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

Sio Silica Corporation (SSC) Responses to Information Requests (IRs) Round No. 1

IR Number: **DLN-IR-001**

Submitted by: DLN

Date Submitted: November 23, 2022

Subject Matter: Air injection

Reference Documents: (i) Section 2.2.1 Extraction Method

Preamble: According to Table 6-3 of the extraction EAP the air lift extraction method uses an Oil Free Rotary Screw Air Compressor. Industrial literature documents that the compressed air from oil-free air compressors can contain contaminants such as microbes, organic vapours such as diesel fumes and oil vapours from the compressor oil breather and particulate. The compressor concentrates contaminants found in the ambient air around the compressor.[1,2,13] The extraction EAP states that a diesel powered air compressor will be used.

A typical air compressor is rated at 90 kW for up to 125 psi.[4] The compressed air must be at least 125 psi to overcome aquifer fluid pressure at depth and to provide extra pressure to loosen sand as described in the Sio Silica patent reproduced in Supplementary Information, Silica Extraction June 2, 2022.

The diesel fuel consumption for a rotary screw compressor can be calculated by 0.238 L/(kW.h) x 90 kW= 21.4L/hr.[5] Using 0.0214 m^3/hr one air compressor for a well cluster operating for 5 days would consume about 2.568 cubic meters of diesel fuel. Each cluster has five extraction/injection wells. Assuming one compressor per well the total diesel fuel consumption for one extraction cluster would be 12.84 cubic meters

The Canadian NPRI emission factors are given in the table below.[6]

Table 1. NPRI emission factors [5]

Substance	NPRI emission factor (kg/m^3 of diesel fuel)
SO2	4.761
NO2	72.396
Benzene	1.532×10^{-2}

The Sio Silica target sand production for one well cluster is 21000 tonnes. Using a density of the sand of 1.65 tonnes/cubic meter and a porosity of the sandstone of 0.25, the volume of the extraction cavity is estimated to be 21000 tonnes /1.65 tonnes/cubic meter /0.75 = 16970 cubic meters. Note Sio Silica has not specified the value for the sand dry density. The value of 1.65 tonnes/cubic meter is used as a reference example.

The concentration of the contaminant in the well cavity would depend on the capture fraction transferred to the aquifer of the air compressor for diesel emissions which is unknown. The capture fraction would be enhanced by the compressor action of concentrating the concentration of contaminants in the air. It is well known that both SO2 and NO2 in water will form acid, hence acid rain. Nitrous oxide (NO2) will dissolve in the water in the excavation cavity to form nitric acid and nitric oxide according to the formula,[7]

$3NO_2 + H_2O \rightarrow 2HNO_3 + NO$.

Nitric acid, HNO3, is a strong acid that will almost completely dissociate. Three moles of NO2 forms two moles of nitric acid in water.[7] Microbes can denitrify NO3- to produce N2O and N2 gasses that may decrease the amount of nitric acid over time.[9] However nitrates could act to stimulate harmful microbial growth.

The overall chemical formula for production of sulphuric acid in water is;[10]

$2SO_2+O_2+2H_2O \rightarrow 2H_2SO_4$.

One mole of SO2 would produce one mole of H2SO4. Air injection in the air-lift silica sand extraction process would provide the source of oxygen required for the formation of sulphuric acid.

Carbon dioxide from the burning of the diesel would also be transferred to the aquifer according to the conversion ratio of 2.7 kg of CO2 per litre of diesel fuel.[11] CO2 will form carbonic acid in water. Only a small portion of the CO2 dissolved forms carbonic acid that may be buffered by bicarbonate in solution, therefore the pH cannot from CO2 dissolution cannot be determined.[12]

Acid production would be buffered by the bicarbonate concentration in the sandstone aquifer that ranges from 226 to 532 mg/L however the dissolved CO2 could diminish the buffering capacity of the groundwater.[12] A detailed chemical speciation calculation is required to estimate the resulting acid concentration in the aquifer.

Table 2 gives the estimated acid and benzene concentration in an extraction cavity from air injection

Table 2. Estimated contaminant concentrations in the extraction cavity for 12.84 cubic meters of diesel fuel used for each well cluster air compressor and a cavity volume of 16970 cubic meters.

Substance	Capture fraction	Aquifer Concentration (mg/L)	pH for 3M NO2 → 2M HNO3 and 1M SO2 → 1M H2SO4	Capture fraction	Aquifer Concentration (µg/L)	pH
SO2	0.1	3.60	4.25	0.01	360	5.25

NO_2	0.1	54.8	3.10	0.01	5480	4.10
CO_2	0.1	204	-	0.01	20400	-
benzene	0.1	1.16×10^{-2}	-	0.01	1.16	-

The allowed limit of benzene in drinking water is 5µg/L.[8] An air compressor capture fraction transferred to the aquifer of about 4.3% could result in benzene contamination. Even a very low 0.1% of capture of NO_2 from the exhaust fumes of the diesel generator for the air compressor could result in a strong acid depending on the amount of buffering in solution. Dissolution of heavy metals such as arsenic into the excavation cavity would occur with acidification of the groundwater of the aquifer. These calculations do not include emissions from the drill rigs and Sio Silica vehicles and equipment which would increase the contamination of the aquifer. Contamination by microbes is also not included.

These calculations and references establish that filtration of the air injected into the sandstone aquifer is required.

