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

Sio Silica Corporation (SSC) Responses to MBEN/OLS - Matrix Solutions Inc – Hydrogeological Review
February 2023

Sio has reviewed the Hydrogeological Review of Sio Silica Corporation's proposed Vivian Sand Project, Manitoba from Matrix Solutions Inc to MBEN/OLS and would like to provide further response to items contained within.

1.0 Groundwater Modelling

AECOM acknowledges the statement made by the Reviewers that: *"In Matrix's opinion, the hydrogeological assessment with regards to the evaluation of project's short-term direct effects was appropriate."* However, the following topics were discussed in the Matrix memorandum and require some clarification.

1.1 Farvolden Method

AECOM acknowledges that the project's effects on regional groundwater quantity were evaluated using a regional groundwater model, and that the magnitude of the effects will be significantly reduced due to the re-injection of a significant proportion of the groundwater produced during the extraction process. A calibrated, regional, three-dimensional groundwater flow model based on natural hydrologic boundary conditions and distributed hydraulic properties is the most appropriate method for estimating impacts to the groundwater flow system. The Farvolden Method is not an appropriate hydrogeological assessment criterion for a regional aquifer because it is focused on estimating the safe yield of a single water supply well for an assumed period of 20 years of continuous pumping. The sand extraction wells for the Project will not be operated continuously for a period of 20 years as operations will cease each year over the winter months. Groundwater modelling results indicate that "*simulated groundwater levels at observation wells return to static water level conditions after approximately 20 days*" following the cessation of pumping each year.

1.2 Consideration of Other Groundwater Withdrawals from the Regional Aquifers

Sio rejects the statement that the groundwater model "*does not take into consideration any other potential groundwater withdrawal within the regional aquifer*" because the Licensed Water Wells in Table 6-A were incorporated into the model as Well Boundary Conditions. Further, the use of groundwater during project operations and by existing well owners was also considered as discussed in Section 7.2.1 of the Hydrogeology and Geochemistry Assessment:

> "*The Regional Project Area (Figure 1-2) contains approximately 1,505 domestic water wells (from the Groundwater Information Network database). Assuming a water use of 200 L/day per person (Friesen, 2019) and an average of four (4) people per domestic well, consumptive water use in the Regional Project Area is approximately 439,000 m^3/year. In the 0% re-injection scenario, total water use in Years 1 through 4 would be approximately 144% of the volume used for domestic purposes. Known large volume licensed groundwater users in the model domain have a combined allotment of*

4,070,000 m^3/year. Groundwater use for the project under the highly conservative 0% Re-Injection scenario equates to approximately 13% of the existing allotment to other large industrial users within the model domain over the 5-year operational period. Based on an assumed water use of 200 L/day per person and an average of four people per domestic well."

Importantly, the water balance presented for the highly conservative 0% Re-Injection Scenario demonstrates that the existing licensed wells consume far more groundwater than Sio's proposed project operations.

2.0 Potential Effects on Aquifer Properties

In Section 4.2 of their memorandum, Matrix expressed concerns around two main topics, "*1) degradation of the Winnipeg Shale Aquitard, and 2) increase in fracture density of the Red River Carbonate Aquifer."*

2.1 Degradation of Winnipeg Shale Aquitard

It is acknowledged that the "*Winnipeg Shale Aquitard hydraulically isolates the Winnipeg Sandstone Aquifer from overlying geologic formations and acts to limit groundwater flow between these different units*" in areas where existing groundwater wells have not already interconnected the Red River Carbonate and Winnipeg Sandstone aquifers. It is also acknowledged that the "*degradation of the shale would result in an increase in … permeability and hydraulic connectivity/communication between the Red River Carbonate and Winnipeg Sandstone aquifers*" where the aquifers are not already locally interconnected by existing water supply wells.

Matrix asserts that "*The importance of preserving the hydraulic isolation between aquifers is paramount in a precautionary approach with regards to potential migration of contaminants in the groundwater. The potential alteration of a natural hydraulic barrier such as the Winnipeg Shale Aquitard as an effect of the proposed project is increasing the vulnerability of both aquifers, which is an undesired outcome."* While preserving hydraulic isolation between aquifers is very important in some aquifer systems, AECOM does not agree that the presence of openings through the natural hydraulic barrier (i.e. Winnipeg Shale) alone will substantially increase the vulnerability of both aquifers to surface contamination.

