Attendees:

- Dominion Diamond – Rick Bargery, Eric Denholm (E Denholm Consulting)
- Government of Northwest Territories, Environment and Natural Resources, Water Resources – Paul Green, Jamie van Gulck (Arktis Solutions Inc.), Barry Zajdlik (Zajdlik & Associates Inc.)
- Golder Associates Ltd.– Don Chorley, Christine Bieber, John Faithful, Kristine Mason, Mike Herrell

Summary of discussion:

- Discussion of Hydrogeological Modelling (Appendix 8A and 8B)
- Clarified that the transition period from where the 3-dimensional model stops (end of operations) and the 2-dimensional model starts (closure modelling) is the end of Period 12 (referenced Figure 8A4-3 and Figure 8B3-2). The results of the predicted groundwater inflow and groundwater quality (as presented in Table 8A3-5) are from the 2-dimensional model.
- The initial conditions of pit lake water quality applied in the 2-dimensional model are based on a TDS profile provided from the site water quality model following refilling of the pit.
- Discussed that the GNWT would prefer a quantitative level of certainty for the hydrogeological model (e.g., Monte Carlo simulations). A proposed method to quantify the uncertainty was provided by the GNWT to Dominion on April 16, 2015 (correspondence provided below). The April 16 correspondence provides discussion on the reasons for the request for additional modelling, proposed approach, and a preliminary list of model parameters to consider in the Monte Carlo simulations. These specifics were further discussed with Dominion during the April 22 meeting.
- Dominion discussed that the EA Conservative Scenario in Appendix 8A and carried through the DAR represented the upper bounds and is very conservative so that effects on the environment are not underestimated. Again the GNWT discussed that the uncertainty in the hydrogeologic model has not been sufficiently quantified and that there is uncertainty regarding the simultaneous effects of enhanced permeability zone (EPZ) properties and total dissolved solids (TDS) concentrations in the groundwater.
- The conservative scenario included the transmissivity of an assumed EPZ equal to Duey's Fault at the Diavik mine, which is considered the most transmissive EPZ at the Diavik and Ekati mines. However, there would potentially be limited data from EPZs to include in a simulation that may be meaningful.
- GNWT recognized this, and there was a discussion of a few potential approaches. The GNWT offered to provide further advice and input into the method of analysis and inputs to the Monte Carlo simulations, including but not limited to: parameters to assess, the bounds of the parameter inputs,the probability distributions for the parameters and providing support to Dominion on the record for ruling out non-realistic results that are based on stochastic input distributions based on a limited dataset. The purpose of the latter is to avoid other parties referring to these results as worst-case when they would not likely occur in reality. The GNWT considers that the findings from the Monte Carlo simulations would provide a quantitative understanding of the uncertainty in the hydrogeological model.

Developer Commitments:

- Dominion committed to further considering the additional simulations to quantify uncertainty

GNWT Commitments:

- GNWT offers to work with Dominion on this subject and provide advice and input into the method of analysis and inputs to the Monte Carlo simulations.

Outstanding Issues:

- Quantification of level of certainty in hydrogeological model

Action Items:

1. Dominion to consider request and report back to GNWT and the Board before the end of the technical sessions (DDC reported another meeting between the GNWT and DDC and other interested parties scheduled for Tuesday, April 28).

From: Nathen Richea <Nathen_Richea@gov.nt.ca>
Date: April 16, 2015 at 3:02:50 PM MDT
To: "Bargery, Richard" <Richard.Bargery@ekati.ddcorp.ca>
Subject: Ekati hydrogeology request

Hi Rick,

In preparation for the upcoming technical sessions we wanted to share some thoughts with you in advance so you and your team have a few days to consider the request. It is something that we would be bringing up at the technical session.
Our consultants have identified some concern over the hydrogeology modeling provided in the DAR. So far, DDEC has not quantified the level of conservatism in their groundwater inflows and the permeability of EPZ. We are not sure that this is possible given the information provided to date.
To address this concern and progress through the review process, the following is proposed. To address the uncertainty around the EPZ, and to quantify the conservatism of the hydrogeologic modeling for pit inflows and water quality, it is our opinion that some additional modelling should occur. It is proposed that this additional modelling could be completed before the interventions and support the environmental impact assessment. This modeling would be an alternative to completing additional field work to characterize the EPZ further (which would likely not be possible to complete before end of permitting). It is estimated the modeling could be completed in a 2 week timeframe. The following is a description of the suggested modeling approach:
SUBJECT: Proposed 2D Hydrogeological Domain and Uncertainty
It is clear from all the hydrogeologic studies and numerical modeling performed that the enhanced permeability zone (EPZ) as postulated in the documents exhibits the strongest control over mass transport and quantities of water inflow into the proposed pit. (see Table 8A3-6). The EPZ extent (lateral and vertical) over the entire modeling domain is unknown as well as its properties (e.g. width, hydraulic properties, chemical signature, and even its existence itself) are not well characterized which leads to uncertainty in the model results. According to Appendix 8B (2D modeling), it is believed that if such a feature exists it would contribute to 70% to the total flow into the pit. Basically, the EPZ feature, as conjectured, has a hydraulic conductivity of about three orders of magnitude greater that the host rock, meaning that it would behave like a confined aquifer and tend to focus flow and transport, and dominate total flows in the area.
It would appear that without more detailed geological exploration (drilling, geophysics or structural mapping) limited quantitative confidence then can be placed in any of the numerical modeling, with respect to determining actual risks associated with aquatic wildlife and water quality and quantity in general.
Fortunately, there are methods that allow for formal quantification of uncertainty in a groundwater model and these consist of repeated sampling/simulation and are referred to as Monte Carlo (MC) methods. The basic idea is that parameters such as porosity, hydraulic conductivity, etc., and structural parameters like thickness, even starting chemistry and so on are considered fundamentally uncertain. These parameters are then represented by probabilities and not fixed (deterministic) quantities. For each MC run, a sample value of each unknown parameter is taken from its probability, the model is run, and output such as flow, heads, concentration are stored. This process is repeated and eventually enough data is collected such that the computed potentials, like flow, can be represented by a frequency distribution. This data can then be parsed in terms of mean values, confidence limits and so on; the results of which can be fed into other risk models if desired. The above algorithm and methodology is well accepted and widely used today (see Woodbury, A. D., A probabilistic fracture transport model: Application to siting a municipal landfill on a fractured clay deposit, Can. Geot. J., 34, 784 -798, 1997).

Is this something that DDEC can complete? It is assumed that the following parameters should be considered in the MC runs: porosity of competent bedrock, effective porosity, specific storage, K of weathered bedrock, K of

competent bedrock, K of the EPZ, extent of the EPZ horizontally and vertically, width of the EPZ, K of the kimberlite, dispersivity, and any other necessary hydraulic parameters. This list is by no means exhaustive, and is intended to be informative, and that final choice of parameters to assess should be determined by the DDEC. It is likely that some parameters may be fixed and others would be random.

Again, please note that this is something that we wish to discuss further at the upcoming technical sessions. Let me know if you have any questions.

Thanks,

Nathen