Manitoba Clean Environment Commission
Hearing for the Vivian Silica Sand Extraction Project (Project)

Sio Silica Corporation (SSC) Responses to Technical Experts Reports – Geotechnical
November 2022

Issue Number:	1
Section and Page #:	Page 1- Executive Summary (Pg ES-1)
Issue/Question Raised:	*Arcadis' assessment and comments as provided to CEC in the 27 July 2022 report were based on information contained in the Project Proposal and its associated supporting documents. With regard to the potential failure of the Winnipeg Shale aquitard, Arcadis also considered comments from Sio Silica's technical advisors provided during a technical meeting (as per the recommendation in Section 7.2) held on 6 September 2022. No technical changes were made to the 27 July 2022 document as a result of the meeting*
Response:	A technical meeting between Sio Silica's experts and the CEC Technical Experts was held on the 6th of September 2022 where Sio Silica understood that questions were to be asked by the CEC Technical Experts to the Sio Silica technical team to provide clarity and understanding prior to finalization of the Technical Reports by the CEC Technical Experts. During the three-hour meeting only a small percentage of the overall concerns expressed within the Technical Reports were discussed. The majority of the meeting time (the last 2 hours) was a PowerPoint presented by the CEC Technical Experts summarizing their views where Sio was not offered any substantive opportunity to respond. Although Sio Silica's experts responded to the questions posed to them during the meeting, and in several cases explained why the views/understandings presented by the CEC Technical Experts were factually incorrect, the CEC Technical Experts decided to finalize their Technical Reports without making any substantive changes to them (Page ES-1) or without seeking additional information from Sio Silica's experts to correct the factual deficiencies in the Technical Reports. It is therefore unclear to Sio Silica why this meeting was held in the first place.

Issue Number:	2
Section and Page #:	Section 4.2, Page 8
Issue/Question Raised:	*The "air lift" method has not been used as a full-scale mining method. This introduces a degree of uncertainty regarding which justifies adopting a more precautionary approach when developing and implementing project designs. This is particularly important given the need to protect local and regional groundwater resources.*
Response:	Air lifting is a method that is used regularly in the water well drilling industry. It is used locally and internationally to drill wells in various formations. Sio's extraction method combines the traditional method of airlift used to develop water wells and

a dual rotary set up usually used to drill wells in unconsolidated formations to extract sand.

Combining all of the collected information, pilot testing results, modelling and design, the environmental effects associated with the proposed extraction methods are generally well-understood.

Issue Number: 3

Section and Page #: Section 4.3, Page 10

Issue/Question Raised: *In the opinion of Arcadis, the abbreviated temporal scope, substantively smaller spatial scope and exclusion of critical project components constitutes "project splitting". In simple terms, this involves breaking a project into smaller pieces that individually fall below EA impact thresholds that might otherwise result in significant impacts.*

Arcadis considers this to be a material deficiency with the Project Proposal and recommends that the CEC explore options to evaluate the potential environmental impacts of the entire Vivian Sand Project, not just sand extraction.

Response: It is AECOM's opinion that commentary on the permitting of the Facility Project, which has already obtained an EAL, is outside of the scope of what the Clean Environment Commission (CEC) and Arcadis were instructed to review. However, as explained within the AECOM Environment Act Proposal (EAP) and supplemental materials, the permitting process and timing of both the Facility Project and Extraction Project were discussed at length and reviewed in detail with provincial regulatory agencies, and at no time was there an indication that the filing of Sio's EAPs were inappropriate and/or fail to meet the requirements of The Environment Act. Section 1.7, Page 8 within the Extraction Project EAP provides the rationale for the consideration of the Facility Project and Extraction Project as separate projects, and not 'project splitting' as inaccurately claimed by Arcadis.

Additional comments regarding the issue of 'project splitting' is provided in responses to Key Issue / Question # 282 and 283 in the 'Vivian Sand Extraction Project (File# 6119.00) - Environment Act Proposal Review Responses to the Public' table submitted to Manitoba Conservation and Climate, Environmental Approvals on January 14, 2022, and posted on the Public Registry on January 25, 2022.

It should be noted that the authors of the Arcadis report seem to be under the impression that the Facility EAP is still being reviewed. An EAL for the Facility Project was granted on December 16, 2021.

Issue Number:	4
Section and Page #:	Section 5.1, Page 15
Issue/Question Raised:	*If the Project implements the design parameters recommended by Stantec (2022), Arcadis supports the Proponent's conclusion that the undertaking will not result in significant adverse impacts to the geotechnical/topographic environment. This conclusion applies exclusively to impacts at surface and does not address potential hydrogeological impacts that may occur as a result of sub-surface geotechnical failures. The conclusion does not apply to areas outside of the spatial scope assessed by Stantec (2022) and is subject to change as additional information becomes available.* *In addition to the conclusion noted above, Arcadis has provided a series of Geotechnical Findings and Recommendations in Appendix A.*
Response:	Stantec acknowledges that Arcadis has reviewed and overall agrees with the conclusions of the geotechnical analysis. Stantec will provide further comments on Appendix A in a separate document.

Issue Number:	5
Section and Page #:	Section 5.2, Page 16
Issue/Question Raised:	*If the Project is subjected to standard regulatory requirements and implements appropriate environmental controls and mitigation measures, Arcadis supports the Proponent's conclusion that the undertaking will not result in significant adverse impacts to soils.*
Response:	No additional comment.

Issue Number:	6
Section and Page #:	Section 5.3, Page 17
Issue/Question Raised:	*The Project Proposal does not identify the collapse of the shale aquitard as a critical failure mode, nor does it explicitly evaluate the hydrogeological or regulatory implications of such a failure. While Arcadis considers this to be a material deficiency in the Project Proposal, we defer to the CEC's hydrogeological advisors on the topic.*
Response:	This comment is incorrect. Based upon geotechnical borehole drilling and publicly available material, the shale unit was identified in the Geotechnical Analysis for Sio Silica Extraction Project (found in Attachment A of Table 2 Responses to Public Review Comments Vivian Sand Extraction Project) as typically not competent material. Therefore, the shale was considered to provide zero stability as caprock and was not included in the model or assessment as a result. In other words, from

a geotechnical perspective, the assessment was conducted assuming that the shale aquitard could collapse. Geotechnical analysis focused on competent units above the shale to identify void spans which would remain intact and eliminate the potential for surface subsidence.

Additionally, it should be noted that the Hydrogeological and Geochemistry Assessment also considered the possible collapse of the shale aquitard from a geochemistry perspective. Further details concerning the hydrogeological components of this comment can be found in the Responses to Technical Experts – Hydrogeology Technical Review document (Issue #8 and #93 responses in that document).

Issue Number: 7

Section and Page #: Section 5.3, Page 18

Issue/Question Raised: *The design of water treatment systems to sterilize extracted groundwater prior to re-injection into the Winnipeg Sandstone aquifer remains at an early conceptual stage. As a result, there is currently insufficient information regarding the treatment requirements and process to confirm whether there are any potentially significant impacts associated with the reinjection of treated water. The topic should be pursued further during the course of the Environmental Assessment.*

Response: It should be noted that the use of UV is purely precautionary, as contamination is not expected during the sand extraction process. UV will be utilized in an abundance of caution. Based on the available technology, and the work done to date, Sio is confident that water can be effectively treated utilizing UV and filtration, and that reinjection of water into the aquifer will not cause any significant impacts to water quality.

At the time of submission of an EAP, applicants are not required to have completed their detailed engineering and design. Detailed engineering and design is typically completed during and after the regulatory review process, incorporating input from government agencies and other interested parties. Sio is working with industry leading ultraviolet (UV) treatment specialists and a certified laboratory to determine appropriate equipment selection for UV treatment and filtration.

UV systems are widely used to disinfect industrial and municipal water for potable and non-potable uses and the systems being considered by Sio are all proven, commonly used, and available from many established suppliers. To support the design of the UV treatment system, Sio will be undertaking additional water quality testing. Several parameters will be monitored in the field and verified by the analytical laboratory to guide system design.

As indicated in Table 1, Response #11 in Sio's 'Response to the Technical Advisory Committee (TAC) Review Comments', posted on the Public Registry on December 20, 2021:

"*Regarding technical specifications of the UV treatment system, a design dose of 25-30 mJ/cm² is typical for waste water treatment systems designed to meet 200 MPN/100mL fecal coliform limit, but a higher dose may be required based on local water quality and UV lamp fouling estimates. At this preliminary stage, the final design criteria for the UV treatment system are being developed. The final system design may also include a system that provides a target of 3-log (99.9%) inactivation of both Giardia and Cryptosporidium in accordance with local drinking water standards, although this is a higher level of treatment than is typically used in other applications when returning treated water back to the environment. An upstream filtration system may be required*."

"The control narrative related to pumping operation is still in the preliminary design stages, but will include industry-standard operational fail safe requirements such as: alternating Duty/Standby UV disinfection units, the inability for the UV system to be bypassed, separate alarms to indicate lamp failure, low UV intensity and other causes of UV disinfection unit failure. A dedicated programmable logic controller (PLC) may be provided given the mobile nature of the systems, and multiple PLCs may be provided as necessary to ensure continuous treatment, depending on the final controls design."

Issue Number: 8

Section and Page #: Section 5.3, Page 19

Issue/Question Raised: *In the opinion of Arcadis, further quantitative assessment and modelling may be necessary to support the Proponent's conclusions that oxygen introduced by the extraction process will not have an adverse impact on groundwater geochemistry. Consideration should also be given to potential microbial contamination of groundwater aquifers from the injection of large volumes of air during the sand extraction process. Arcadis defers to the CEC's hydrogeological advisors on these topics.*

Response: For the reasons outlined below, water quality at nearby water wells would be unchanged or possibly marginally improved as a result of the Extraction Project. Concerns regarding the impact of introducing oxygen into an anaerobic aquifer has been previously addressed in Sio's Responses to the Public table submitted to Manitoba Conservation and Climate, Environmental Approvals on January 14, 2022.

As explained in response to Key Issue / Question # 33, it is unlikely that dissolved oxygen will facilitate the proliferation of iron bacteria and other microbes. Most of the air utilized during the extraction process will not interact with the aquifer but

will return to surface with the sand slurry and return to the atmosphere. The groundwater returned to the aquifer after treatment will contain only a very small volume of dissolved oxygen. Extraction activities will not introduce any biological contaminants into the aquifer.