The assessment of aquifer vulnerability considers many factors including the soil and unsaturated zone material, the depth to the water table or aquifer, the amount of recharge to that aquifer, the slope of the land surface, the aquifer material itself, and any preferential pathways such as fractures that contaminants may follow. Many of these factors will be unaffected by sand extraction.

The Winnipeg Shale is located below the Red River Carbonate Aquifer and does not presently protect the Red River Carbonate Aquifer from surface contamination. The Red River Carbonate Aquifer is primarily protected from surface contamination by the relatively thick (approximately 27 m or 90 ft) Quaternary Sediments that largely consist of finer grained materials within the footprint of the proposed sand extraction wells. These sediments will not be affected by sand extraction activities and will continue to protect the underlying Red River Carbonate Aquifer and Winnipeg Sandstone Aquifer in spite of any degradation of the Winnipeg Shale Aquitard. Further, the top of the Winnipeg Shale is found at a depth of approximately 54 m (177 ft). For surface contamination to reach that aquifer, it would need to travel through 27 m (90 ft) of Quaternary Sediments, an estimated 24 m of Red River Carbonate and a further 3 m of Winnipeg Shale prior to reaching the Winnipeg Sandstone. Prevailing hydraulic gradients are primarily horizontal and surficial contaminants would migrate in a primarily horizontal direction along the direction of groundwater flow. The physical processes (advection, dispersion, diffusion, attenuation, etc.) affecting contaminant fate and transport do not favour migration from surface to depths of 54 to 76 m below ground surface, and will likely allow sufficient time for attenuation of other contaminants through physiochemical processes (e.g. sorption, decay, mineral precipitation, etc.) prior to reaching the confined aquifers. Implementation of the Progressive Well Abandonment Plan and the Groundwater Monitoring and Mitigation Plan will protect the existing groundwater resource and enable monitoring of the influence of project activities on groundwater quantity and quality.

The potential effect of the degradation and/or collapse of the Winnipeg Shale and increased hydraulic connectivity of the two aquifers was explicitly evaluated using numerical groundwater modelling tools by way of calibration, sensitivity analysis, transient simulations of project activities and scenario analysis. Because the groundwater levels in the Winnipeg Sandstone were simulated to recover to pre-mining levels for all scenarios, the vertical gradients across the Winnipeg Shale are interpreted to remain similar to existing conditions (i.e., near-zero to slightly downward) at the regional scale following operations. Hence, the exchange of groundwater between the aquifers is anticipated to be similar to that observed presently. Similar to conditions surrounding wells that interconnect the Red River Carbonate and Winnipeg Sandstone aquifers at present, local scale exchange may occur through any areas where the Winnipeg Shale has degraded or collapsed and where there is also a hydraulic gradient driving exchange of groundwater between the two aquifers. As stated in CEC-IR-012 Round 2:

> "*Water levels measured in observation wells indicate the vertical gradients between the two aquifers are downward and near zero meaning that downward flow from the universally fresh Red River Carbonate aquifer across the Winnipeg Shale aquitard and into the underlying Winnipeg Sandstone aquifer is the more likely flow direction, with little potential for saline impacts*".

Because water quality in both aquifers is fresh within the project area, upwelling of saline groundwater from the Winnipeg Sandstone into the Red River Carbonate will not occur as it has west of the project area.

Furthermore, AECOM acknowledges that Matrix has reviewed "t*he mixing of the waters from the Winnipeg Sandstone and Red River carbonate aquifers geochemical assessment," "and results and interpretations were validated."*

2.2 Increase in Fracture Density of Red River Carbonate Aquifer and Influence on Possible Contaminant Migration Pathways

In response to concern #2, it is expected that additional fracturing in the limestone will occur as a result of sand extraction. The geotechnical caprock stability modelling demonstrates that, when following the design recommendations presented in Table 9 of Stantec's report, sufficient competent limestone remains intact to support the overlying quaternary deposits. The increase in vertical hydraulic conductivity and the potential for increased flow would be mitigated by the factors noted above that include: 1) water levels measured in observation wells indicate the vertical gradients between the two aquifers are downward and near zero meaning that downward flow from the universally fresh Red River Carbonate aquifer across the Winnipeg Shale aquitard and into the underlying Winnipeg Sandstone aquifer is the more likely flow direction, with little potential for saline impacts; and 2) The relatively small gradients will result in a relatively small quantity of groundwater exchange. In addition to the boreholes and monitoring wells proposed under the Groundwater Monitoring and Mitigation Plan, Sio will be advancing several angled boreholes to allow for completion of downhole ATV/OTV surveys that will enable better characterization of subvertical fracturing and possible refinement of the geotechnical stability model based on the results of the surveys. Depending on the results of these surveys, Sio may make minor refinements to the geotechnical model and extraction plan.

