measured. The reviewers question the feasibility of testing the permeability of a material with very large aggregate.

Response 5:

Slump testing and permeability testing are done on samples with the coarse fraction removed. The fine particles control the fluidity of the material and the permeability and therefore removing the coarse fraction does not have a significant impact on the results. Removal of the coarse fraction (above a specified size) of materials frequently forms part of the standard laboratory test procedures.

Comment 6:

Section S6.3.6 – CB Backfill – Note that CB Backfill will cure in the dike at temperatures that will probably be considerably colder than in the laboratory. In this case, strength gain in situ will probably be less rapid than in the laboratory, and the ultimate strength may also be substantially less. It is therefore questioned whether the desired 172 kPa strength is truly required. If it is, it may be more appropriate to specify strength for specimens cured at a temperature that more realistically reflects the in situ curing temperature for the CB Backfill or, conversely, a higher required strength for samples cured under laboratory conditions.

Response 6:

CB Backfill is no longer being considered for the cutoff wall construction. A combination of soil-bentonite (SB) and cement soil bentonite (CSB) will be used for the construction of the cutoff wall for the medium depth portions of the Bay Goose Dike. A slower rate of curing is considered advantageous and strength is not critical for the walls functionality.

Comment 7:

Section S8.2.3 &.6 – Cabins and Accessories – There is no specification or details on the drawings for the cabins, supports and accessories that are supposed to be supplied by the contractor.

Response 7:

These will be selected in consultation with the Owner following completion of dike construction.

Comment 8:

Section S8.3.7 – Data Acquisition and Processing Equipment – There is no specification for the data acquisition systems to be installed.

Response 8:

These will be selected following completion of dike construction in consultation with the Owner.

4.0 CLOSURE

We hope the above information provides the required clarification. If additional information is required, please do not hesitate to contact us.

Yours very truly,

GOLDER ASSOCIATES LTD.

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