As explained in response to Key Issue / Question # 36, although most of the air utilized during the extraction process will not interact with the aquifer (air will return to surface with the sand slurry and return to the atmosphere), a net addition of a small amount of dissolved oxygen may occasionally occur within the aquifer. However, if this does occur the addition of dissolved oxygen would have a positive effect on groundwater aesthetics. Chemical reactions between iron, manganese and oxygen would produce less soluble mineral precipitates, which generally will attach to local substrate or will be filtered out of the water by the sandstone and not result in discoloration of water used by domestic well users. This is the reason that geochemical modelling found that Sio's operations may result in a reduction of the naturally elevated concentrations of dissolved iron and manganese in the groundwater in the immediate vicinity of the extraction wells.

Issue Number: 9

Section and Page #: Section 5.4, Page 20

Issue/Question Raised: *Quantitative analysis are required to confirm the Proponent's conclusion that the project will not result in significant air quality impacts. These analysis should include baseline air quality measurements, the preparation of emission inventories, atmospheric dispersion modelling and air quality monitoring.*

Response: Arcadis is in agreement that the Extraction Project is unlikely to result in the atmospheric emissions of silica sand that would have a significant negative impact on air quality.

However, Arcadis suggests that a quantitative analysis of emissions from mobile and stationary equipment be conducted. It is our opinion that the quantitative analysis proposed by Arcadis, including the development of an air emissions inventory and air dispersion modelling, is not warranted given the scope and scale of the Extraction Project. The vehicles and equipment used for Project activities (listed in Table 2-1 of the EAP) would not all be operating simultaneously and will move around the Project Site as extraction wells are drilled and progressively decommissioned. This equipment is also not all concentrated in one small location, nor is there a large volume of equipment. Where possible, equipment will be electrified thereby further reducing the potential for emissions. For these reasons, Sio concluded that this equipment and activity would not cause significant air quality impacts.

The greenhouse gas (GHG) calculations for the EAP (Section 6.3.2) are based on guidance in Canada’s Greenhouse Gas Quantification Requirements (Environment

and Climate Change Canada, 2019). The annual calculations reflect the full numbers of diesel equipment types, expected engine Tier (i.e., age of equipment), hours of operation (detailed in the EAP, Table 6-3) and fuel consumption during extraction operations. The calculation also includes all electrical power consumed for extraction activities.

Although it has not been stated in the EAP, Sio expects that the Environmental Approvals Branch (EAB) will include requirements for air quality monitoring during Project operations within the terms and conditions of the EAL, and Sio will comply with any air quality monitoring requirements as stipulated

Issue Number:	10
Section and Page #:	Section 5.5, Page 21
Issue/Question Raised:	*Arcadis has no material concerns with the Proponent's assessment of climate/greenhouse gas impacts. However, given the extended duration of the Project (i.e., 24 years), proactive reviews of approaches that can be used to minimize future emissions are justified.*
Response:	No additional comment from AECOM regarding assessment of GHG impacts. As noted above, Sio expects that the EAB will include requirements for air quality monitoring during Project operation within the terms and conditions of the EAL, and Sio will comply with any air quality monitoring and reporting requirements as stipulated.

Issue Number:	11
Section and Page #:	Section 5.6, Page 22
Issue/Question Raised:	*Quantitative analysis are required to confirm the Proponent's conclusions that the Project will not result in significant noise impacts. These analysis should include baseline noise assessments of the study area, noise modelling and monitoring.*
Response:	Similar to the previous comment from Arcadis regarding the requirement for quantitative analysis to confirm potential for air quality impacts, it is our opinion that the quantitative analysis proposed by Arcadis to confirm our assessment of noise impacts is not warranted. Our rationale has been previously addressed in the Responses to the Public table submitted to Manitoba Conservation and Climate, Environmental Approvals on January 14, 2022. As indicated in response to Key Issue / Question # 82, based on the findings of the Noise Impact Assessment completed by AECOM for the Vivian Sand Facility

Project, an initial setback distance of 100 m of Project activities from the nearest residences has been selected as an initial measure to mitigate nuisance noise that maybe generated by Project activities at local residences. A review of the isopleths from the Noise Impact Assessment indicates that noise levels typically do not exceed an average of 60 dBA (the Manitoba Guidelines Maximum Desirable Sound Level for year-round operations) at a distance of 100 m from the loudest noise generating activities at the Processing Facility during daytime hours. We consider the highest sound level generated at the Processing Facility to be comparable to the noise that will be generated during extraction activities.

Regarding Arcadis's recommendation to conduct a baseline noise assessment, Sio has already committed to this in our response to Key Issue / Question # 82 in our Responses to the Public. Prior to commencement of drilling activities, Sio will test the noise-generating equipment used during the extraction process and collect sound measurements at multiple points at 100 m distance from the extraction site (or at the nearest residence) to confirm that sound levels meet the 60 dBA limit at these monitoring points. Ambient sound levels (background noise) will also be collected at each location. Noise generated from extraction equipment shall not exceed 60 dBA at these monitoring locations, unless the ambient noise level already exceeds the 60 dBA limit.

Issue Number: 12

Section and Page #: Section 6.1, Page 24

Issue/Question Raised: *In the opinion of Arcadis, the CEC's EA decision should be informed by a comprehensive conceptual closure plan. The Project Proposal and supporting documents do not include the level of detail that would typically be required in such a plan.*

Response: A comprehensive conceptual Closure Plan is not an EAP requirement, as per the Information Bulletin - Environment Act Proposal Report Guidelines. However, based on AECOM's experience it is expected that Sio will be required to prepare a comprehensive Closure Plan as a condition of the EAL.

As indicated in the EAP and the Responses to the Public table submitted to Manitoba Conservation and Climate, Environmental Approvals on January 14, 2022 (Key Issue / Question # 242), a Closure Plan, together with financial assurances, will be developed and submitted to the Manitoba Director of Mines in accordance with *The Mines and Minerals Act* , the Manitoba Mine Closure Regulation 67/99, and the General Closure Plan Guidelines. A copy of the Closure Plan will be submitted to the EAB by the required date or time frame specified in the EAL.

In accordance with the Manitoba Mine Closure Regulation 67/99, the Closure Plan will include a detailed schedule of costs for proper closure and rehabilitation

activities, including costs for programs to monitor and manage the site after closure, if required. Financial assurances based on the detailed schedule of costs will be provided to the Manitoba government in a form and amount acceptable to the Director of Mines.

Issue Number: 13

Section and Page #: Section 6.2, Page 25

Issue/Question Raised: *The Project Proposal and supporting documents do not include an assessment of cumulative effects. Given the wide range of land uses in the vicinity of the Project and the importance of the groundwater resource, this represents a substantive deficiency in the Project Proposal.*

Response: As per Information Bulletin – Environment Act Proposal Report Guidelines, which was prepared by the Province of Manitoba and applies to all Environment Act Proposals (EAPs) prepared under *The Environment Act*, the completion and inclusion of a cumulative effects assessment is not an EAP requirement. Therefore, by the standard set by the province, the exclusion of a "*cumulative effects assessment"* from the EAP is not a deficiency.

It should be noted that although a section on cumulative effects was not included in the EAP, cumulative effects were considered in the Hydrogeology and Geochemistry Assessment Studies that were completed in support of the EAP and the noise assessment which considered cumulative effects in the form of ambient noise. The Hydrogeology and Geochemistry Assessment Studies completed by AECOM considered presence of historical and existing water wells and impact on existing users; a diverse range of groundwater usage including domestic, industrial, irrigation, and livestock; expanded spatial Project boundary; and impact of pumping and development on the aquifer structure, all of which are aspects commonly considered within a cumulative effects assessment.

Other environmental and socioeconomic valued components have been assessed in the EAP as having either no residual adverse impacts (fish and fish habitat) or negligible to minor residual adverse impacts (with the possible exception of up to moderate temporary noise impacts) after implementation of mitigation measures. These residual adverse Project impacts combined with effects of past, present and reasonably foreseeable future physical activities are not expected to result in an exceedance of regulatory thresholds or other threshold of acceptable change on these other environmental and socioeconomic valued components. This is because Project activities will be limited to small and temporary footprint areas of disturbance on a local and regional landscape that is largely previously disturbed or developed (e.g., agriculture activities). Additionally, Sio Silica will be limiting clearing of vegetation to the extent feasible by using existing roads/trails and other previously disturbed areas and will be rehabilitating and revegetating the disturbed areas annually. Sio Silica will also be implementing monitoring

studies and follow-up actions as described in the EAP (e.g., Revegetation Monitoring Program), as committed to in responses to the EAP Technical Advisory Committee and public review comments (e.g., Noise Mitigation Plan) and as required by the Environmental Approvals Branch in an Environment Act Licence.

Issue Number: 14

Section and Page #: Section 6.3, Page 25

Issue/Question Raised: *The Project Proposal and supporting documents do not include an assessment of impacts that climate change could have on the environmental performance of the Project.*

Response: As per Information Bulletin – Environment Act Proposal Report Guidelines, which was prepared by the Province of Manitoba and applies to all Environment Act Proposals (EAPs) prepared under *The Environment Act*, the completion and inclusion of an assessment of impacts that climate change could have on the environmental performance of the Project is not an EAP requirement. However, it should be noted that the impact of climate change, most notably the potential effects on groundwater/aquifer during drought conditions, has been discussed in Responses to the Public table submitted to Manitoba Conservation and Climate, Environmental Approvals on January 14, 2022 (Key Issue / Question # 32).

Issue Number: 15

Section and Page #: Section 6.4, Page 26

Issue/Question Raised: *The Project Proposal and supporting documents do not include an assessment of impacts that would be caused by accidents and malfunctions. In addition, it does not assess the potential impacts associated with an underground geotechnical failure that results in a major subsidence at surface.*

Response: Potential impacts and mitigation measures associated with accidents and malfunctions is provided in Section 6.9 of the EAP.

It should be noted that the Project has been specifically designed such that no subsidence is expected. If the assumption is made that a major subsidence at surface has occurred, impacts would be limited to Project areas within the extraction area with progressively lesser impacts further from the extraction area. This would be expected to result in little to no impacts outside the Project area.