Request:

a) Describe in detail the methods used to evaluate and test filtration of compressor air during Sio Silica air- lift sand extraction operations over the last several years of development?

b) What was the concentration of contaminants such as SO_2, NO_2, benzene, microbes and particulate per cubic meter of air from the compressor before and after air filtration as determined by field test measurements? Release all data and description of the methods of such measurements to the Hearing.

c) What was the measured concentration of contaminants such as VOC, NO_2, SO_2, CO_2, benzene and microbes in the ambient air around the compressor during field testing? Release all data and description of the methods of such measurements to the Hearing.

d) What was the pH, TOC, benzene, CO_2, NO_2, SO_2, and microbial concentrations of sandstone groundwater water before and after sand extraction as measured during field testing? Release all data and description of the methods of such measurements to the Hearing.

e) Describe in detail the air decontamination methods that have been tested by Sio Silica during development such as removing all liquid water from compressed air, filtration to reduce water aerosols, reduction of dew point, and filtration. Describe in detail how these decontamination methods would be implemented during production.

f) If Sio Silica has not done any ambient air, compressed air, and aquifer water contaminant baseline and after sand extraction measurements during field testing, describe in detail the measurements that will be made prior to production.

g) Describe in detail a plan to measure all potential contaminants introduced into the aquifer by air lift- injection including VOC, NO2, SO2, CO2, benzene and microbes prior to production if no comprehensive measurements have yet been made and recorded.

h) Describe in detail a compressor air filtration plan that would be implemented during production.

i) Measure and release data on the baseline aquifer contaminant baseline concentration and the aquifer contaminant concentration after air filtration methods are implemented and tested during full-scale well cluster extraction tests using the latest cluster design including five extraction wells. During the testing measure at least, TOC, benzene, CO2, NO2, SO2, pH, heavy metals, selenium, and microbial concentrations in the aquifer.

j) Specify how often compressed air will be measured for contaminants during production including ISO8573-7 and ISO 8573-4 testing for microbes.

k) What remedial measures and compensation will be afforded by Sio Silica in the event of aquifer contamination and deterioration in water quality by compressed air injection?

l) Quantify the total amount of contaminants such as NO2, SO2, CO2, benzene, microbes, chlorine and particulate Sio Silica has injected into the sandstone aquifer during development.

m) Specify the volume of solid filter waste that would be required per tonne of extracted sand during production.

n) If water air filtration is used, specify the volume of waste water per tonne of extracted sand that would be required for air filtration during production.

o) What would be the cost to the Project per year to filter compressor air and dispose of waste air-filtration products? Compare this cost to all other overall Project costs.

p) Describe in detail all the waste management treatment and disposal methods required for air filtration during production including the total volume of waste, locations of disposal and GHG released during disposal activities.

References:

a) How to Get Clean, Dry, Oil Free Compressed Air From Any Compressor A White Paper By Mark White - Compressed Air Treatment Applications Manager, Parker Manufacturing Ltd Gas Separation & Filtration Division EMEA, Dukesway, Team Valley Trading Estate Gateshead, Tyne & Wear, NE11 0PZ United Kingdom https://www.parker.com/Literature/Hiross%20Zander%20Division/PDF%20Files/Brochures/WPCDOAAC-00-EN.pdf

b) Controlling Micro-organism Growth in Compressed Air A White Paper By Mark White Compressed Air Treatment Applications Manager, https://www.parker.com/Literature/IGFG/PDF-Files/WPCMGICA-00-NA-012021_POST.pdf https://www.parker.com/Literature/Hiross%20Zander%20Division/PDF%20Files/Brochures/WPCAC-EN_00.pdf

c) 32 Myths of Oil-free Compressed Air, Mattei, https://www.matteicomp.com/32-myths-of-oil-free-compressors-mattei

d) Plant Services Home Blog, Compressor power - Actual vs nameplate https://www.plantservices.com/home/blog/11314044/compressor-power-actual-vs-nameplate

e) Rotocomp Screw Compressor Co. Ltd. Calculation Method of Fuel Consumption for Diesel Air Power Compressor, http://www.rotorcompressor.com/calculation-method-of-fuel-consumption-for-diesel-air-power-compressor.html#:~:text=The%20ratio%20of%20water%20to

f) Government of Canada, Environment and Natural Resources, Pollution and Waste Management, National Pollutant Release Inventory, Diesel fuel generator – fuel usage. https://www.canada.ca/en/environment-climate-change/services/national-pollutant-release-inventory/report/tools-calculating-emissions/diesel-fuel-generator-fuel-usage.html

g) Chemistry School, https://www.chemistryscl.com/reactions/nitrogen-dioxide+water/index.php

h) Guidelines for Canadian Drinking Water Quality https://www.canada.ca/content/dam/canada/health-canada/migration/healthy-canadians/publications/healthy-living-vie-saine/water-benzene-eau/alt/water-benzene-eau-eng.pdf

i) Denitrification- an overview Science Direct, https://www.sciencedirect.com/topics/agricultural-and-biological-sciences/denitrification

j) Acid Rain, Chemical Education Digital Library (ChemEd DL, Ed Vitz, John W. Moore, Justin Shorb, Xavier Prat-Resina, Tim Wendorff, & Adam Hahn, Aug. 17 2020, https://chem.libretexts.org/Ancillary_Materials/Exemplars_and_Case_Studies/Exemplars/Environmental_and_Green_chemistry/Acid_Rain

k) Auto Smart, Natural Resources Canada, https://www.nrcan.gc.ca/sites/nrcan/files/oee/pdf/transportation/fuel-efficient-technologies/autosmart_factsheet_9_e.pdf

l) Geochemical and Isotopic Characterization of a Regional Bedrock/Surficial Aquifer System, Southeastern Manitoba Graham Phipps Manitoba Water Stewardship, Winnipeg, MB, Canada R.N. Betcher and J. Wang Manitoba Water Stewardship, Winnipeg, MB, Canada, IAH 2008, https://www.gov.mb.ca/sd/water/pubs/water-science-management/groundwater/publication/2008_phipps_geochemical_isotopic_characterization_regional_aquifer_system_southeastern_manitoba.pdf