Matrix notes that: "*Fracture networks are known to be highly heterogeneous, and therefore so are the hydrogeological properties of fractured bedrock aquifer such as the Red River Carbonate Aquifer. As described earlier, one of the effects of the project is to increase the density of fractures through the Red River Carbonate Aquifer (refer to Stantec 2022 figure).*" It is agreed that on the scale of meters to tens of metres, the bedrock aquifers may be highly heterogeneous, with groundwater flow pathways strongly influenced by local scale fracturing with groundwater flow along bedding planes, joint sets and dissolution features within the Red River Carbonate Aquifer. However, at the regional scale these discrete features are typically interconnected, and as noted by Matrix, the use of an Equivalent Porous Media (EPM) approach is "*deemed appropriate for a regional groundwater flow model*". It is also agreed that regional groundwater models that invoke the EPM assumption are not always appropriate for simulation of contaminant transport, and that model refinements would be required if that was the intended purpose of the groundwater model (which it is not). Because the Winnipeg Sandstone Aquifer is weakly cemented and has a moderate to high porosity, the influence of fracture flow is considered much less, and an EPM approach is justified to evaluate problems at both the local and regional scale. Further, the influence of a higher density of fractures in proximity to sand extraction boreholes can largely be mitigated by following standard well abandonment procedures that eliminate preferential pathways along the wellbore and therefore prevent contaminants from entering the bedrock aquifers altogether. These procedures are described in the Progressive Well Abandonment Plan.

2.3 Release of Contaminants to Aquifers Due to Anthropogenic Activities

All well owners and drillers in Manitoba are required to construct, operate and abandon groundwater wells in a manner that is protective of Manitoba's groundwater and aquifers as defined under *The Groundwater and Water Well Act* and the Well Standards Regulation. The Red River Carbonate and Winnipeg Sandstone aquifers are deeply buried, so it is highly unlikely that anthropogenic activities will release contaminants directly to those aquifers. If contaminants were released to the aquifers, they would migrate according to prevailing groundwater flow directions which are primarily horizontal. This is supported by the near zero to relatively small vertical gradients between the aquifers in the project area. Over large distances, longitudinal and transverse dispersion would spread the contaminants across the thickness of the aquifers and typically act to reduce concentrations associated with instantaneous point source releases. If contaminants are somehow introduced adjacent to the Winnipeg Shale aquitard in an area where prevailing hydraulic gradients encourage exchange of groundwater between the two aquifers, it is acknowledged that the deterioration of the Winnipeg Shale may allow for enhanced exchange of groundwater and its associated constituents between the two aquifers similar to that observed where existing water wells are screened across both aquifers.

Additionally in Section 4.2, Matrix references the response to MBEN/OLS-IR-028, part c) and MBEN/OLS-IR-029 part a) and states, "*the qualification of "highly unlikely" that anthropogenic activities* ***<u>from the project</u>*** *would release contaminants to those aquifers presumably assumes a point source release of short duration during the five-year lifespan of the proposed project in areas with thick (approximately 30 m) overburden materials."*

AECOM disputes the statement that "*anthropogenic activities* ***<u>from the project</u>*** *would release contaminants*". Sio has no intention to re-inject any water or substances other than the groundwater that is extracted from the Winnipeg Sandstone during sand extraction operations, filtered to remove solids and treated with ultraviolet light prior to re-injection to the same aquifer. Because the sand extraction and conveyance systems are enclosed, controlled, and not combined with any other processes, there is very low potential for contamination of reinjected groundwater. Sio will implement stringent monitoring of all water that is re-injected to ensure that water quality is maintained. If water quality is found to be unacceptable for re-injection operations will cease until the source of contamination is found and the water meets criteria for re-injection.