Issue Number:	16
Section and Page #:	Section 6.5, Page 27
Issue/Question Raised:	*The Management Plans submitted to date lack the information necessary to confirm that operational practices will be capable of identifying and mitigating potential environmental impacts from the Project.*
Response:	Currently, AECOM is preparing draft plans that will be circulated prior to the CEC hearing. This issue was previously addressed in the EAP and in our Vivian Sand Extraction Project (File# 6119.00) - Environment Act Proposal Review Responses to the Public table submitted to Manitoba Conservation and Climate, Environmental Approvals on January 14, 2022, and posted on the Public Registry on January 25, 2022. Please refer to our response to Key Issue / Question # 234 in our Responses to the Public which includes the following: *"It is best and common practice for mitigation and monitoring plans, and operating procedures, to be prepared in association with or on completion of detailed design of the Project, and for these plans to be reviewed and updated periodically. In this manner, continual environmental planning is built into both the commencement and on-going operation of the Project, and environmental management reflects current operational, legislative and permitting requirements.* *Thus, it is essential that such plans and operating procedures be handled as 'living documents' to ensure that they will be subject to ongoing and periodic revisions to capture operational refinements that are acquired through experience, monitoring and inspection, compliance review, equipment upgrades, and follow-up assessments. Plans and procedures will also be reviewed and revised when there are any changes to licensing and permitting conditions, applicable legislation, or roles and responsibilities within Sio. Maintaining current plans and procedures will allow for continuous operational improvement and further protection of the environment. Where required revisions to these documents will be prepared with the cooperation of the applicable regulatory authority and will be provided for regulator review."*

Issue Number:	17
Section and Page #:	Section 6.6, Page 27
Issue/Question Raised:	*The Proponent has provided some information on the condition that it be kept confidential and withheld from the Public Record. None of the information provided to Arcadis to date would normally be classified as confidential. This has*

the potential to limit the use of critically important information during EA decision-making and to erode public trust.

Response: Sio Silica disagrees with Arcadis. The redacted information in the Geotechnical Assessment is commercially sensitive information that could be used by Sio's competitors to gain a competitive advantage over, and therefore prejudice, Sio Silica. Nonetheless, Sio has provided the full unredacted report to the regulator, CEC Commission and the Technical Experts hired by the CEC. Sio has also offered to provide the unredacted version of the report to hearing participants if they sign a Non-Disclosure Agreement. Therefore, the full, unredacted, report will be considered in the EA decision-making process.

Issue Number: 18

Section and Page #: Section 6.7, Page 28

Issue/Question Raised: *The Proponent's level of public engagement on the proposed undertaking is not commensurate with known and potential public concerns.*

Response: We reject Arcadis's claim that "*the level of public engagement in this case appears to be less than we would have expected*".

It is unclear to Sio what information about Sio's public engagement Arcadis reviewed, but Sio has been following the process of public engagement that is required by the EAB and Rural Municipality of Springfield, and other provincial agencies. There have been multiple advertised public engagement opportunities and local events designed to provide information to, and obtain input from, the public regarding the extraction Project specifically, including a virtual public open house on August 24, 2021 which included a question and answer period; an in-person community information session on November 29, 2021 in Anola, Manitoba; the EAP public review process; and a pending Clean Environment Commission Hearing. Sio has also engaged in several other meetings focused on the Facility project or general updates and individual and group meetings with the intent of sharing project information and obtaining feedback from the public and interested stakeholders. Other public meeting dates included: May 26, 2020 virtual meeting; December 15, 2020 virtual meeting; April 9, 10 and 11th 2019 in person meetings in La Broquerie, Anola and Richer; as well as a May 2017 in person meeting in Anola.

Manitoba Clean Environment Commission
Hearing for the Vivian Silica Sand Extraction Project (Project)

Sio Silica Corporation (SSC) Responses to Technical Experts Reports – Hydrogeology
November 2022

Issue Number:	1
Section and Page #:	**Non-Technical Plain Text Summary**, Pg 3, Point #1
Issue/Question Raised:	*The work described in the proponent's proposal only refers to a four-year planning horizon with about 1680 wells but ultimately could result in over 10,000 wells over 24 years. The proponent needs to fully describe the entire 24-year development and its likely effects.*
Response:	The project as described in the environmental assessment includes five years of operation (Years 0, 1, 2, 3 and 4), which were the subject of the Hydrogeology and Geochemistry Assessment Report. All activities with potential to impact groundwater quantity and quality were assessed as described in that report. The Environment Act Licence application for this Project, and scope of this current Environment Act Proposal document containing the Hydrogeological and Geochemistry Assessment, is for the first four years of extraction. Notices of Alteration will be submitted to the Environmental Assessment Branch for each subsequent four-year block of future proposed extraction activities for the 24-year life of the Project. Any development beyond Year 4 is outside the scope of the current project and this assessment. However, continued extraction of sand from the same formations is likely to produce a similar temporary and reversible impact to groundwater quantity as the aquifers and their properties are similar to the area covered by the current project. Any future development would be evaluated and assessed separately at the time of any future regulatory approval process(es).

Issue Number:	2
Section and Page #:	**Non-Technical Plain Text Summary**, Pg 3, Point #2
Issue/Question Raised:	*One of the aquifers (sandstone) is to be extensively mined with a new and unproven technology.... The potential impacts are many and not all the relevant issues were identified and resolved with the work described in the proposal. For example, potential impacts include release of potentially health impacting substances from the shale formation into aquifers which is used for drinking water purposes.*
Response:	The report is unclear as to what is meant by the physical or chemical mechanisms by which "*release of potentially health impacting substances from the shale formation*" could impact human health beyond those evaluations undertaken and documented in Chapter 4. Proposed mining activities will remove a very small proportion of the aquifer materials. Conventional rotary drilling is a proven technology that has been

utilized for several decades to advance boreholes through a variety of soil and bedrock formations in Manitoba and around the world. The drilling method involves the physical removal of soils/rock using a drill bit (e.g., downhole hammer) and compressed air or water to remove cuttings and allow for advancement of steel casing using either a casing hammer or rotary drive head. It is acknowledged that the application of this proven technology to silica sand mining is novel, but the methods and interactions between this method and the surrounding environment are relatively well understood and many technical guidance documents have been developed to protect the groundwater resource. In fact, this method has been utilized to install a large number of the groundwater supply wells in southern Manitoba.

The potential for the shale to impact water quality in both the Red River Carbonate and Winnipeg Sandstone aquifers was evaluated in detail. A detailed geochemical assessment was undertaken to identify chemical parameters that may be influenced by the project, those that may be present at naturally elevated concentrations, or those that may be influenced by project related activities. The methods utilized and results of the assessment are presented in Chapter 4 of the Hydrogeology and Geochemistry Assessment Report, which includes a detailed assessment of solid phase and aqueous phase geochemistry. Groundwater samples collected prior to and following pumping tests and pilot extraction activities indicated no significant change in water quality. It is important to consider that the shale aquitard is present across the majority of the study area and has not been linked to any health impacts.

Issue Number: 3

Section and Page #: **Non-Technical Plain Text Summary**, Pg 3, Point #3

Issue/Question Raised: *The effects of removing sand from one of the main aquifers and its subsequent effect on the overall properties of the aquifer (locally and regionally) is not considered and this will likely be significant. Unfortunately, there are no estimates of this effect given in the report and no testing of the main sandstone aquifer after mining out a section. The effects on potential future water-well users in areas that have been disturbed by mining is not considered.*

Response: The report is unclear as to the basis for the statement that the effects of sand removal on the overall properties of the aquifer (locally and regionally) will likely be significant. The project proposes to remove a very small proportion of the overall volume of sand in the Winnipeg Sandstone aquifer and will leave residual water-filled voids where the sand has been extracted. It is understood that this will increase the overall storativity of the aquifer as the effective porosity of the water-filled void will be 100%. Between the voids, the sandstone aquifer will not be disturbed by mining and will remain intact. Local hydrogeological properties (e.g., hydraulic conductivity and storativity) will be quite variable depending on whether measurements are collected within a water-filled void or within the intact aquifer between the voids. However, the scale of the project is regional, and the response of the aquifer to sand removal will be governed by regional aquifer

properties as measured at the scale of the Representative Elementary Volume (REV), as the source of recharge is from both surface and distal inputs near the Sandilands Complex east of the project.

Reasonable efforts were undertaken to simulate the effects of sand extraction and groundwater reinjection on the aquifer and adjacent well users. Similar to other conventional underground mining projects, it is not possible to directly measure the magnitude of any change in aquifer properties prior to completion of mining. The numerical groundwater model developed for this assessment implemented time-variant changes in hydraulic properties around the production wells, in an effort to simulate the response of the aquifer to sand extraction. The cessation of pumping over winter months was simulated to allow groundwater elevations to recover each year. In recognition of the uncertainty associated with any modelling efforts, a Groundwater Monitoring and Mitigation Plan will be developed and implemented to monitor groundwater levels and quality before, during and after mining to verify modelling results and ensure groundwater users are protected. Protocols will be established to survey existing domestic wells in advance of operations, monitor groundwater quantity and quality during and following project operations, and respond if there are any well owner complaints. Mitigation measures will be developed to avoid and/or mitigate any well interference issues, as required by *The Water Rights Act*. Mitigations may include lowering of pumps, provision of alternate water supply or adjustment of operations. Findings will be reported to the community on a regular basis.

Issue Number: 4

Section and Page #: **Non-technical Plain Text Summary,** Pg 3 & 4, Point #4

Issue/Question Raised: *One hydraulic pump-test was completed in the sandstone aquifer, but analysis of the data suggests that the pump test need to be redone. More importantly, the project area is crudely estimated at 168,000 hectares and only one pump test was competed that tested about 460 hectares. Basically, more and better-quality testing needs to be performed.*

Response: The report is unclear as to the basis for the assertion that "*analysis of the data suggests that the pump test need [sic] to be redone*". As a point of clarification (and as discussed in detail in Section 3.7.2 of the Hydrogeology and Geochemistry Assessment Report), it is acknowledged that the pumping well would have benefited from additional development efforts to improve its hydraulic efficiency. However, several methods were utilized to analyze the pumping test data, many of which do not rely on a hydraulically efficient connection between the pumping well and the aquifer. The pumping well was pumped at a rate that was judged to be representative of an operational scenario, and responses were measured in several observation wells completed in the Red River Carbonate, Winnipeg Shale and Winnipeg Sandstone aquifers, and several distances from the pumping well. The solution that was selected for determination of aquifer properties was able to simultaneously fit drawdown measured in several wells and at a variety of

distances. The data from the pumping well was not relied upon for determination of aquifer properties, placing focus on the observation well data.