Response:

a) This question assumes filtration methods are required beyond the standard utilized equipment already used every day in the water well industry worldwide. Sio contracted licensed and authorized water well drilling companies who used industry accepted and standardized equipment for the purposes of drilling and developing water wells.

b) Sio did not monitor the air quality in the air from the compressor during field testing, as this is neither a regulatory requirement nor common industry practice.

c) Sio did not monitor the ambient air around the compressor during field testing, as this is neither a regulatory requirement nor common industry practice.

d) Sio did not monitor the groundwater quality during field testing for TOC, benzene, CO2, NO2 or SO2, as this is neither a regulatory requirement nor common industry practice. Microbial contamination due to drill rigs or exhaust is not a known issue.

Sio sampled pH results from routine samples taken periodically from monitoring and extraction wells, which yielded pH results ranging from 8.12 to 8.35.

Sio also took microbial samples 6 months after the extraction test both on the extraction test location including the extraction well and monitoring wells, as well as monitoring wells off location. The results were all negative for total coliforms and E.coli.

e) Sio is not proposing to use “air decontamination methods” as this is neither a regulatory requirement nor common industry practice. Sio is proposing to use standard equipment that is used every day in the water well industry worldwide.

f) Water monitoring and baseline sampling will be outlined in Sio's Water Monitoring and Impact Mitigation Plan, which will be filed prior to the Hearing.

With respect to air emissions, 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.

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.

g) See the response to DLN-IR-001(f).

h) See the response to DLN-IR-001(e).

i) See the response to DLN-IR-001(f).

j) Sio is not proposing to monitor air quality in the compressed air, as this is neither a regulatory requirement nor common industry practice.

k) Sio does not expect any adverse impacts on groundwater quality as a result of compressed air injection. However, Sio will be monitoring groundwater quality throughout operations. See the response to DLN-IR-001(f).

l) Sio has no reason to believe it has injected any contaminants into groundwater.

m) Sio's proposal will not result in filter waste. See the response to DLN-IR-001(e).

n) Sio is not proposing to use air filtration. See the response to DLN-IR-001(e).

o) Sio is not proposing to use air filtration. See the response to DLN-IR-001(e).

p) Sio is not proposing to use air filtration. See the response to DLN-IR-001(e).

IR Number: **DLN-IR-002**

Submitted by: DLN

Date Submitted: November 23, 2022

Subject Matter: Process Water Re-injection to the Sandstone Aquifer and Geochemical Testing

Reference Documents:

(i) Section 1.7.3 Other Approvals

(A) Injection permit(s) for return of water to the sandstone aquifer,

(ii) Responses to Public Review Comments,

(iii) Waste Characterization and Management plan,

(iv) Table 4-3 and 4-5 of the Hydrogeology and Geochemistry Assessment Report,

(v) Arcadis Technical Review of Sio Silica Corporation's Environment Act Project Proposal Vivian Sand Extraction Project13 September 2022, and

(vi) Hollander and Woodbury Technical Review Sio Silica Corporation's Environment Act Project Proposal 19. September 2022.

Preamble:

Public Review Comments Background:

The text pertaining to water re-injection from the Sio Silica Responses to Public Comments Document on the Project Registry 6110.00 is reproduced below as background information for the request.

Responses to Public Review Comments:
Key issue 13

Public Question:
"*Injection wells can over pressurize resulting in fractures to the limestone. As the limestone is considered a crucial support structure in the prevention of subsidence it is alarming that the Report did not analyze and provide this requisite information. What is the safe pressure limit to ensure integrity of the limestone, the shale aquitard, and the integrity of the aquifer system?"*

Sio Silica Response:
"No pressure will be applied during the reinjection process, as water will be returned to the aquifer by gravity only. This is why CanWhite will be returning water to an operating well, so that the drawdown created by the extraction can be replaced by the water being returned to the aquifer (and no pressure is required)."

Key Issue 219

Public Question:
"Have permits been issued for all CanWhite injection wells since 2017? CanWhite has been mining since 2017. Why was this monitoring data, taken during actual extraction operations, withheld from the EAP and the Report? What treatment was provided for this water and where is that data?"

