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Our Ref: 317011-00013

1 April 2021

The City of Calgary
625 - 25 Avenue SE
PO Box 2100, Station M#436
Calgary, Alberta
T2G 4R5

Attention: Ms. Amy Stansky

Dear Ms. Stansky:

RE: THIRD-PARTY REVIEW OF HYDROGEOLOGICAL CHARACTERIZATION AND GROUNDWATER FLOW MODELLING REPORT – BOWNESS FLOOD CONTROL BARRIER PROJECT

Worley Canada Services Ltd. (Worley), operating as Advisian, has been engaged by The City of Calgary (The City) to provide a third-party review of the hydrogeological study and development of a numerical groundwater flow model for the proposed Bowness Flood Barrier Project.

This letter presents Advisian's final technical review of the Hydrogeological Characterization and Groundwater Flow Modelling Report (the Report) prepared by Klohn Crippen Berger Ltd. (KCB) and dated January 4, 2021.

KCB provided also a letter dated March 2021 (draft) which summarized the third-party review process and the updates to the conceptual hydrogeological model (CHM) and the groundwater flow modelling based on Advisian's review comments.

1 Previous Review Comments

Advisian has previously provided two review letters as follows:

Letter # 1: Submitted to the City on August 22, 2020 and finalized on November 19, 2020. The letter provided review comments on the conceptual hydrogeological model (CHM) and groundwater model design basis memorandum (DBM) provided by KCB in a Technical Memorandum dated July 13, 2020. The letter included a list of documents provided by KCB and reviewed by Advisian, and a list of technical clarification meetings held with the City and KCB.

Letter #2: Submitted to the City on November 21, 2020 and finalized on December 18, 2020. The letter provided review comments on Draft Hydrogeological Characterization and Groundwater Flow Modelling Report prepared by KCB dated November 3, 2020.

Advisian also attended the Bowness Flood Mitigation Working Group meeting of December 7, 2020, in which model simulation results were presented by KCB, and Working Group members were provided an opportunity to ask questions.

2 Final Report: "Hydrogeological Characterization and Groundwater Flow Modelling Report" – January 4, 2021

For the final report, KCB updated the Uncertainty Analysis (Section 6) by running key predictive scenarios for the alternative calibration 2 (increased hydraulic conductivity and increased recharge), thus complementing the results obtained for the alternative calibration 1. These results indicate that the hydraulic conductivity of the Alluvial Aquifer is a key aquifer property controlling the extent and magnitude of the groundwater-induced flooding due to the river flood events.

An important outcome of the model simulations has been the identification of areas that are potentially susceptible to groundwater-induced flooding due to river flood events, *with* and *without* the proposed surface flood barrier (surface event barrier; SEB), as depicted in Figures 5.6, 5.7 and 5.8 of the Report. The new Figure 5.8, in particular, provides focus on potentially affected areas through the magnitude and extent of the changes in the water table.

Our final review confirms that:

a. The Report has adequately addressed the review comments provided in Advisian's Letter #1 and Letter #2.

b. The conceptual hydrogeologic model, as developed, is considered adequate to fulfill the objectives of the study, as defined in Section 1.1 of the Report.

c. The numerical groundwater flow model as developed and applied has met the objectives stated in Section 1.4 of the Report.

3 Recommendations

We make the following recommendations for consideration by The City for the next design phase of this project:

a. We agree with KCB's recommendations, as presented in Section 7.3 of the Report, to focus additional investigations in the areas that are potentially susceptible to groundwater-flooding resulting from river flood events with the proposed surface flood barrier in place.

   In addition, we recommend that high-rate pumping tests be designed and conducted in each of the focus areas to stress the Alluvial Aquifer and obtain estimates of the hydraulic conductivity and storage coefficient that are representative of the Alluvial Aquifer in each of the focus areas and associated variability within the Alluvial Aquifer. Additional observation wells will be required in

conjunction with each pumping well. It is suggested that the groundwater flow model would be a useful tool to assist with the design of the pumping tests in each of the focus areas.

The rationale for this recommendation is the relatively high sensitivity of the hydraulic conductivity on the model results, as discussed in Section 6 of the Report. The hydraulic conductivity and the storage coefficient derived from a high-rate pumping test will be representative of a larger aquifer area and will reduce the uncertainty in both the prediction of effects to the water table and the design of mitigation measures, should they be required.

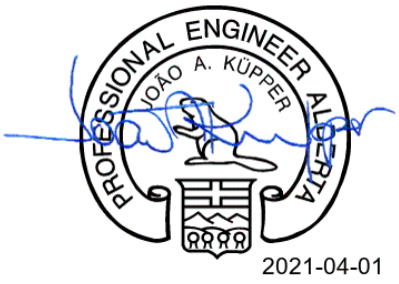
b. With respect to data gaps, data gaps in water levels and groundwater flow conditions remain in the portion of the study area that is away from the river. While we recognize that the Zone of Influence is the critical area for assessment of effects of a surface flood barrier on groundwater, we are of the opinion that there is merit in better defining the groundwater conditions in the area away from the river and confirming the extent of dry areas and the segmented nature of the aquifer. This is of interest for the southeast Bowness, where the groundwater appears to be partially to mostly isolated from the larger Alluvial Aquifer and in direct connection with the river. For this objective, installation of additional monitoring wells would be recommended.

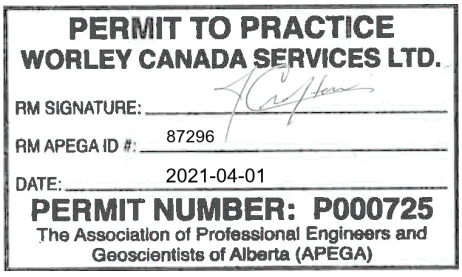
4 Closure

We trust this letter provides closure to our third-party review of the final "Hydrogeological Characterization and Groundwater Flow Modelling Report prepared by KCB.

Should you have any questions or need additional information, please contact the undersigned at your earliest convenience

Yours sincerely,





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