Matrix also states: "*However, if extraction wells are completed and abandoned as described in responses to information requests, aquifer contamination may be possible under the following specific conditions. Vertical propagation of fractures in the Red River Carbonate Aquifer and overburden material occurs to ground surface, and/or a preferential pathway exists in the annular space between the formation and the inner PVC casing (refer to Section 4.3), then these conditions could lead to contaminant migration into the Winnipeg Sandstone Aquifer.*" AECOM agrees that sand extraction activities may affect the hydraulic conductivity of the rock mass, with the magnitude and extent of any changes determined based primarily on the characteristics of the rock mass, degree of disturbance and time. However, AECOM disagrees with the statement that "*vertical propagation of fractures in the Red River Carbonate Aquifer and overburden material occurs to ground surface*" may occur. The extents of fracturing have been simulated by Stantec. When sand extraction wells are constructed in accordance with the design criteria in Table 9 of the Stantec report (e.g., >15 metres of competent carbonate bedrock), fracturing of the carbonate is not expected to extend to the base of the Quaternary Sediments. Further, the overburden sediments are not anticipated to fracture. As noted previously, groundwater gradients within the Red River Carbonate and Winnipeg Sandstone Aquifers are primarily horizontal.

Matrix quotes: "*The proponent suggests that the interconnection between the two aquifers is a common occurrence because many drinking water wells have been screened across the Red River Carbonate and the Winnipeg Sandstone aquifers."* They subsequently state: *"In Matrix's opinion, this is not a valid response."* AECOM would like to clarify that the interconnection of the aquifers is a statement of fact and not a professional opinion. The interconnection of the aquifers has been documented in the large body of literature produced by government agencies, consultants and academic researchers in Manitoba over a period of decades as discussed in Section 5.8.3 of the Hydrogeology and Geochemistry Assessment. A comprehensive list of references is provided in Section 1.3 of the same document.

Matrix also notes: "*If contaminated groundwater was found in the Red River Carbonate Aquifer at a drinking water well, then according to the Groundwater and Water Wells Act, Part 3, 32(3) the director may take action to prevent the spread of contamination. Contamination spreading across both aquifers could be mitigated through standard well abandonment procedures."* AECOM accepts that there are regulatory provisions for a director to take action to address wells that do not conform to requirements of *The Groundwater and Water Wells Act* to address contamination of groundwater. AECOM also acknowledges that contamination typically enters confined aquifers through unsealed or improperly sealed boreholes or monitoring wells, and that these issues can be mitigated through standard well abandonment procedures as described in the Progressive Well Abandonment Plan.

Matrix continued: "*However, if a similar situation was to occur in the vicinity of an abandoned extraction well from the Sio Silica Corporation operation where the Winnipeg Shale Aquitard is deteriorated on a radius of 25 to 40 m (Stantec 2022; Table 9) above the void space from the sand extraction process, there are no standard mitigative measures that could be taken to prevent the spread of contamination between both aquifers. The existing water wells that are completed across multiple aquifers represent a small proportion of all the existing wells completed in those aquifers. In the case of the Sio Silica Corporation proposed project, the enhancement of inter-aquifer connectivity is an engineered consequence of several hundreds of extraction wells in the project area.*" It is agreed that Sio is not proposing engineered mitigation of deteriorated shale over a radius of 25 to 40 m around each well, and the aquifers will likely be more interconnected in the vicinity of sand extraction wells. As noted in Section 5.8.3 of the Hydrogeology and Geochemistry Assessment, "*Wang et al. (2008) reported that over 1,000 wells installed as open holes to extract softer groundwater from the Winnipeg Sandstone Aquifer have resulted in groundwater level decline in the Winnipeg Sandstone due to equalization of aquifer heads*". This is not a small proportion of the existing wells as stated by Matrix. If the study areas of Wang et al. (2008) and AECOM were coincident, this would represent approximately 10% of the registered water wells within the groundwater model domain. Further, AECOM does not agree with the hypothetical situation suggesting spreading of contamination from a source unrelated to project operations between both aquifers. While it is theoretically possible, it would require discharge of a large volume of contaminants from an unknown source without detection to cause widespread contamination. This is an unrealistic and very low probability scenario in that the aquifers are confined by thick and low permeability Quaternary Sediments over much of the project area. Much of the recharge to the bedrock aquifers within the project area is inferred to originate from the Sandilands Glaciofluvial Complex located to the east. There is no direct pathway for surface contamination to enter the Red River Carbonate or Winnipeg Sandstone aquifers, and groundwater travel times from surface to the underlying aquifer would be very long, allowing for substantial hydrodynamic dispersion and attenuation of any constituents. AECOM is not aware of any such instances occurring within the project area despite the large number of wells and widespread residential, agricultural and commercial land uses within the area. Any surficial contaminant releases would be detected in a multitude of operational water supply wells and groundwater monitoring wells before surface contamination was able to impact groundwater in the Winnipeg Sandstone Aquifer.