As noted in Sections 1.2 and 1.3 of the Hydrogeology and Geochemistry Assessment Report, a significant number of hydrogeological investigations have been conducted within the Local Project Area and Regional Project Area by a variety of groups, including well drillers, consulting hydrogeologists, academic researchers, and the provincial government. Many of these studies were regional in nature and compiled extensive hydrogeological information from a variety of data sources, in an effort to characterize the heterogeneity of the aquifer and estimate aquifer properties. A comprehensive summary of hydraulic conductivity measurements was provided in Table 5-1 of the Hydrogeology and Geochemistry Assessment Report and discussed in detail in Section 5.7. Overall, the results indicate that the hydraulic properties of the aquifers are fairly similar over large spatial distances. This comprehensive literature review, and discussions with academic researchers and consultants with extensive experience in the area, formed the basis for this assessment and additional pumping tests for the purposes of determining aquifer properties are not required.

Geometric mean values were derived from the comprehensive database of hydraulic conductivity values presented in Table 5-1 of the report, and used to parameterize the numerical groundwater model. Through the calibration process, aquifer properties were modified following industry-standard practice and the resultant calibrated aquifer properties were similar to measured values. The calibration metrics for the model were well within industry-standard values, as defined by groundwater modelling guidelines produced by provincial government agencies within Canada (British Columbia Ministry of Energy, Mines and Low Carbon Innovation and Ministry of Environment), and internationally (US EPA; Australian Government National Water Commission), further justifying the position that the aquifer systems are well understood, and the hydrogeological properties of the aquifers assigned in the model are reasonable. Further, a robust sensitivity analysis was conducted to evaluate the impact of variability in hydraulic properties and boundary conditions on simulation results.

Issue Number: 5

Section and Page #: **Non-technical Plain Text Summary,** Pg 4, Point #5

Issue/Question Raised: *There are some problems noted with respect to the modeling. These issues are detailed in the main text and are related to the conditions imposed on the boundaries of the numerical model. In addition, there are numerous wells to the east of Winnipeg that are screened and connected over both main aquifers. It is not clear if these physical effects in the proponent's model were accounted for. Numerical models of geologic reality need to be compared to what data can be measured in the field. This "calibration" to an existing data set for water levels is crucial and has been attempted. However, there is insufficient detail given in the report to assess if an appropriate calibration has been achieved. There are no times or dates listed for the observation points and some suggested-statistical*

tests are missing. Most importantly, calibrated final hydraulic parameters from the proponent do not match with the actual well test data. The proponents also assumed that material properties were the same everywhere in each geologic unit in the model which goes against known understanding of the regional geology. Analysis suggests that the hydraulic parameters used in the modeling need to be reassessed.

Response: The report is unclear as to the basis for the comment, "*problems noted with respect to the modelling*" including the specific references made in the main text to issues that "*are related to the conditions imposed on the boundaries of the numerical model*". The report is also unclear as to the basis for the statement that "*there is insufficient detail given in the report to assess if an appropriate calibration has been achieved*" as the report meets industry standard in terms of describing the process followed to develop the conceptual model and calibrate the numerical groundwater model. AECOM disagrees with the claim that items are missing and is willing to provide additional information about its modelling and calibration if requested.

It is acknowledged that previous hydrogeological assessments have identified numerous wells to the east of Winnipeg that are screened across both the Red River Carbonate and Winnipeg Sandstone aquifers. The numerical modelling effort did not attempt to review and classify each of the 3,845 wells assigned to the Red River Carbonate aquifer or the 565 wells assigned to the Winnipeg Sandstone aquifer from the conceptual model stratigraphy detailed in Section 5 of the Hydrogeology and Geochemistry Assessment. Due to the fact that the wells installed in the Red River Carbonate aquifer do not extend into the underlying Winnipeg Sandstone aquifer, they have been interpreted as not having any cross-connection issues and only the 565 wells installed in the Winnipeg Sandstone aquifer have the possibility of being screened across both formations. There is some residual uncertainty associated with numerical modelling results in proximity to historical wells that extend through the Red River Carbonate and Winnipeg Sandstone aquifers, where measured hydraulic heads (i.e., calibration targets) may reflect an equilibrated water level between both aquifers. This imparts some uncertainty in the calibration efforts, as noted in Section 7.4 (Prediction Confidence and Uncertainty) of the Hydrogeology and Geochemistry Assessment Report.

As noted by the Reviewer, there is also uncertainty with respect to the time of water level data collection for many of the wells within the study area. This information is rarely available in large regional publicly available databases that span several decades of data collection and on balance the data set is assumed to represent the multi-year average groundwater elevations in each aquifer. Kennedy (2002) apparently utilized similar borehole and water level data sets and acknowledged this challenge, and the resultant model was judged to have achieved a suitable calibration. There are several wells that are routinely monitored by the Province of Manitoba that inform the understanding of seasonal variability of groundwater elevations in the aquifers. Based on a review of the spatially distributed water level data set and a robust sensitivity analysis, the influence of seasonal variability in measured groundwater elevations on

calibration results was judged to be minor. However, interannual variability was judged to be more important at the extreme western extent of the model domain near the Red River Floodway, where some historical water level measurements predate the development of the floodway and subsequent lowering of water levels in the Red River Carbonate aquifer. Similarly, the high artesian heads historically observed in the Winnipeg Sandstone aquifer have dissipated over time due to development of the groundwater resource in that area. Some of the oldest static groundwater elevations produced high hydraulic head residuals during calibration, illustrating the effects of active groundwater pumping and equilibration of water levels near cross-screened wells. Overall, these impacts and the resultant uncertainty did not materially affect the quality of model calibration, which produced calibration statistics that were well within industry-standards.

It is also acknowledged that the calibrated final hydraulic parameters do not exactly match the results of the pumping test conducted as part of this assessment. Pumping test results represent localized aquifer properties, but model-calibrated aquifer properties represent average values of the properties within the model domain or hydrostratigraphic unit. As a result, modeled parameter values are usually different from pumping tests. This project is the case. As defined in Section 6 of the Hydrogeology and Geochemistry Assessment Report, the calibration exercise was intended to achieve a reasonable match between simulated and measured hydraulic heads when boundary conditions were assigned in a reasonable manner and aquifer properties fell within the range of measured or literature reported values. The initial model development specified the aquifer properties based on the results of the pumping test, but as noted in the Reviewer's comments, the pumping test is only representative of one portion of the study area and some heterogeneity is present in the aquifer. All of the calibrated values for the carbonate, shale and sandstone reported in Table 6-C in the Hydrogeology and Geochemistry Assessment Report fall within the range of measured values reported for each hydrostratigraphic unit as presented in Section 5.7 and Table 5-1 of the report. A more refined approach to assigning spatially distributed aquifer properties across the very large model domain would have required estimation of properties in large areas where there are no water supply wells, which led to the application of uniform hydraulic properties for each hydrostratigraphic unit in the model.

Issue Number: 6

Section and Page #: **Non-technical Plain Text Summary,** Pg 4, Point #6

Issue/Question Raised: *...all conclusions listed in the model simulation discussion rely on an assumption that the mining operation does not affect the hydraulic properties of the sandstone aquifer and hence cannot be viewed as being conservative or even appropriate.*

Response: See the response to Issue #3 above. The project proposes to remove a very small proportion of the sand contained within the sandstone aquifer. While hydraulic properties may be locally affected on the scale of tens of metres, each extraction well void will be separated from other voids by intact aquifer materials at the scale

of the Representative Elementary Volume that is being modelled. Models are routinely utilized to evaluate the impacts of future conditions and are by definition intended to be a representation of reality, rather than an exact replica. The sensitivity analysis approach is routinely applied to understand the influence of uncertainty on modelling results. Further, scenario analysis also informs the influence of alternative parameter values on simulation results. Both approaches were applied for this assessment. Changes to aquifer storage will affect both the time of drawdown and the time of rebound following cessation of pumping. Based on the project operation procedures, the hydraulic properties of the Winnipeg Sandstone aquifer are not anticipated to change significantly at the scale of the model. The modelling and accompanying sensitivity analysis evaluated the influence of variability in model parameters in both directions, which is a conservative approach and aids in improving the understanding of model sensitivities.

Issue Number: 7

Section and Page #: **Non-technical Plain Text Summary,** Pg 4 & 5, Point #7

Issue/Question Raised: Regarding potential for degradation of the shale layer between the two main aquifers that would result in more direct communication between the Winnipeg Sandstone and Red River Carbonate aquifers*: This is a crucial risk to the operation.*

Response: The Red River Carbonate and Winnipeg Sandstone aquifers are already hydraulically connected by way of the Sandilands Glaciofluvial Complex east of the Local Project Area. This is evidenced by a very similar hydrologic response to seasonal meteoric inputs (e.g., recharge) to both aquifers, whereby seasonal fluctuations are synchronized (see Figures 5-12 to 5-14 in the Hydrogeology and Geochemistry Assessment Report). Further, the amplitude and frequency are also very similar in a number of multilevel monitoring wells managed by the Province of Manitoba across the model domain.

Further from the bedrock sub crop below the Sandilands Glaciofluvial Complex, differences between water levels in the two aquifers indicates there are areas where they are not highly interconnected. Several studies conducted by others reported the presence of numerous interconnected wells within and surrounding the Project Site Area. One study by Manitoba Conservation and Water Stewardship (Toop and Iqbal 2014) reported 223 existing wells interconnect the limestone and sandstone aquifers in the Cooks-Devils Creek Watershed. Another study (Friesen Drillers and Edge Effects Environmental Planning Inc. 2019) reported 215 interconnected wells within the Rural Municipality of Springfield. A paper prepared by the National Hydrology Research Institute (Betcher, Grove and Pupp 1995) indicated that:

> *"Most wells drilled into the Winnipeg Formation aquifer have been completed as open holes through the bedrock section, interconnecting the Winnipeg Formation aquifer with the overlying carbonate-evaporite unit. This has allowed continuous exchange of fluids of differing quality between*

the two aquifers, resulting in a substantial loss of groundwater from the Winnipeg Formation."