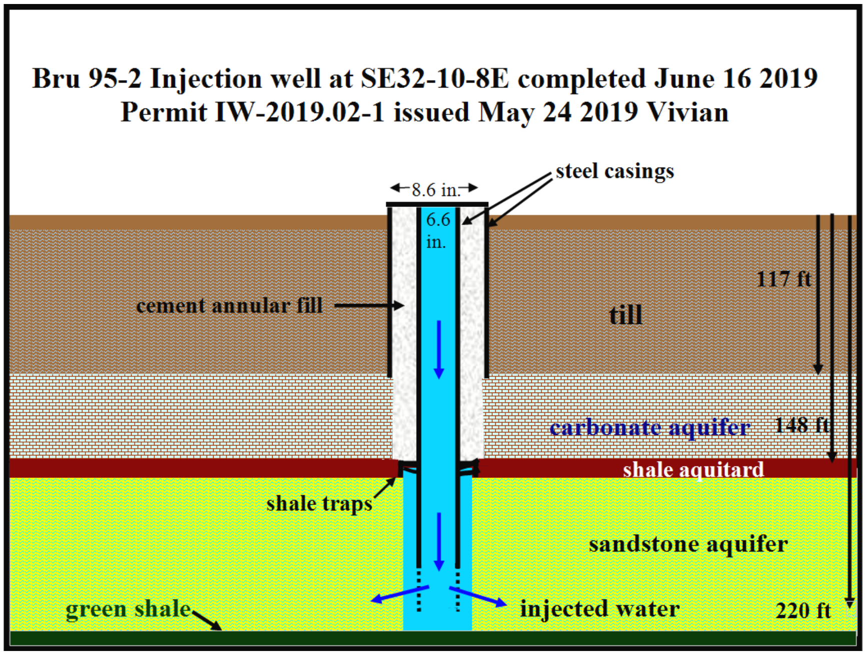
Sio Silica Response:
"CanWhite has been issued injection permits for any and all wells that were re-injected. Not all wells were reinjected, as some well water was diverted to surface, and a permit was also issued for this. Re-injected water was treated with chlorination in accordance with CanWhite's application for the re-injection permit. Monitoring data was collected and would be made available to regulatory authorities upon their request."

Further Background Information:

Sio Silica has never reported any data or measurements from field testing of the extraction methods from isolated wells that Sio Silica has tested. Any full-scale extraction tests for single wells that Sio Silica has done have not been documented in the EAP. This is an egregious critical deficiency in the EAP.

According to information from the Manitoba Water Science and Watershed Management Branch, Sio Silica has obtained only four injection well permits in their advanced exploration operations. Manitoba groundwater reported that two of the injection permits were not used leaving only two permits IW-2019.02-1 for two wells Bru 95-2 and Bru 95-3 at SE32-10-8E1 south of Vivian issued in May of 2019 and IW-2021.01-1 for two wells Bru 92-8 and Bru 92-9 at SW29-10-8E in a quarry south west of Vivian issued Aug.11, 2021. Manitoba Groundwater reported that the injection well permit for well Bru 92-9 was not implemented. For completion of full-scale extraction tests including water re-injection, injection well permits must be obtained.

Figures 2 and 3 illustrate the well configurations for the injection wells Bru 95-2 and Bru 95-3 at SE32-10- 8E1 south of Vivian.



WELL INFORMATION REPORT
2022 Feb 11
Well PID: 201400
Location: SE32-10-8E
UTMX:682236.3 UTMY:5527605.9 XY Accuracy:1 EXACT [<5M] [GPS]
UTMZ:276 Z Accuracy:4 FAIR - Shuttle at Centroid
Owner: HD MINERALS
Driller: Friesen Drillers Ltd.
Well Name: BRU 95-2 / BH 7-19
Date Completed: 2019 Jun 16
Well Use: INJECTION
Well Status: SEALED Aquifer: SANDSTONE
REMARKS:
WITN:002445; OTHER SEALING AT 149FT-MECHANICAL PLUG
WELL LOG (Imperial units)

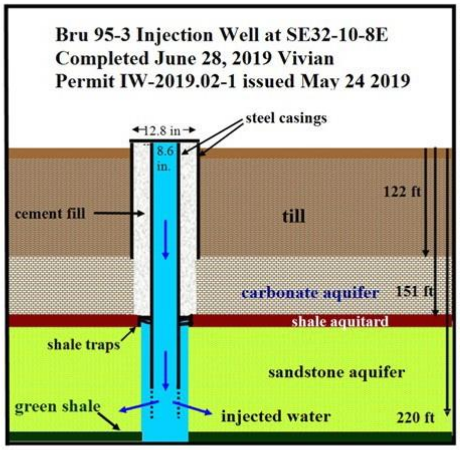
From	To(ft.)	Log
0.0	5	BLACK FILL AND PEAT MOSS
5.0	27	GREY FINE SAND
27.0	85	GREY TILL
85.0	117	GREY TILL WITH GRAVEL AND BOULDERS
117.0	148	PINK LIMESTONE
148.0	158	RED SHALE
158.0	218	WHITE SANDSTONE
218.0	226	GREEN/WHITE SHALE WITH SANDSTONE LAYERS
226.0	230	GREEN SHALE

WELL CONSTRUCTION

From	To(ft)	Const.Method	Inside Dia.(in)	Outside Dia.(in)	Type Material
0.0	122.0	CASING	8.0	8.6	WELDED STEEL
0.0	178.0	CASING	6.0	6.6	WELDED STEEL
0.0	150.0	ANNULAR FILL	6.6	8.0	CEMENT
178.0	220.0	WELL SCREEN	6.0	6.6	WELDED STEEL
122.0	230.0	OPEN HOLE	7.9		
150.0	150.0	SHALE TRAP			
155.0	155.0	SHALE TRAP			

