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1007 Century Street
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January 21, 2022

Project #
60640258

RE: Vivian Sand Extraction Project (File# 6119.00) – Response to Additional Technical Advisory Committee (TAC) Comments

Dear Ms. Winsor:

On behalf of Sio Silica Corporation (formerly CanWhite Sands Corp.), please find below our response to additional comments received from the Technical Advisory Committee (TAC) in the memorandum dated January 7, 2021 (assumed to be January 7, 2022) regarding the Vivian Sand Extraction Project Environment Act Proposal (EAP) submitted to Manitoba Conservation and Climate on July 23, 2021.

Comment to Response of Question #47 and #50:

It is acknowledged that several industrial standards for numerical groundwater modelling were adopted as calibration performance assessment reference. The mentioned widely used evaluation criteria was agreed, but the calibration quality of this model remained question-marked as: First of all, NRMSE = RMSE/(hmax – hmin); based on the plotted head observation range and the calculated RMSE (Figure 6-2), NRMSE is estimated to be approximately 5-6%, not 1.7% mentioned in the proposal and the TAC response. Secondly, zero or near-zero is a common target for residual mean being adjusted to mean residual of 3.27 m is considered obvious over-prediction comparing to the maximum observed head difference (~100 m). Finally, there is more room to optimize the calibration within the Project Site (Figure 6-3), apply weighing calibration to the provincial observation wells and the wells within the Project Site for Steady State calibration is recommended, in addition, this may benefit to set a better initial condition for the transient model and justify if the model presented the issue with equifinality (FERGUSON-5, appendix B).

CanWhite Response:

The groundwater model was calibrated in two phases. The first phase involved a steady-state calibration of the model to groundwater elevations reported in public databases across the model domain. The second phase of model calibration was a transient calibration with the objective of matching simulated and observed groundwater elevations measured during the November 2020 pumping test.

The steady-state model was calibrated to water level measurements that were generally collected at the time each well was drilled and reflect aquifer conditions that have since changed. This is particularly true for the western portion of the model domain (near Winnipeg and the Red River Floodway), where historical artesian conditions in the sandstone aquifer are known to have been affected by operation of pumping wells completed in the sandstone aquifer and inter-aquifer exchange. In the same area, water levels in the carbonate aquifer have been lowered following construction of the Red River Floodway. It is acknowledged that provincial or municipal monitoring wells that are continuously monitored may warrant greater weight than domestic wells during future calibration efforts. However, the spatial coverage

afforded by the domestic wells was judged to provide value to supplement the provincial observation well network.

The transient calibration had the objective of matching simulated and observed groundwater elevations measured during the November 2020 pumping test. The transient calibration dataset included water levels in the pumping well and several observation wells in both the sandstone and carbonate aquifers. Aquifer properties were adjusted, and simulated heads were shown to reasonably match water levels observed during pumping and recovery phases of the test. Aquifer properties were also similar to those reported in the literature and estimated from pumping test data within the Project Site. This exercise, though very time intensive, provided a far more rigorous set of calibrated model parameters and therefore was given greater weight than achieving an optimal steady-state calibration.

While the calibration statistics are presented for the steady-state model, it is the transient model calibration process that best addresses the equifinality issue because hydraulic conductivity and specific storage have been adjusted to produce the results that are judged to simulate observed water levels and the behaviour of both the carbonate and the sandstone aquifer reasonably well. The ability of the model to replicate the transient behaviour of the complex multi-aquifer system reasonably well when reasonable aquifer properties and boundary conditions have been assigned adds much more credibility to the calibration than the steady-state calibration.

In response to the Reviewer's first comment, the NRMSE statistic was calculated as NRMSE = RMSE/(hmax – hmin) based on observed (not simulated) hydraulic heads (groundwater elevations) across the model domain. The maximum observed hydraulic head (hmax) was 321.34 masl, and the minimum observed hydraulic head (hmin) was 170.90 masl. The RMSE is calculated as 5.46 m. During a supplemental review of the 2,534 simulated head values, a single errant value of "0" was noted to have been incorporated into the calculation. This value was removed to produce a corrected NRMSE of 3.63%. This value remains below 5% and according to the previously referenced industry standards, the model calibration would be classified as "very good".

Further to the Reviewer's second comment, it is acknowledged that zero to near-zero is a common target for mean head residuals, and that the model does slightly overpredict hydraulic heads. Many factors (e.g. changed aquifer conditions, seasonality, pumping, etc.) can influence reported water levels, and may contribute to higher head residuals. As shown on Figure 6-3 (Appendix A to the EAP), the majority of the highest hydraulic head residuals are located near Winnipeg and the Red River Floodway, which is several 10's of kilometres from the Project Site. There are additional wells that are spread across the model domain that report relatively large residuals. While the cause for each of the elevated residuals has not been directly investigated, it is suspected that some well logs reported water levels that had not fully recovered following drilling. It is also possible that some wells have been assigned to the incorrect location or aquifer as is common in large data sets developed over a period of nearly 100 years. It is important to note that the vast majority of simulated heads match observed heads reasonably well across the entire model domain.

It is important to recognize that it is the magnitude of drawdown (not the absolute groundwater elevation) that is being used to evaluate the impacts of the proposed project. For a given set of calibrated aquifer properties, the magnitude of drawdown is not affected by antecedent groundwater elevations. Therefore, the slight overprediction of hydraulic heads by the model is inconsequential to the current assessment and the implications of the modelling results, and the modelling results are judged to reasonably simulate the extents of the drawdown associated with the Project.

Further to the Reviewer's third comment, it is widely known that steady-state calibration of groundwater models may be achieved by applying different combinations of aquifer properties and boundary conditions, which is referred to as "non-uniqueness" or "equifinality". To address this issue, the transient calibration incorporated monitoring data in both aquifers at various distances from the pumping well and a reasonable fit was achieved to these observation wells. Although there are many approaches that can be implemented during model calibration, it is AECOM's opinion that the model is suitable for the intended purpose for the reasons discussed above. Models are tools that should be periodically updated as new information becomes available to inform management of the groundwater resource. It is agreed that further refinements to the calibration could be implemented during routine model updates, including those suggested by the Reviewer (i.e., censoring and/or weighting of calibration targets).

Despite the fact that there are always opportunities for refinement of groundwater models, the model as presented was developed following industry standard practice and meets or exceeds industry benchmarks used to judge the adequacy of calibration. It is therefore judged to be able to reasonably simulate aquifer behaviour and its response to Project operations. A robust groundwater monitoring and mitigation will be developed to monitor the aquifer, confirm modelling results, and guide management decisions to avoid and/or mitigate any impacts to groundwater users.

Thank you, and please contact me directly with any questions or comments.

Sincerely,

[redacted]

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