The referenced paper discusses the risk of upwelling saline water from within the saline portion of the Winnipeg Sandstone aquifer. The body of literature suggests that both aquifers are interconnected in several places due to the large number of historical water supply wells drilled and completed as open holes. Further, it suggests that the need for maintaining separation between the aquifers is greatest in areas where the Winnipeg Sandstone contains brackish to saline water and the groundwater gradients tend to be upward, which occurs west of the Project Site Area.

During the pumping test, pumping in the Winnipeg Sandstone aquifer initiated a response in the overlying Red River Carbonate aquifer, indicating there is already some hydraulic communication across the shale aquitard. Isotopic analysis indicated that stable isotope composition is different in the carbonate, shale, and sandstone. During the pumping test, isotope compositions became more depleted, and the extraction well had the most depleted isotope composition compared to other wells screened in carbonate, sandstone, and shale units. This indicates that direct communication between the Winnipeg Sandstone and Red River Carbonate aquifers was not observed during the extraction, and pumping did not result in an appreciable downward movement of water from the Red River Carbonate across the Winnipeg Shale and into the Winnipeg Sandstone.

It is agreed that it is important to understand the role of the shale aquitard. Detailed geochemical modelling investigated this question as described in the response to Issue #8. Groundwater elevations and pumping rates will be monitored prior to, during and following operations as defined by the Groundwater Monitoring and Impact Mitigation Plan, to confirm the results of the modelling assessment. Results will be utilized to support future updates to the model.

Issue Number: 8

Section and Page #: **Non-Technical Plain Text Summary**, Pg 5, Point #8

Issue/Question Raised: *The analysis for chemistry changes within the aquifers was carried out at one location only and limited samples were taken. None of the analysis investigated groundwater quality changes due to the mining operations. The worst-case should be defined as the collapse of the shale barrier ... Any impacts related to groundwater quality are not investigated. The goal regarding water qualify was also somehow unclear, as the report recommends a water quality study which should have been finalized at this point.*

Response: The analysis for chemistry changes in response to pumping was conducted at three locations (Bru 95-6, 95-7 and 96-1) within the Winnipeg Sandstone aquifer and two locations (Bru 95-5 and 96-2) in the Red River Carbonate aquifer. Results indicate that water quality remained stable, and no material changes were observed. The degradation of the Winnipeg Shale as a result of project operations

may result in mixing of groundwaters in the Winnipeg Sandstone and Red River Carbonate. The effect of this on groundwater quantity and flow was accounted for in the numerical groundwater model by adjusting the properties of the shale to reflect the properties of the overlying carbonate aquifer following completion of extraction.

As described in Sections 4.3 (Geochemical / Groundwater Quality Modelling) and Section 7 (Impact Assessment) of the Hydrogeology and Geochemistry Assessment Report, impacts related to groundwater quality were explicitly evaluated by characterizing baseline conditions, monitoring water quality during pumping and/or extraction tests, and then conducting geochemical modelling to evaluate the influence of mixing of waters contained in each of the aquifers. PHREEQC simulations were conducted to evaluate the impacts of mixing of waters between the Red River Carbonate and Winnipeg Sandstone aquifers, in which all constituents except for iron and manganese were simulated to remain below all applicable regulatory criteria. Naturally elevated concentrations of iron and manganese exceeded drinking water aesthetic criteria as is commonly found in natural systems and within these aquifers.

The effect of release of shale porewater (collapse of shale aquitard) into sandstone was not considered in the PHREEQC model. However, material impacts to groundwater quality within the Project Area are unlikely for the following reasons: 1) both the Red River Carbonate and Winnipeg Sandstone host fresh and relatively dilute groundwater, and the volume of water stored within shale aquitard is small or negligible; 2) groundwater in the shale unit was relatively good and met all applicable drinking water criteria; 3) Shake Flask Extraction (SFE) leachate from Bru 121-1_36.57 to 37.00, where the shale had "uncertain" ARD status, indicated that very limited metals (arsenic, selenium and uranium) exceeded one or more of the applicable criteria. SFE is a very conservative or aggressive approach for evaluating leaching characteristics of bedrock materials.

The Hydrogeology and Geochemistry Assessment recommended a Groundwater Monitoring and Impact Mitigation Plan be developed and implemented prior to, during and following operations to establish a robust monitoring program that is able to detect changes in response to operations and guide mitigation measures. It is not a study, but rather an operational monitoring and management plan that will guide implementation of mitigation measures in the event they are required. These are typical of all industrial projects and may be requirements of permits following completion of environmental assessment/permitting. The Groundwater Monitoring and Impact Mitigation Plan intends to establish a program for monitoring of groundwater levels and quality to confirm the results of the Hydrogeology and Geochemistry Assessment and ensure that operations do not negatively affect the quantity or quality of water in the aquifer.

Issue Number: 9

Section and Page #: **Technical Executive Summary** Pg 6, Point #1

Issue/Question Raised: *...there is a need to assess the impacts of pumping and development on the aquifer structure, extent of drawdown cones, impacts on existing users, intrusion of water of questionable quality, subsidence and potential pathways connecting the limestone and sandstone aquifers. Not all of these aforementioned issues were identified and resolved with the work described...*

Response: The Hydrogeology and Geochemistry Assessment Report assessed the majority of the items referenced. The extent of drawdown cones, impacts to groundwater users, intrusion of water of questionable quality and pathways connecting the limestone and sandstone aquifers were specifically evaluated either quantitatively or qualitatively within the report. Geotechnical models are a better tool for evaluating impacts of mining on structural changes in the subsurface and were completed by others (Stantec 2021).

Issue Number: 10

Section and Page #: **Technical Executive Summary** Pg 6, Point #2

Issue/Question Raised: *...salinity induced density-dependent flow is something that is well understood and the majority of the flow and transport in the aquifer systems to the west of Winnipeg, and parts of the study area to the east are affected with this physical problem. Kennedy (2002) incorporated these density effects in her extensive three-dimensional model of the aquifers in southern Manitoba, but the proponent did not. It is important for understanding the possibility of movement of more saline waters from the west of the Red River moving into and contaminating fresh-water portions of the sandstone aquifer.*

Response: Within the Project Site, water chemistry in Red River Carbonate and Winnipeg Sandstone is generally comparable and classified dominantly as Ca–Mg–HCO3 water type. The overall low TDS (<500 mg/L) indicates groundwater in the Project Area is fresh and not brackish or saline because much of the water entrained in the rock at the time of deposition and diagenesis has since been flushed by more recent recharge. This is consistent with previous investigations, regional aquifer characterization studies and water source mapping. The Project Area is near the Sandilands area, where the highlands form local recharge areas (Simpson et al. 1987; Betcher et al. 1995). Based on laboratory test results collected within the defined Local Project Area, the water is fresh and density-dependent flow was determined not to be locally important.

AECOM is aware of the work by Kennedy (2002) and recognizes that density-dependent flow is important in areas where water is brackish or saline. It is acknowledged that groundwater in the Winnipeg Sandstone aquifer west of Anola and outside the Project Site exhibits concentrations of TDS that slowly increase in the westward direction. It is important to recognize that the project activities will not be consuming large quantities of water and will reinject essentially all of the groundwater back into the aquifer. The net "pumping" rate will be limited to the volume of groundwater required to replace the volume of solids removed from the sandstone aquifer. The overall groundwater flow direction is west to

northwestward toward the Red River and Lake Winnipeg, with localized discharge to the Red River Floodway. The Groundwater Monitoring and Mitigation Plan will monitor groundwater quality with a view to tracking concentrations over time and confirming that water is not becoming more saline as a result of project operations, and confirm the findings of the Hydrogeology and Geochemistry Assessment Report.

Issue Number:	11
Section and Page #:	**Technical Executive Summary** Pg 7, Point #3
Issue/Question Raised:	*The simulations presented by the proponent only refer to a 4-year planning horizon. They also refer to 1680 wells over a four 4-year horizon which could total more than 10,000 wells over 24 years. It would be very prudent for the proponent to fully describe the entire 24-year development and its likely effects.*
Response:	See the response to Issue #1.

Issue Number:	12
Section and Page #:	**Technical Executive Summary** Pg 7, Point #4
Issue/Question Raised:	*Although there are schematics of the extraction wells and sub-surface geology there are no engineering drawings with the accompanying dimensions of cavities produced from the mining. There were no independent measurements of formation porosity given.*
Response:	See the Geotechnical Assessment Report by Stantec (2021) for detailed information pertaining to the cavities that will be created by mining. Engineering drawings are not usually produced for the purposes of environmental assessment. Pilot extraction tests have been conducted and the resultant voids surveyed using a variety of methods, as documented in the Geotechnical Assessment Report. The report establishes the dimensions of the excavations (cavities) produced by mining. Porosity is rarely directly measured as part of hydrogeological assessments of bedrock formations. However, the porosity has been indirectly accounted for in the measurement of aquifer properties that were used to guide calibration of the numerical groundwater model. At full operation, the Project will have an estimated annual production rate of 680,000 cubic metres of silica sand. When a bulking factor and in-situ density are applied, it will be possible to estimate the dimensions of "cavities produced from the mining" every year, and for each borehole.

Issue Number:	13
Section and Page #:	**Technical Executive Summary** Pg 7, Point #5
Issue/Question Raised:	*The effects of removing sand from the aquifer and its subsequent effect on the overall hydraulic properties of the main sandstone aquifer (locally and regionally) is not considered and this will likely be significant. Unfortunately, there are no estimates of this effect given in the report and no testing of porosity either before or after mining a section of the aquifer. It also assumes that the sandstone bridging material remains intact but does not mention if the sandstone itself may liquify and flow into the voids that are created by the mining operation. The effects of potential future water-well users in areas that have been disturbed by mining is not considered.*
Response:	See the responses to Issues #3, #5 and #6 for discussion of aquifer properties and the influence of mining on regional scale aquifer properties. Further, the Geotechnical Assessment Report by Stantec (2021) provides the basis for the slope and shape of each cavity created by mining. Several post-extraction surveys have been conducted by a third-party wireline logging company specializing in underground caverns and well logging. The results were then reviewed by Stantec and there is empirical information that documents the shape of the cavities. The hydraulic properties of the shale unit after extraction were adjusted in the FEFLOW groundwater model by way of scenario analysis (shale remains intact vs. collapsed) to explore the influence of possible shale collapse in response to mining.