As Sio stated in response to MBEN/OLS-IR-028, part c),

> "*All well owners and drillers in Manitoba are required to construct, operate and abandon groundwater wells in a manner that is protective of Manitoba's groundwater and aquifers as defined under The Groundwater and Water Well Act and the Well Standards Regulation. The Red River Carbonate and Winnipeg Sandstone aquifers are deeply buried, so it is highly unlikely that anthropogenic activities will release contaminants to those aquifers. If contaminants were released to the aquifers, they would migrate according to prevailing groundwater flow directions which are primarily horizontal. This is supported by the near zero to relatively small vertical gradients between the aquifers in the project area. Over large distances, longitudinal and transverse dispersion would spread the contaminants across the thickness of the aquifers and typically act to reduce concentrations associated with instantaneous point source releases. If contaminants are somehow introduced adjacent to the Winnipeg Shale aquitard in an area*

> *where prevailing hydraulic gradients encourage exchange of groundwater between the two aquifers, it is acknowledged that the deterioration of the shale may allow for enhanced exchange of groundwater and its associated constituents between the two aquifers similar to that observed where existing water wells are screened across both aquifers.*"

As also stated in Sio's response to MBEN/OLS-IR-029, part a),

> "*Sio intends to comply with: The Groundwater and Water Well Act and regulations; Manitoba guidance documents, including Constructing and Sealing Wells in Manitoba, Information for Well Drillers and Well Sealers and Constructing and Sealing Wells in Manitoba - Information for Private Well Owners; and The Mines and Minerals Act and regulations thereunder governing well drilling, construction and well sealing procedures and standards. Well decommissioning will be conducted in accordance with the Progressive Well Abandonment Plan that will be provided prior to the Hearing.*
> *No shale collapse will occur during well construction. The well abandonment/sealing activities will occur within the wellbore and prevent surface potential contamination in addition to aquifer isolation within the wellbore.*
>
> *The scenario of shale collapse, or shale not being present was considered in the Hydrogeology and Geochemistry Assessment and considered to not be a concern should this occur: "Interconnection between the two aquifers is a common occurrence because many drinking water wells have been screened across the Red River Carbonate and the Winnipeg Sandstone. Should project operations result in a more interconnected aquifer system comprising the Red River Carbonate aquifer and the underlying Winnipeg Sandstone aquifer, groundwater quality would tend to reflect conservative mixing of the two water types (i.e. limited geochemical reactions) resulting in water quality that is similar or slightly better." As discussed in the response to MBEN-IR-030, Sio will monitor groundwater quality before, during and after extraction operations and will employ appropriate mitigation if this monitoring identifies unexpected results. The details of Sio's groundwater monitoring and mitigation will be set out in its Groundwater Monitoring and Mitigation Plan.*"

Stewardship of groundwater resources is a regional issue that requires careful management of contaminants such as fuels, road salt, fertilizer, manure, septic systems and other chemicals at ground surface to direct their management and ensure spills do not occur. Protection of groundwater supplies is most effective through development and implementation of Aquifer Protection Plans, Groundwater Source Protection Plans, Management Plans (Nutrients, Manure, Spills, Well Abandonment, etc.), public education and use of regulatory tools that consider the natural conditions and anthropogenic activities in the area. Use of potential contaminants should be carefully managed. If spills do occur, they need to be rapidly cleaned up to protect the groundwater resource.

2.4 Weathering of Carbonate

In reference to Matrix comment in Section 5.2 about, "*It is unclear how weathering effects are taken into consideration in the geotechnical assessment."* The geotechnical stability model does not rely upon probable weathered zones for the Red River Carbonate caprock (bedrock) stability assessment. Upper and lower zones of possible fractured/ weathered caprock (bedrock) were identified using an ATV/OTV survey and were considered to provide no support. Conservative assumptions were used for modelling the tensile strength of the limestone, which allows for weathering effects. With no change in the Quaternary contact, weathering in the upper Red River Carbonate is understood to be substantially complete. The weathering effect on the strength of the layered Red River Carbonate following extraction is an important consideration. This will be assessed and the geotechnical model will be updated during full-scale extraction based on the results of the geotechnical Trigger Action Response Plan (TARP). Sio Silica will also be advancing several angled boreholes to allow for completion of downhole ATV/OTV surveys that will enable better characterization of subvertical fracturing and possible refinement of the geotechnical stability model based on the results of the surveys. Depending on the results of these surveys, Sio may make minor refinements to the geotechnical model and extraction plan.