Top of Casing: 2.5 ft above ground
WELL SEALED
Sealed Date: 2020-Aug-26
Sealed Bv: CANWHITE SANDS CORP

Figure 2. Bru 95-2 CWS permitted injection well south of Vivian 2019. *Illustration is by D. M. LeNeveu. Well information report was from Manitoba Groundwater.*



Location: SE32-10-8E
UTMX:682214.9 UTMY:5527623 XY
Owner: HD MINERALS
Driller: Friesen Drillers Ltd.
Well Name: BRU 95-3 / BH 7-19
Date Completed: 2019 Jun 28
WITN:002447; MOC:ROTM,DROT;
Well Use: RECHARGE/RETURN
WATER USE: Other
Well Status: SEALED
WELL LOG (Imperial units)

From	To(ft.)	Log
0.0	8	BLACK FILL AND PEAT MOSS
8.0	32	GREY FINE SAND
32.0	75	GREY TILL
75.0	122	GREY TILL WITH GRAVEL AND BOULDERS
122.0	151	PINK LIMESTONE
151.0	159	RED SHALE
159.0	217	WHITE SANDSTONE
217.0	226	GREEN/WHITE SHALE WITH SANDSTONE LAYERS
226.0	230	GREEN SHALE

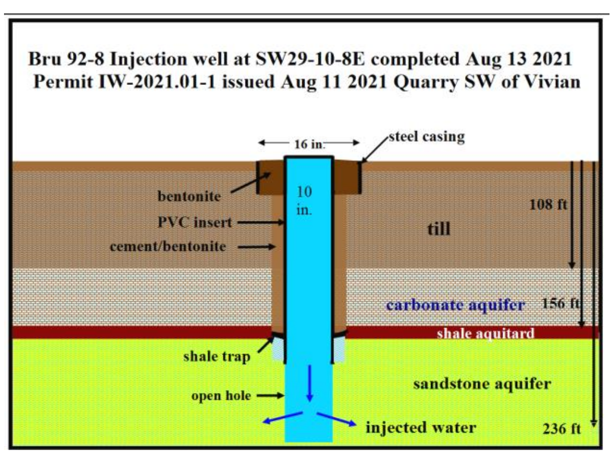
WELL CONSTRUCTION

From	To(ft)	Const.Method	Inside Dia.(in)	Outside Dia.(in)	Type Material
0.0	126.0	CASING	12.0	12.8	WELDED STEEL
0.0	178.0	CASING	8.0	8.6	WELDED STEEL
0.0	152.0	ANNULAR FILL	8.6	12.0	CEMENT
122.0	230.0	OPEN HOLE	11.8		
178.0	220.0	WELL SCREEN	8.0	8.6	WELDED STEEL
152.0	152.0	SHALE TRAP			
157.0	157.0	SHALE TRAP			

Top of Casing: 2.0 ft above ground
WELL SEALED
Sealed Date: 2020-Aug-26
Sealed By: CANWHITE SANDS CORP

Figure 3. Bru 95-3 CWS permitted injection well south of Vivian 2019. *Illustration is by D. M. LeNeveu. The well information report was from Manitoba Groundwater.*

The wells Bru-95-2 and Bru 95-3 do not conform to the Sio Silica design for extraction wells given in supplementary filing of June 2, 2022, Silica Extraction Method and illustrated in figure 5. Only a single casing in Bru 95-2 and Bru 95-3 extends into the sandstone. A single casing extending into the sandstone could not have been used for simultaneous water re-injection and sand extraction. An outer casing was installed into the carbonate with the annular spacing sealed. The sealing date of the annular spacing cannot be determined. Manitoba Groundwater issues one combined well information report for extraction and sealing even though for the sealing dates reported that are much later than the completion date, two reports are required. At the time of sand extraction the annulus between the inner and outer casing could have been open. In this event, according to the well design, water could have been re-injected into the carbonate formation only which is not allowed by regulations. Thus valid full-scale field tests with re-injection that conforms to the Sio Silica EAP sand extraction well design could not been performed on these two wells. This leaves only well Bru 92-8 available for full-scale filed tests with water re-injection. The design of well Bru 92-8 is illustrated in Figure 4.



2022 Feb 11
Well PID: 208473
Location: SW29-10-8E
UTMX:681631.6 UTMY:5526384.6 XY Accuracy:1 EXACT [<5M] [GPS]
UTMZ:275 Z Accuracy:4 FAIR - Shuttle at Centroid
Owner: CANWHITE SANDS
Driller: EARTH DRILLING CO. LTD.
Well Name: BRU 92-8
Date Completed: 2021 Aug 13
Well Use: INJECTION
WATER USE: Other
Well Status: ACTIVE Aquifer: SANDSTONE
WELL LOG (Imperial units)

From	To(ft.)	Log
0.0	108	GREY TILL
108.0	156	PURPLE/BEIGE LIMESTONE
156.0	166	RED/GREEN SHALE
166.0	236	WHITE SANDSTONE

WELL CONSTRUCTION

From	To(ft)	Const.Method	Inside Dia.(in)	Outside Dia.(in)	Type Material
0.0	20.0	CASING	15.0	16.0	T & C STEEL
0.0	180.0	BOREHOLE	13.8		
0.0	180.0	CASING	10.0	10.8	INSERT PVC
180.0	236.0	OPEN HOLE	9.8		
126.0	162.0	ANNULAR FILL	10.8	13.8	CEMENT/BENTONITE
0.0	126.0	SURFACE SEAL			BENTONITE
162.0	162.0	SHALE TRAP			OTHER

Top of Casing: 0.0 ft above ground

Figure 4. CWS permitted injection well Bru 92-8 at a quarry south west of Vivian 2021. *Illustration is by D. M. LeNeveu. Well information report was from Manitoba Groundwater*

Well Bru 92-8 does not conform to the Sio Silica sand extraction well design shown in figure 5.