Issue Number:	14
Section and Page #:	**Technical Executive Summary** Pg 7, Point #6
Issue/Question Raised:	*The proponent notes that degradation of the Winnipeg Shale layer may occur because of project operations which would result of more direct communication between the Winnipeg Sandstone and the Red River Carbonate. This is a crucially important risk of the operation.*
Response:	See the response to Issue #7.

Issue Number:	15
Section and Page #:	**Technical Executive Summary** Pg 7, Point #7
Issue/Question Raised:	*There was no testing at a pilot-project site in which the aquifer was actually mined out and drawdowns were measured at various locations from a producing well cluster. This is another critically important point.*
Response:	Several pilot test extractions have been conducted over the past several years by Sio Silica. The data and learnings from these tests have been leveraged into the

work to date and will inform the follow up plans, such as the Groundwater Monitoring and Mitigation Plan.

"Mining out" of the aquifer is not permitted until an Environment Act Licence (EAL) is issued. In the absence of an EAL, no mining activity has occurred to date.

Issue Number: 16

Section and Page #: **Technical Executive Summary** Pg 7 & 8, Point #8

Issue/Question Raised: *Hydraulic tests were completed in the main sandstone aquifer at the site, but analysis of the data suggests that the pump tests should be re-run and the test data re-interpreted. Drawdown data suggests a leaky connection between the two main aquifers and importantly the test methods should allow for a calculation of the leakage properties of the shale layer that separates the main aquifers.*

Response: The primary purpose of the pumping test was to evaluate the extents of drawdown under a pumping rate similar to that which will be employed during operations. Extraction wells will not be developed or operated as pumping wells, and as such, it was decided that well development was less critical. While this comes at a cost of not being able to rely on pumping well drawdown data for determination of aquifer properties, the volume of water removed and water levels recorded in a number of distal monitoring wells and vibrating wire piezometers allowed for determination of aquifer properties at the scale of the test (kilometres). While well efficiency may be important for water supply well design and determination of aquifer properties from single well response tests, it is not important to this assessment as pumping wells will not be installed or utilized during mining (which is from open boreholes).

Pumping test data were analyzed using the Theis and Cooper-Jacob solutions without consideration of analytical solutions that accommodate leakage across an overlying confining unit into the pumped aquifer. It is acknowledged that several other analytical solutions are available to evaluate the pumping test data, but a reasonable fit to the distance-drawdown data and displacement-time data was obtained with the Theis and Cooper-Jacob solutions. The results of the analysis were within the range of values reported for other pumping tests within the same aquifer system and are judged to be reasonable. Further, use of a numerical model calibrated to spatially and temporally distributed hydraulic heads was judged to be a more reasonable approach to evaluation of a regional scale problem. The demonstrated ability of the model to simulate hydraulic heads that are a reasonable match to measured values indicates that the model is a useful tool. Slug testing of the shale was limited to one test, but visual observations of a core suggest it is generally a low permeability unit that restricts flow between the Winnipeg Sandstone and Red River Carbonate aquifers. The hydraulic gradients between the two aquifers are relatively small (~0-2m), suggesting that the permeability of the shale is much less important in the study area than previously thought. The relatively small vertical gradients indicate groundwater flow is

primarily horizontal through the Project Site Area. The Winnipeg Shale Aquitard is not the only element that limits the interaction between the two aquifers.

Issue Number: 17

Section and Page #: **Technical Executive Summary** Pg 8, Point #9

Issue/Question Raised: *The lithology at the site is described by the proponent in their conceptual model in terms of large zones and/or layers representing homogeneous aquifers and aquitards. However, there is considerable information on material heterogeneity not considered by the proponent. Certainly, if there is any information available at the site on heterogeneities, this should be considered in the numerical model.*

Response: It is understood that there is heterogeneity present with respect to lithology at the local scale. However, the model domain and evaluation were conducted at a scale that is interpreted to be larger than the Representative Elementary Volume. It was therefore assumed that the heterogeneity within each hydrostratigraphic unit could be represented at the scale of the problem, with an equivalent homogeneous porous material that is attributed to a single value for its hydraulic conductivity, storativity, and other parameters which govern fluid flow through the porous material. Although heterogeneity of materials is expected due to spatial variability of materials, incorporating fine scale variability was not considered to materially affect the numerical modeling results even though real-world hydrogeologic response may be locally sensitive to heterogeneity. This assumption will be validated during operations through the collection of water level and pumping data, combined with regular model updates to guide impact avoidance and mitigation strategies. These processes will be further outlined in the Groundwater Monitoring and Impact Mitigation Plan.

Issue Number: 18

Section and Page #: **Technical Executive Summary** Pg 8, Point #10

Issue/Question Raised: *There are some problems with respect to the boundary conditions in the numerical modeling. These issues are detailed in the main text. For the groundwater flow equation, these concerns are related to the conditions imposed on the boundaries of the numerical model. In addition, there are numerous wells to the east of Winnipeg that are screened over both of the main aquifers. It is not clear these if physical effects were accounted for.*

Response: See the response to Issue #5.

Issue Number:	19
Section and Page #:	**Technical Executive Summary** Pg 8, Point #11
Issue/Question Raised:	*Calibration to an existing data set for hydraulic heads has been attempted. However, there is insufficient detail given in the text to assess if an appropriate calibration has been achieved. There are no times or dates listed for the observation points and some suggested-statistical tests are missing. Most importantly, calibrated final hydraulic parameters from the proponent do not match with the actual well test data. Analysis suggests that the hydraulic parameters used in the modeling need to be reassessed.*
Response:	Regional scale modelling assessments require use of information collected by multiple parties over an expansive area and over an extended period of time. This is a known limitation of any regional modelling assessment and was documented as a limitation in Section 7.4 of the Hydrogeology and Geochemistry Assessment Report. However, this can also be considered a strength of the calibration as it is more likely that temporally and spatially averaged conditions are captured rather than point in time, point in space measurements. An acceptable match between simulated and observed groundwater levels was quantitatively assessed through calculation of residuals, the residual mean, root mean square error (RMSE), normalized root mean square error (NRMSE), and the correlation coefficient (r), with results considered reasonable in accordance with several groundwater modelling guideline documents. Other assessment approaches, such as a map of hydraulic head residuals, were also presented in the calibration effect evaluation (see details in the Section 5 of the Hydrogeology and Geochemistry Assessment Report). See the response to Issue #5 for more information on the calibration of the model and an explanation for differences between one local scale measurement of hydraulic properties and the values assigned in the regional scale numerical groundwater model.

Issue Number:	20
Section and Page #:	**Technical Executive Summary** Pg 8, Point #12
Issue/Question Raised:	*Boundary condition sensitivity should be addressed in any simulations. Unfortunately, this was not done (with the exception of recharge rates).*
Response:	It is acknowledged that sensitivity to boundary conditions could be conducted. However, there is good confidence in the governing boundary conditions because they are related to topographic survey information that determines the elevations of streams, measured pumping rates, and observed hydraulic heads. Further, the boundary conditions are located several tens of kilometres from the Project Site Area and would have minimal or negligible impact on the calibration or simulation

results. For these reasons, a sensitivity analysis of boundary conditions was not conducted at this stage but would be conducted as part of future model updates.

Issue Number: 21

Section and Page #: **Technical Executive Summary** Pg 8 & 9, Point #13

Issue/Question Raised: *...all of the conclusions listed in the model simulation discussion all rely on an assumption that the mining operation does not affect the hydraulic properties of the sandstone aquifer and hence cannot be viewed as being conservative.*

Response: See the response to Issue #3 and Issue #6. Further, a Water Management Plan and a Groundwater Monitoring and Mitigation Plan will be implemented to monitor groundwater extraction/injection activities and water level monitoring within the aquifer surrounding the Project Area, and to mitigate any impacts to surrounding wells.

Issue Number: 22

Section and Page #: **Technical Executive Summary** Pg 9, Point #14

Issue/Question Raised: *The numerical model was used for a series of scenarios involving different pumping rates. These included the case when no water from a pumping cluster is re-injected; so, all water is lost, and the case where 50% of water pumped out is re-injected. Note that it is the proponent's intention to re-inject all pumped water from the aquifer as part of the mining operation so certainly a 100 % re-injection rate would be a theoretical ideal. A perhaps more realistic 50% re-injection rate represents cases where, it is not possible for a variety of reasons to be able to re-introduce water back into the aquifer. If this happens to be realized, it is not clear how this extra water that cannot be re-injected is disposed of or if this amount is sustainable to extract from the aquifers without replacement.*

Response: As a point of clarification, the volume of slurry (sand and water) pumped from the aquifer is the reference point for 100% re-injection. Based on operational monitoring during pilot extraction events, an estimated 50% of that volume will be solids (sand) and the remaining 50% will be water. The 0% reinjection scenario represents a conservative scenario where no water is reinjected (i.e., both sand and water are removed from the aquifer without any reinjection). The 50% reinjection scenario represents a scenario where all (nearly 100%) of the extracted groundwater is reinjected except for the small volume of residual moisture held in the sand. In this scenario, the remaining 50% represents the sand that is mined and therefore cannot be reinjected. Each of these scenarios was run with modified hydraulic properties that simulate the effects of degradation of the shale aquitard. If the hydraulic properties of the shale are altered by mining, impacts to water levels in the Red River Carbonate aquifer were simulated to be greater, but impacts to the Winnipeg Sandstone aquifer were simulated to be lower. The 0% re-injection scenario is highly conservative and was considered in the groundwater

model to understand the maximum impact of operational activities on water quantity in both aquifers. In reality, all groundwater except for residual moisture content in the sand will be re-injected into the sandstone aquifer. The lower net withdrawal rates were simulated to reduce the depth and spatial extent of drawdown impacts and shorten the recovery time for water levels. Pilot testing has demonstrated that reinjection of essentially all groundwater extracted with the sand slurry is feasible.