3.0 Well Construction and Abandonment

In Section 4.3, Matrix discusses extraction well completion and provides comment on grout and cement. Matrix states: "*The proponent is not committing to cement by mentioning that grouting is also accepted and utilized regularly in the water well industry (Figure E inset A). Figure E illustrates the potential difference between the use of grout versus cement in the annular space between an outer and inner PVC casings and the edge of the borehole.*"

Grout is defined in industry reference textbooks including Groundwater and Wells - Third Edition (Sterrett, 2007) as a "*suitable slurry of cement or bentonite*". The textbook elaborates that grout slurry "*can contain cement and water (neat cement), sand, bentonite, pozzolan (fly ash) calcium chloride (as an accelerator), or hydrated lime. A slurry made with a high-solids bentonite (granular or chips) also can serve as grouting seal, provided this is used at a depth where dehydrating and shrinking of the grout will not occur, and where water movement will not wash away the clay particles*". As noted, cement is one of many possible ingredients of grout, and "cementing" is a colloquial industry term that is more commonly intended to represent the action of establishing a hydraulic seal within a borehole or well to prevent migration of water and contaminants along the axis of the borehole or well, and is not intended to reflect the ingredients of the cementitious grout mixture. Under certain conditions, cement can shrink. Similarly, bentonite (clay) does not have structural strength on its own. For this reason, grout mixtures often contain both cement and bentonite.

Sio would like to clarify that it intends to use a cement-based grout that is fit for purpose that may include bentonite and/or other inert well completion materials as additives. The primary goal will be to establish a structurally sound hydraulic seal within a borehole or well to prevent migration of water and contaminants along the axis of the borehole or well, including any remaining annular spaces after downhole equipment has been removed. Sio has exclusively used a cement-based grout for test extraction well construction to date. The proportion of bentonite additive to the grout mixture will be evaluated further as "*Bentonite holds cement particles in suspension, reduces shrinkage and improves the fluidability of mixture*." (Sterrett, 2007). Addition of 5% bentonite to grout mixtures is a common practice in the well drilling industry.

This is consistent with statements made in Section 4.2 (Sealing Materials) of the draft Progressive Well Abandonment Plan filed February 6, 2023:

> *"Sealing materials will meet the requirements of the Drilling Regulation under The Mines and Minerals Act, or the Groundwater and Well Regulation and Well Standards Regulation under The Groundwater and Water Well Act.*
>
> - *Grout will be a neat mixture of sulphate resistant (CSA Type 50) grout.*
> - *The grout mixture will be tested in advance to ensure it is able to produce a minimum strength of 41,000 kPa after 28 days of placement.*
> - *Bentonite chips, bentonite pellets, pea gravel, cement or other inert materials may be used to supplement grout and affix a lockable protective well casing at ground surface (monitoring wells only).*
> - *Water from the same aquifer or potable water will be used to mix grout or hydrate bentonite sealing materials."*

Reference: Sterrett, J. 2007. The Groundwater and Wells - Third Edition. Johnson Screens, a Weatherford Company.

4.0 Monitoring and Mitigation Plans

Based on their review of the monitoring and mitigation plans, Matrix notes: "*In response to Round 2 IR question MBEN/OLS-IR-031, the proponent provided a comprehensive list of measures to monitor the infiltration rates, groundwater levels and quality, and how data will be compiled, interpreted, and communicated to different stakeholders. Matrix agrees that the groundwater monitoring plan should be adequate to identify potential groundwater quality and quantity issues within the aquifers due to project effects".* The statement made by Matrix is acknowledged and AECOM agrees that the groundwater monitoring plan should be adequate to identify potential project effects on groundwater quantity and quality.

Matrix also makes the following comment: "*In Table D of the groundwater monitoring and impact mitigation plan, the margin of error between simulated and measured drawdown seems too high for the local monitoring zone wells. Improved performance between the numerical model and measured data is an important consideration in predicting the effect on local resident wells".* AECOM agrees that the predictive ability of the model should continue to be improved, and the thresholds in the third column of Table D may require reevaluation. Consideration will be given to addition of a secondary criteria "... OR Decrease in Water Level Suggests Possibility of Unacceptable Water Level Impacts to Private Water Supply Wells" to Stage 1, Stage 2 and Stage 3 to reduce the reliance on simulated groundwater modelling results and provide a level of redundancy in the TARP.