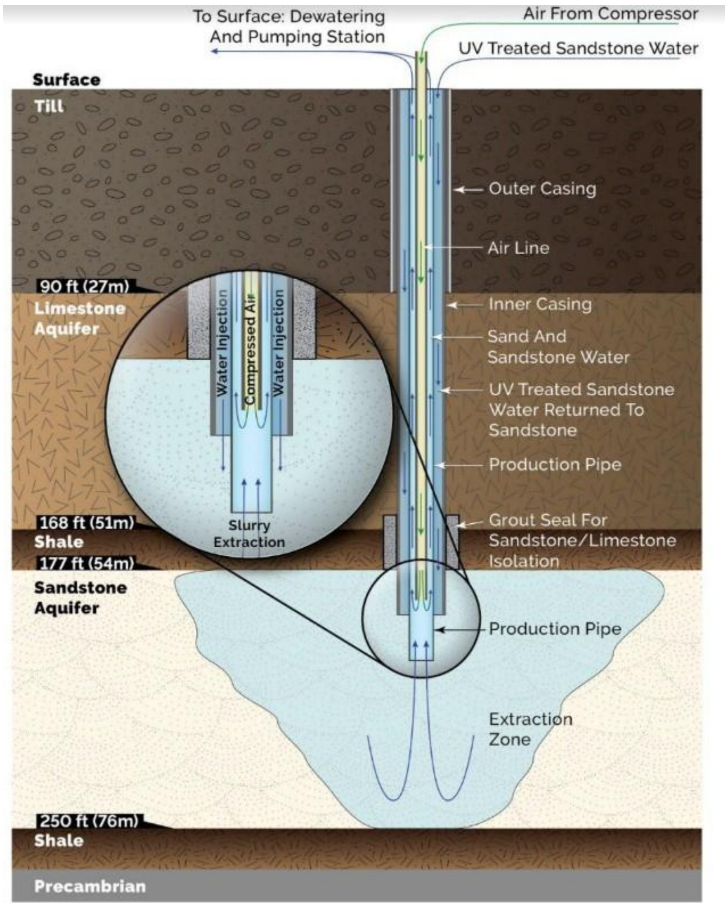


Figure 5. Sio Silica EAP well extraction design *"Reproduced from Figure 2-3 in the Sio Silica Supplementary Information – Extraction Method June 2, 2022"*

There is no production casing extending into the sandstone formation for Bru 92-8. The Sio Silica design states that the production casing is removable. It is possible that the production casing was removed and therefore not shown in the well information report. In an email Manitoba Groundwater reported that the only extra casing penetrating deep into the sandstone was a casing around the well drill that was removed immediately after the well drilling was completed. The text of the email response of Sept.22, 2022 is given below.

"Good Morning Mr. LeNeveu,

Thank you for your inquiry regarding further information on the wells drilled for the Sio Silica Sands Project in Manitoba.

In regards to your questions about liners and the reporting of these, including the extraction method being utilized, I spoke with a company representative from Sio Sands for further information two weeks ago to clarify extraction techniques and whether there are well construction details which should be included in reporting. It was explained that there is no liner being utilized. Reportedly, when they extract the silica sand, a Dual Rotary Method is employed so the sand is removed via this dual drilling casing and upon completion, it is then removed. Therefore, this is not part of the permanent well construction material being installed so there is no requirement within our regulations for the drilling company to report this.

Specifically, regarding BRU 92-8, an injection well permit was issued for this well. Reportedly, the well was used as a test well for both injection and production and was eventually solely used as an injection well."

Therefore it appears not only was no production liner used, Bru 92-8 was eventually used solely for water re- injection. Use of an extraction well solely for re-injection does not conform to the Sio Silica extraction design and protocol. Without a production tube extending into the sandstone, process wastewater could not have been re-injected into the aquifer by gravity as per the Sio Silica well cluster extraction protocols and as shown in figure 5.

The only conceivable method for water re-injection in Bru 92-8 would have been to store the water on surface and inject it under pressure in pulses between pulses of sand extraction. Limited storage would be available during production with five or more extraction wells operating simultaneously such that sole pressurized re-injection during production may not be feasible. Sole re-injection with no sand extraction did occur in Bru 92-8 as stated in the above email.

Pressure from sole re-injection may damage the shale aquitard and the limestone aquifer. Sio Silica has maintained that no direct pressurized re-injection of water occurs. Re-injected water according to Sio Silica design specifications is to enter the sandstone aquifer only by gravity flow aided by the negative suction pressure created by air lift.