Issue Number: 23

Section and Page #: **Technical Executive Summary** Pg 9, Point #15

Issue/Question Raised: *The numerical model predicts a maximum drawdown in the sandstone aquifer at 146 m from a producing cluster, under 0% re-injection of water and with no interconnection between aquifers, to be about 14 m. One scenario not considered is the case of a distance of 100 m from a pumping cluster (closest planned distance to nearest supply well) at 225 USGPM (50% re-injection). Based on a well-known hydraulics formula, this drawdown would be about 12 m after 72 hours. This amount, if realized, exceeds the stated the magnitude of the groundwater impacts of between 1 m and 5 m for the majority of the water supply wells.*

Response: As noted by the Reviewer, the Theis method allows for conservative estimation of drawdown at various distances and times in a confined aquifer. It is acknowledged that the specific case of situating an observation well 100 metres from a pumping cluster was not specifically presented but could easily be incorporated into future model runs. Further, the pumping test results present measured drawdown with distance and are useful for estimating the radius and magnitude of influence. The observation wells selected for modelling were chosen to be situated at the centre of several sections, with a few additional observation wells that are operated by the Province of Manitoba with relatively long-term and continuous water level and water quality records. The magnitude of the simulated groundwater impacts of between 1 metre and 5 metres is for the majority of the water supply wells and for most of the project operations. The setback distances were established primarily to minimize noise and interruptions to private landowners. The Groundwater Monitoring and Mitigation Plan will establish acceptable levels of drawdown that will not be exceeded without adequate mitigation measures being applied. A Trigger-Action-Response-Plan (TARP) framework will be developed and implemented to evaluate monitoring results and address any predicted impacts that could affect the quantity and quality of water available to existing users.

It is important to recognize that a groundwater model is a more useful tool for evaluating and managing groundwater resources as it can consider much more complex boundary conditions (e.g., multiple pumping wells, seasonal changes in recharge, etc.) and temporal changes in pumping that violate the assumptions of simple analytical solutions. Further, the short operating period for each well means that a complex field of expanding and contracting drawdown cones will

result. Additional data outputs can be evaluated as part of future modelling efforts after the issuance of an Environment Act Licence.

Issue Number:	24
Section and Page #:	**Technical Executive Summary** Pg 9, Point #16
Issue/Question Raised:	*The analysis for acid mine drainage, aqueous geochemistry and stable isotopes were carried out at one location only and limited samples (e.g., related to acid mine drainage) were taken. None of the analysis investigated groundwater quality changes due to the mining operations. The worst-case should be defined as at the collapse of the Winnipeg Shale. Any impacts related to groundwater quality are not investigated. The goal with regard to water qualify was also somehow unclear, as the report recommends a water quality study which should have been finalized at this point.*
Response:	See the response to Issue #8. It is acknowledged that isotopic analysis of porewater contained in the shale was conducted at only one location. However, these types of analyses are typically reserved for academic studies and are not a core requirement of most hydrogeological investigations, as noted by a Peer Reviewer and academic researcher (i.e. Dr. Grant Ferguson, Professor, University of Saskatchewan). Several isotopic samples were collected from monitoring wells and the pumping well throughout the duration of pumping to help understand the origin of pumped groundwater and whether it changed over time.

Issue Number:	25
Section and Page #:	**PorousTech Comment #1,** Pg 20 (paragraph 1)
Issue/Question Raised:	*There was only one pump test to characterise the aquifers. Therefore, no information on heterogeneity inside the aquifers could be obtained. The results of one non-conforming pump test cannot be used to estimate the effects of a mining operation projected to potentially include at least 1680 wells in the short-term and more than 10,000 wells over the 24-year life of the project.*
Response:	The basis for the statement that there is no information on heterogeneity of the aquifers is unclear. Although only one pumping test was conducted as part of this assessment, numerous pumping tests have been conducted to characterize these aquifers by a multitude of academic researchers, government agencies and consultants working on behalf of municipalities or corporations. The historical results reported in the literature were reviewed to determine whether historical results were representative of the aquifer system and then utilized to inform the conceptual understanding of the aquifer system and guide numerical model calibration and sensitivity analysis efforts. The extensive literature review and reference list is provided in Section 9 of the Hydrogeology and Geochemistry Assessment Report and was noted by the Reviewer to be missing only two reference documents of the multitude of relevant studies. Further, numerous slug

test analyses were conducted as part of this assessment aimed at understanding variability (i.e., heterogeneity) of hydraulic properties.

As noted in Sections 1.2 and 1.3 of the Hydrogeology and Geochemistry Assessment Report, a significant number of hydrogeological investigations have been conducted within the Local Project Area and Regional Project Area by a variety of groups, including well drillers, consulting hydrogeologists, academic researchers, and the provincial government. Many of these studies were regional in nature and compiled extensive hydrogeological information from a variety of data sources, in an effort to characterize the heterogeneity of the aquifer and estimate aquifer properties. A comprehensive summary of hydraulic conductivity measurements was provided in Table 5-1 of the Hydrogeology and Geochemistry Assessment Report and discussed in detail in Section 5.7. Overall, the results indicate that the hydraulic properties of the aquifers are fairly similar over large spatial distances. This comprehensive literature review and discussions with academic researchers and consultants with extensive experience in the area, formed the basis for this assessment and additional pumping tests for the purposes of determining aquifer properties are not required.

Geometric mean values were derived from the comprehensive database and used to parameterize the numerical groundwater model. Through the calibration process, aquifer properties were modified following industry-standard practice and the resultant calibrated aquifer properties were similar to measured values. The calibration metrics for the model were well within industry-standard values, as defined by groundwater modelling guidelines produced by provincial government agencies within Canada and internationally, further justifying the position that the aquifer systems are well understood, and the hydrogeological properties of the aquifers assigned in the model are reasonable. Further, a robust sensitivity analysis was conducted to evaluate the impact of variability in hydraulic properties and boundary conditions on simulation results.

As previously stated, the Environment Act Licence application for this Project, and scope of this current Environment Act Proposal document containing the Hydrogeological and Geochemistry Assessment, is for the first four years of extraction. Notices of Alteration will be submitted to the Environmental Assessment Branch for each subsequent four-year block of future proposed extraction activities for the 24-year life of the Project.

Issue Number:	26
Section and Page #:	**PorousTech Comment #1**, Pg 20 (paragraph 2)
Issue/Question Raised:	*The analysis of the data suggests that the pump test should be re-run and the test data re-interpreted. Drawdown data suggests a leaky connection between the two main aquifers and importantly the test methods should allow for a calculation of*

the leakage properties of the shale layer. For examples of multilayered aquifer systems see Kruseman and de Ridder (1990).

Response: As a point of clarification (and as discussed in detail in Section 3.7.2 of the Hydrogeology and Geochemistry Assessment Report), it is acknowledged that the pumping well would have benefited from additional development efforts to improve its hydraulic efficiency. However, several methods were utilized to analyze the pumping test data, many of which do not rely on a hydraulically efficient connection between the pumping well and the aquifer. The pumping well was pumped at a rate that was judged to be representative of an operational scenario, and responses were measured in several observation wells completed in the Red River Carbonate, Winnipeg Shale and Winnipeg Sandstone aquifers, and several distances from the pumping well. The solution that was selected for determination of aquifer properties was able to simultaneously fit drawdown measured in several wells and at a variety of distances. The data from the pumping well was not relied upon for determination of aquifer properties, placing focus on the observation well data. Additional analysis of pumping test results could be completed using alternative analytical solutions, but it should be recognized that the testing protocols and assumptions invoked to allow for use of multilayered aquifer systems are very limiting (e.g., isotropic aquifers) and may not be suitable for application to the study area. Therefore, this is not deemed necessary or reasonable at this time.

Also refer to Issue #4 and #16 for additional information.

Issue Number: 27

Section and Page #: **PorousTech Comment #1**, Pg 20 (paragraph 3)

Issue/Question Raised: *Slug and bail tests are inadequate for regional identification of aquifer properties.*

Response: Agreed. Slug test results represent local scale hydraulic properties and were not used for determination of regional aquifer properties. Rather, they were used to understand the variability in local scale hydraulic properties. A pumping test and extensive literature review was conducted to develop a database of regional aquifer properties from other studies conducted within the aquifer system.

Issue Number: 28

Section and Page #: **PorousTec Comment #2,** SEC. 4, Pg. 25 & 26

Issue/Question Raised: *The conceptual model is that of a transient, three-dimensional, layered-homogeneous, saturated, single-fluid phase, porous medium. The area of the conceptual model is not chosen using the knowledge that both aquifers are confined. Each layer is isotropic, with exceptions. However, there is considerable information on material heterogeneity not considered by the proponent. Also, it is*

well known that the majority of the flow and transport in the aquifer systems to the west of Winnipeg, and parts of the study area to the east are known to be saline. (Kennedy, 2002) incorporated these salinity and density effects in her extensive three-dimensional model of the aquifers in southern Manitoba but the proponent did not. It is important that we understand the possibility of movement of more saline waters from the west of the Red River moving into fresh portions of the sandstone and carbonate aquifers. The HAFR modeling does not include density dependent flows and saline intrusion which may be important and is a missed opportunity.

Response: As a point of clarification (and as discussed in detail in Section 6.9.3 and presented in Table 6-C of the Hydrogeology and Geochemistry Assessment Report), the hydraulic properties of each layer are anisotropic, not isotropic as suggested by the Reviewer. Similar to the work of Kennedy (2002) and others, an anisotropy ratio of 10H:1V was assigned to the majority of hydrostratigraphic units, owing to their sedimentary depositional history. Only one unit (Red River Carbonate) utilized isotropic hydraulic properties and the resultant hydraulic conductivity value and anisotropy ratio was determined through calibration.

It is acknowledged that there is some relatively minor heterogeneity within the aquifers, and that incorporation of the hydraulic conductivity field as determined by Kennedy (2002) may have been useful for this assessment, but the information is not publicly available in a format that can be correlated to the current study area with any exactitude. However, the assessment benefits from a robust sensitivity analysis that evaluates the influence of variability in hydraulic parameters on calibration results. Further, the work of Kennedy (2002) highlighted the limitations of the available data set including a general lack of sandstone aquifer property measurements in the westernmost portion of the model domain, and their work therefore assumed uniform properties across the aquifer (i.e., similar to this assessment).