Matrix also noted: "*At stage 3 of degraded groundwater quality in regional observation well network, the proponent's mitigative measure is to cease sand extraction "from that well". If an impact on water quality is observed in the regional observation well network, in Matrix opinion, this would be a cumulative effect from project operations, not from a single well. It is noted that the assessment of the*

Winnipeg Shale Aquitard integrity is not monitored in the proposed draft monitoring program". The TARP is issued in draft and will continue to benefit from input from technical reviewers and regulatory agencies before it is finalized. The eventual final TARP would also incorporate any license conditions. In its current form, it provides a framework that will be followed during operations to inform appropriate responses based on measured data. Sio maintains that the proposed Stage 3 mitigation measures will be appropriate if water quality impacts are detected in a small number of nearby monitoring wells. If impacts are detected in a greater number of wells, Sio acknowledges that it may require ceasing sand extraction from more than one well. TARPs have been successfully implemented as a tool to manage uncertainty for mining and other industrial activities, while also enabling rapid decision making and mitigation of unforeseen issues. Further, they can be refined as knowledge of the groundwater system and its response to project activities increases over time.

Matrix also suggested: "*The proposed monitoring program should be designed to specifically assess the changes in the effectiveness of the Winnipeg Shale Aquitard and Red River Carbonate Aquifer to limit vertical groundwater movement between the baseline conditions and post-operations. Results of this monitoring program would also serve to confirm if the geotechnical constraints and parameters used to design the sand extraction well configuration are indeed adequate for future phases of the project*". AECOM agrees that the effectiveness of the Winnipeg Shale Aquitard and Red River Carbonate Aquifer in limiting vertical groundwater movement should be monitored and evaluated based on information collected before, during and after operations. The assessment will consider evaluation of multiple lines of evidence including groundwater levels, aquifer properties and groundwater quality. The results and information will also inform evaluation of the appropriateness of geotechnical parameters used in the design to inform future phases of mining.

Matrix provided the following opinion: "*Matrix's opinion is that transducers installed in local groundwater monitoring zone wells should record water levels on an hourly basis instead of daily during operations, as stated in the Groundwater Monitoring and Impact Mitigation Plan. In addition, since impact mitigation plans incorporate the validation of measured responses with the numerical model of groundwater flow, pumping tests should be conducted in advance of the extraction process to validate the numerical model ability to predict potential effects at residential wells*". AECOM agrees that higher temporal resolution (i.e. on the order of hourly) would benefit the interpretation of aquifer response to project operations, and a higher frequency of data collection could be incorporated into the finalized Groundwater Monitoring and Mitigation Plan. In reality, groundwater levels will likely be monitored at a higher frequency than hourly and plotted in real-time during operations to allow for comparison of simulated and observed drawdown. As noted in Section 1.6 of the Groundwater Monitoring and Mitigation Plan, "*some boreholes will be completed as monitoring wells to allow for hydrogeological testing, and monitoring of groundwater levels and groundwater quality prior to, during and following extraction activities*". However, the plan does not describe in detail the methods that will be employed to complete the hydrogeological testing. It is presently envisioned that permeability testing will be completed on each monitoring well in advance of operations, and the testing will be completed on a recurring basis (e.g. annually or every five years) to determine if aquifer properties have changed over time. This data could supplement available well yield tests contained in the well databases. A fulsome description of hydrogeological data collection (and testing) methods will be incorporated into the finalized Groundwater Monitoring and Mitigation Plan.

5.0 Water Re-injection and UV Treatment

On the topic of re-injection and UV treatment as discussed in Matrix' report in Section 4.2, page 11, Sio has no intention to re-inject any water or substances other than the produced, filtered and UV treated water that came from the sandstone aquifer during extraction operations. Sio will employ stringent monitoring of re-injected water to ensure that water quality is maintained. As the system is enclosed, controlled and not combined with any other processes, the likelihood and source of any contamination is extremely limited. If any contamination is found, re-injection would be shut down until the issue can be resolved.