Such gravity fed re-injection has never been demonstrated and documented in field tests by Sio Silica. The Sio Silica Supplementary Information – Extraction Method June 2, 2022 report contains no documentation of filed testing of the extraction and re-injection methodology. The references include only the Sio Silica EAP's for the Processing Facility, the Extraction Project, a well sealing information report from the Manitoba government, and the Jan. 14, 2022 Stantec geotechnical report. No sand was extracted, no water was re- injected and no well clusters were considered in the modeling and well drawdown studies reported in the Sio Silica Hydrogeological Report of the Extraction EAP. According to the information received from Manitoba

Water Branch, no injection well permits were issued for the wells used in the hydrogeological studies and no water was re-injected to the aquifer. According to the well information reports received from Manitoba Groundwater, no wells of the design shown in figure 2 were constructed and used for the hydrogeological studies. A modeled 50% re-injection scenario was done by simply reducing the well pumping rate as shown by the following excerpt on page 76 of the Hydrogeological Report;

"The extraction rate assigned to the pumping well in the Scenarios 1 through 3 was scaled according to the injection rate as follows:

- *Scenario 1 (0% re-injection): Pumping Rate = 2,998 m3/day (550 US GPM)*
- *Scenario 2 (50% re-injection): Pumping Rate = 1,526 m3/day (280 US GPM)"*

No re-injection occurred. No injection well was used in the hydrogeological model. Only a single pumping well as stated in the above excerpt was used in the model. Thus no relevant measured testing or modeling for the Sio Silica extraction wells and well clusters with sand withdrawal and water re-injection was documented in the Sio Silica Hydrogeological Report.

The re-injection of water is a critical feature of the sand extraction method. It is incomprehensible that the Project has progressed to this stage without documentation and proof of concept of the critical gravity fed re- injection methodology. Over several years of exploration testing Sio Silica has demonstrated extraction of silica sand from the sandstone aquifer but has never documented water re-injection. All that Sio Silica has produced for water re-injection is a drawing shown in figure 5 with no documented implementation.

If no production liner is used air must be directly injected into the sandstone aquifer during extraction. The large amount of injected air would greatly increase oxidizing conditions in the aquifers leading to a cascade of deleterious effects including iron and manganese precipitation, selenium dissolution from the aquitard, microbial proliferation, and oxidization of sulphide sources in the sandstone to acid and subsequent mobilization of heavy metals.

A video shot by a concerned citizen that is posted on an Our Line in the Sands social media site shows a pulsed extraction for well Bru 92-8. Air would be injected directly into the sandstone aquifer in a pulse and then shut off for a short time and then repeated. The injected air would then rapidly escape up the casing completed to the top of the sandstone, lifting the sand with it in a pulsed manner as shown in the video. This extraction method does not conform to the Sio Silica cluster design extraction design and methodology.

This evidence demonstrates that no full-scale Sio Silica field test of the EAP extraction design has ever been performed even for a single extraction well. The field test method implemented by Sio Silica in Bru 92-8 if used during production would seriously increase the risk of severe harm to the environment and the public.

Entrained air

In addition to air dissolved in the process water large amounts of air bubbles will be entrained by the air lifting, sand water separation methods and in the clarifiers and hydrocyclones of the UV filtration process.

For instance figure 6 shows a typical hydrocylone with an air core.[4]

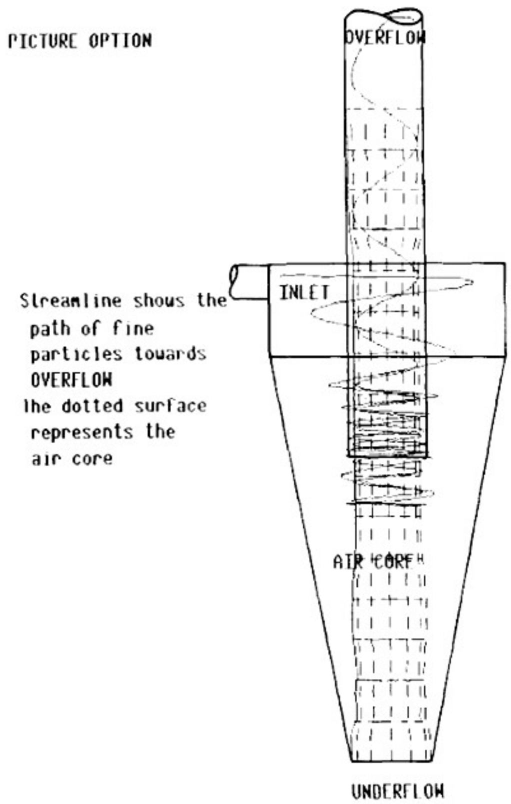


Figure 6. Air Entrainment by a hydrocyclone.[4]

Entrained air can be a very large amount up to 40 % by volume or more.[5,6] The EAP and the Process Water treatment Option Memorandum do not mentioned entrained air. Sio Silica has no stated methods to remove entrained air from re-injected water. Entrained air is a critical omission from the EAP and Project documentation.

Air would be introduced into the extraction cavities by air injection in the air lift method as described above. The entrained and dissolved air in the re-injected water would add to the air in the extraction cavity ensuring oxidizing conditions would occur.