To further clarify, the area of the conceptual model was chosen with full knowledge that both aquifers in the area are confined, as this is well documented in the literature. It is acknowledged that Kennedy (2002) highlighted the importance of density effects on model-simulated concentrations, but clear conclusions are drawn. With respect to the Red River Carbonate aquifer, their work concluded that "*The effect on head is not that significant, however, the change in concentration is quite large.*" Further, with respect to the Winnipeg Sandstone aquifer, their work concluded that "*The effect on head and concentration for the Sandstone Aquifer is not that high and is below the RMS error of the model itself.*" When taken together, this indicates that the theoretical basis for incorporation of density effects remains sound, but they are not necessary. It is also important to highlight that the work of Kennedy (2002) focused on the portion of the aquifer west of the Project Site Area, where salinity (and therefore density) differences between the two aquifers are known to be a much larger issue. Within the Project Site Area and for some distance west, groundwater quality is fresh in both aquifers and simulation of density effects for the purposes of impact assessment is therefore less important.

Also refer to Issue #10 for further information.

Issue Number:	29
Section and Page #:	**PorousTec Comment #3**, SEC. 5, Pg. 27 & 28
Issue/Question Raised:	*One of the major objectives of the hydrogeological investigations was to evaluate the potential for the project to impact groundwater quantity, quality and users of the surface and groundwater in the area. These are appropriate objectives, but they are only broadly outlined. Specifically, there is a need to assess impacts of pumping and development of the aquifer structure, extent of drawdown cones, impacts on existing users, intrusion of water of questionable quality, subsidence and potential pathways opening up through the limestone and sandstone aquifers. Not all of these aforementioned issues were identified and resolved with the work and so not all of these anticipated project needs are addressed.*
Response:	The impacts of pumping and development were assessed using the numerical groundwater model. The model simulated the extent of drawdown in response to sand extraction activities with and without injection, for scenarios where the shale remained intact or degraded. Evaluation of the influence of sand extraction on the integrity of the subsurface was conducted by geotechnical engineers (Stantec 2021) as part of related studies to evaluate the possibility of subsidence and inform project design. Also refer to response #9 for further information.
Issue Number:	30
Section and Page #:	**PorousTec Comment #4**, SEC. 5, Pg. 28
Issue/Question Raised:	*FEFLOW is a well-known and supported code. At this time, the code can fully account for all the processes contributing to groundwater movement and containment transport. It can also account for time-varying material properties; a feature that saw limited use in the various simulations. The chosen model grid appears to be adequate.*
Response:	Acknowledged that the reviewer finds the chosen model grid adequate. Time-varying material properties were implemented, but it is agreed that there is room for expanded use as part of future evaluations as the project design evolves.
Issue Number:	31
Section and Page #:	**PorousTec Comment #5,** SEC. 5.1, Pg. 29 & 30

Issue/Question Raised: *A geometric domain must be established and is a key in the appropriateness of a groundwater model. The best approach is deriving the model domain from regional groundwater table maps and potentially to expand the model domain, in all directions outward from an area of interest until physical features, such as groundwater divides or lakes and so can be represented as boundaries with attached physical-mathematical conditions. Since the model domain does not rely on these features there are concerns about the overall dimensions of the model and attached boundary conditions. Additionally, the model domain may not be large enough to account for large scale physical effects such as saline water intrusion or long-term sustainability but might be adequate from the point of view of a local pumping-well field. In addition, there are numerous wells in the area that are screened over both of the main aquifers. It is not clear these if physical effects were accounted for.*

Response: The existing conditions model relies on features that represent defensible boundary conditions, as described in Section 6.6 of the Hydrogeology and Geochemistry Assessment Report. These include: 1) Specified Head (Lake Winnipeg, Red River Floodway, Red River and Prominent Streams); 2) Spatially Distributed Recharge classified based on academic research and geologic materials exposed at ground surface; 3) No Flow at inferred divides and base of model; and 4) Pumping Wells.

Specified Head values were established for streams, drainages and lakes based on surveyed elevations at gauging stations or by offsetting the boundary condition below topography. Because the majority of the features are relatively shallow, exact elevations are not likely to be significantly different from those employed. Seasonal measurements were not available in many cases. The Project Site area is approximately 10 kilometres from the nearest boundary condition that is not a well. That boundary condition represents a surface water stream that flows parallel to the interpreted groundwater flow direction. See the response to Issue #55 for discussion of saline water intrusion. It is noted that the Reviewer agrees the model domain is adequate for evaluation of local pumping well field operations.

It is also noted that a complete assessment of each private well and the potential for cross-connection of the Red River Carbonate and Winnipeg Sandstone aquifers was not explicitly assessed. While the magnitude of the inter-aquifer flux is moderate and demonstrates that the aquifers are presently interconnected in several locations, the magnitude is relatively small in the context of the overall water balance of the aquifers.

Also refer to Issue #5 and #18 for additional information.

Issue Number: 32

Section and Page #: **PorousTec Comment #6,** SEC. 5.2.2, Pg. 33

Issue/Question Raised:	*Calibration to an existing data set for hydraulic heads has been attempted. However, there is insufficient detail given in the text to assess if an appropriate calibration has been achieved. There are no times or dates listed for the observation points and some suggested-statistical tests are missing. Most importantly, calibrated final hydraulic parameters from the proponent do not match with the actual well test data, or values adopted by geospatial works. History matching or a "transient calibration" to existing data for flow is incomplete and matching to an acceptable data base for concentration is non-existent.*
Response:	Refer to response issue #5. In addition, groundwater quality in the Project Site area is relatively consistent, and did not change appreciably before, during or after the pumping test. Because the model did not include the objective of simulating groundwater chemistry, a mass-transport calibration exercise was not undertaken. Future transient calibration efforts could focus on observation well data collected by the Province of Manitoba, or locally derived water level data collected during operations.

Issue Number:	33
Section and Page #:	**PorousTec Comment #7,** SEC. 5.2.3, Pg. 35
Issue/Question Raised:	*The final material properties are chosen through the calibration process and most properties seem to be physically reasonable. The major exceptions to this are the hydraulic conductivity of the Sandstone aquifer (as in the model), which was not chosen on the basis of well test information. The heterogeneous nature of these aquifers is ignored. The shale layer that separates the two aquifers is viewed as being homogenous but anisotropic; unfortunately, there is no field data to support this conjecture.*
Response:	Refer to response Issue #5. In addition, material properties of the sandstone and shale were modelled as anisotropic for two reasons: 1) To be consistent with theoretical relationships between the horizontal hydraulic conductivity (Kh) and the vertical hydraulic conductivity (Kv) for sedimentary rocks, whereby material properties exhibit a lower permeability in the direction of principal stress during diagenesis; and 2) To build upon previous modelling studies, including Kennedy (2002), that invoked anisotropy in hydraulic properties in the same manner employed within this model. This assumption is commonly employed in the development of conceptual and numerical models of sedimentary sequences, including sandstone and shale.

Issue Number:	34
Section and Page #:	**PorousTec Comment #7,** Sec. 5.4, Pg. 38
Issue/Question Raised:	*A sensitivity testing phase has been carried out but only for a limited number of forcing functions or boundary conditions. Boundary condition sensitivity should be*

addressed in any simulations. Unfortunately, this was not done (with the exception of recharge rates).

Response: It is acknowledged that sensitivity to boundary conditions could be conducted. However, there is good confidence in the governing boundary conditions because they are related to topographic survey information that determines the elevations of streams, measured pumping rates, and observed hydraulic heads. Further, the boundary conditions are located several tens of kilometres from the Project Site Area and would have minimal or negligible impact on the calibration or simulation results. For these reasons, a sensitivity analysis of boundary conditions was not conducted at this stage but would be conducted as part of future model updates.

Issue Number: 35

Section and Page #: **PorousTec Comment #8,** Sec. 5.5, Pg. 39

Issue/Question Raised: *A general worst-case analysis on all parameters has not been performed. However, a worst-case pumping scenario of 0% return flows to the aquifer was considered. Note that all of the conclusions listed in the model simulation discussion rely on an assumption that the mining operation does not affect the hydraulic properties of the sandstone aquifer and hence cannot be viewed as being conservative.*

Response: The report is unclear as to the basis for the statement that the conclusions "*cannot be viewed as being conservative.*" As noted by the Reviewer, the model considered a scenario where 0% of the water was reinjected to the aquifer, which is considered highly conservative. Further, the model did not consider the effects of the increased storage in the aquifer that may result from sand removal. While this may affect the time for groundwater levels to recover following the initial extraction well cluster, the lateral extent of drawdown cones induced by subsequent extraction events may be reduced by the release of groundwater from the enhanced storage zones associated with the residual water-filled caverns. As such, it is judged to be a reasonably conservative estimate. As a point of clarification, the effects of mining on the properties of the shale were explicitly incorporated into the model to evaluate the influence of possible shale degradation.

Additionally, refer to response Issue #3 and #6.

The project proposes to remove a very small proportion of the overall volume of sand in the Winnipeg Sandstone aquifer and will leave residual water-filled voids where the sand has been extracted. It is understood that this will increase the overall storativity of the aquifer as the effective porosity of the water-filled void will be 100%. Between the voids, the sandstone aquifer will not be disturbed by mining and will remain intact. Local hydrogeological properties (e.g., hydraulic conductivity and storativity) will be quite variable depending on whether measurements are collected within a water-filled void or within the intact aquifer between the voids. However, the scale of the project is regional, and the response

will be governed by regional aquifer properties as measured at the scale of the Representative Elementary Volume (REV), as the source of recharge is from both surface and distal inputs near the Sandilands Complex east of the project.

Issue Number:	36
Section and Page #:	**PorousTec Comment #9,** Sec. 6.4, Pg. 44
Issue/Question Raised:	*The analysis for acid mine drainage, aqueous geochemistry and stable isotopes were carried out at only one location and limited samples (e.g., related to acid mine drainage) were taken. None of the analysis discussed groundwater quality changes due to the mining operations. The worst-case should be defined as at the collapse of the Winnipeg Shale. Any impacts related to groundwater quality are not investigated. The goal of work with regard to water quality is also somewhat unclear, as the report recommends a water quality study which should have been finalized at this point.*
Response:	Refer to response Issue #8.