6.0 Cumulative Effects

In Section 5.1, page 13, Matrix has identified "No Cumulative Effects Assessment of the Full Project" as a deficiency in the application. The author provides a number of extracted statements from the EAP that pertain to the 24-year life of the project and the Notice of Alteration process for future potential extraction years. The author then proceeds to provide highlights of various sections of provincial government legislation, including *The Groundwater and Water Well Act*, *The Mines and Minerals Act*, *The Environment Act*, and *The Watershed Districts Act* to support this assertion. Although the author has highlighted various clause and conditions within this legislation that are applicable to the licensing process in Manitoba and the requirements for environmental protection, the information provided by Matrix does not support the assertion that "No Cumulative Effects Assessment of the Full Project" is a deficiency in the EAP application for a number of reasons:

1. A cumulative effects assessment is not an EAP requirement.

   As stated in the Responses to the Technical Expert Reports–Geotechnical, filed November 29, 2022, issue 13:

   > *"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."*

   Matrix does not identify Information Bulletin–Environment Act Proposal Report Guidelines as a reference in Section 5.1, so the author is likely not unaware that a cumulative effects assessment is not an EAP requirement. This lack of understanding and inexperience with the Manitoba environmental permitting process by various reviewers of the project has resulted in an incorrect assertion that the absence of a cumulative effects assessment is a deficiency in the application.

2. Integrated Watershed Management Planning (IWMP) is the responsibility of the Government of Manitoba, not Sio Silica.

   On page 16 of the Matrix report, the author makes the following statement regarding IWMP in Manitoba:

> *"From the Southeast Regional Groundwater Management plan (Government of Manitoba 2010) Manitoba Water Stewardship (MWS) - Groundwater Management Section (GMS) hold responsibilities for overall groundwater management and are involved with all activities related to groundwater. It is currently unclear how the MWS-GMS is assessing the current and foreseeable groundwater use in relation to long-term sustainability and groundwater in the strategic planning. This highlights once more the need for a CIA to be done on a regional scale in the form of a risk assessment of groundwater sustainability (e.g., quantity) and quality."*

Matrix has indicated that "*The Vivian Sand Project is located within the Brokenhead River Watershed, where an IWMP does not appear to exist*". Matrix has also indicated that IWMP is the responsibility of the Government of Manitoba, not Sio Silica. Therefore, comments attributing the absence of an IWMP for the Brokenhead River Watershed should not be considered as a trigger for a proponent (in this case Sio Silica) to complete a cumulative effects assessment as an alternative or precursor to a government led IWMP.

Although a cumulative effects assessment is not an EAP requirement, cumulative effects <u>were</u> evaluated by AECOM in the hydrogeology and geochemistry assessment that was completed in support of the EAP. As stated in the Responses to the Technical Expert Reports–Geotechnical, filed November 29, 2022, issue 13:

> *"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.....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 thresholds 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., by 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.

7.0 Extraction Testing and New Extraction Plan

7.1 Extraction Testing

In Section 6, page 19 Matrix questioned why a pilot project had not yet been undertaken. Sio would like to correct the record on this topic. Sio's extraction method has been adequately proven by multiple extraction tests including a dual well test. Monitoring data from the most recent extraction test was provided in Appendix B of CEC -IR-014, Round 2. Appendix B demonstrates the volume and tonnages extracted.

Stantec recommended conducting multi-well testing after issuance of an Environment Act Licence while operations begin with a smaller number of wells and then increase over time. This staged approach will allow Sio Silica and Stantec to confirm expected conditions before moving to larger multi-well extraction and make minor adjustments that may be required.

7.2 New Extraction Plan

In reference to Matrix's comment in Section 6 "*It is unclear if the proponent expects to produce the same tonnage of sand with fewer wells or not. The change in extraction plan at this stage illustrates the degree of uncertainty that exists with regards to potential fracture development and/or collapse of the Red River Carbonate as a result from the sand extraction process."*

Following the issuance of the updated geotechnical model recommendations (Table 9), Sio Silica initiated an update to the geological model. This entailed a drilling program over the summer and early fall of 2022 to infill additional data and refine the model. Following the update of the geological model, Sio developed a new extraction plan which applied the constraints from the geotechnical model (Table 9), new tonnage values from the most recent extraction testing and related efficiencies gained since. Placement of clusters and the number of wells per cluster were based on the geological model and the geotechnical constraints. The new Extraction plan was provided to Stantec for review and approval. In Sio's development of the Extraction plan, consideration is also given to placement of clusters based on minimum offsets from homes, other wells, roads and utilities as well as previously disturbed land where possible.

The total number of wells has been reduced by 401 for the first 4-5 years after the initial Extraction Plan was first outlined in the 2021 EAP filing. The reduction in the number of wells and changes to the Extraction Plan is largely attributed to advancements in both monitoring capabilities for measuring potential subsidence, acoustic imaging capabilities that have provided additional information on the thickness of the competent limestone, refinements of the geotechnical design and efficiencies in the extraction method.