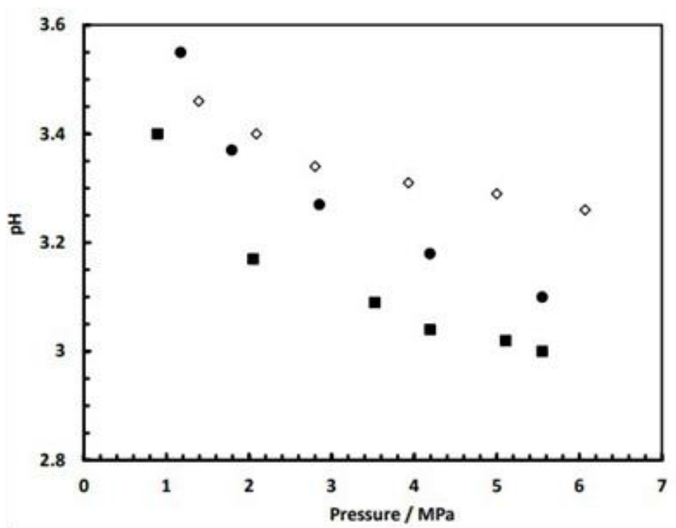
Formation of acid and leaching of heavy metals in the sandstone aquifer from re-injected water

The Sio Silica Hydrogeological Report establishes that both sulphide and heavy metals occur in the sand in the aquifer. Heavy metals and sulphide in greater concentrations are documented in the shale aquitard that would be exposed to the aerated water re-injected to the aquifer. Other sources of sulphide in the sandstone include pyritic oolite, concretions and interbedded shale layers.[7,8] Both the sandstone and the shale aquitard according to the Sio Silica geochemical analysis contain calcium carbonate that can act to neutralize sulphuric acid that would form from the oxidation of the sulphide sources in the extraction cavity. The chemical formula for the reactions of pyrite or marcasite (FeS2), sulphuric acid (H2SO4) with calcium carbonate (CaCO3) are;[2]

4FeS2 + 15O2 + 8CaCO3 → 2Fe2O3 + 8CaSO4 + 8CO2

CaCO3 + H2SO4 → CaSO4 + H2O + CO2

Carbon dioxide will dissolve in water and form carbonic acid. Thus the neutralization of the sulphide sources in the aquifer by calcium carbonate will form acid. Figure 7 below illustrates the pH of water in saturated with dissolved CO2. The hydrostatic water pressure at the depth of the sandstone aquifer below the water table of about 60 meters can be determined from the equation P = ρhg where P is the pressure, ρ the density of water and g , the acceleration of gravity. The hydrostatic pressure would be about 0.6MPa or about 6 atmospheres.



. pH of CO_2 saturated solutions as a function of pressure in the CO_2-H_2O-NaCl system. Filled symbols represent experimental data measured in this work using spectroscopic technique (m = 2 mol·kg^{-1}): T = 293.15K (■) and T = 323.15 K (●). Empty symbols represent the data measured using the electrometric technique by Schaef et al. (2003), (m= 2.11 mol·kg^{-1}): T = 295.15 K (◇).

Figure 7. pH of water for saturated solutions of CO2[5]

From figure 7 the pH at in the sandstone aquifer from the dissolution of CO2 would be as low as about 3.4, a very strong acid. Thus the presence of CaCO3 in a closed aquifer system where the CO2 cannot escape will generate acid conditions when reacting with sulphide sources. Either carbonic acid or sulphuric acid or both will from in the aquifer from the re-injected water at sufficiently low pH under oxidizing conditions to liberate heavy metals. The only means to prevent the acid from forming in the aquifer would be to prevent air from entering the aquifer.

There are methods to reduce entrained air.[3] If the air tube for the air lift system were fixed deep inside the production tube so that all injected air would move up the production tube and not enter the aquifer the amount of air entering the aquifer could be minimized. However keeping the air tube well inside the production tube does not conform the Sio Silica patent and would prevent air from being used to loosen sand for extraction. Confining injected air to inside the production tube may prevent sand from being extracted. Removing the dissolved oxygen may not be feasible. Preventing acid formation in the aquifer from re- injected water does not seem to be possible.

The re-injection of process water has always been one of the major critical problems associated with the Sio Silica air-lift extra extraction method. Sio Silica in its so called full-scale field test has never demonstrated and documented in the EAP the extraction method illustrated in figure 5. This fundamental operational problem of re-injection of process wastewater has never been resolved.

Release of selenium from collapse of the shale aquitard into the extraction cavity and from shale encountered lower in the sandstone formation and acid formation.

Table 4-3 of the Hydrogeology and Geochemistry Assessment Report documents selenium concentration in the core samples of the shale aquitard up to 13.1 ppm, far above the average crustal abundance values for shale. The shake flask results of Table 4-5 report selenium concentrations from the shale aquitard, up to 1.64 mg/L, are above the acceptable for drinking water, irrigation, livestock and aquatic life. Selenium will dissolve into water under oxidizing conditions without the formation of acid in the aquifer. There were numerous questions in the public comments about selenium release in the aquifer. In one of the responses to public questions about pyritic shale, marcasite coating the sand, pyritic concretions and pyritic oolite within the extractions Sio Silica stated;

"CanWhite plans to drill into the Carman Sand Member. The Winnipeg Formation consists of multiple layers. Throughout the Project area, the Black Island Member lies below the Carman Sand Member. Please see Table 1 from the Stantec geotechnical report (Attachment A). The Carman Sand Member does not contain the minerology described in question #8 (A). There is no risk that CanWhite's operations will extend into the Black Island Member at any time or under any circumstances because: - The Black Island Member is below and not above the Carman Sand Member; - The Carman Sand Member is separated from the Black Island Member by a shale layer; and - The Black Island Member does not contain the targeted sand resource."

Table 1 from Attachment A shows the Ice Box member containing shale immediately below the extractable sand layer which is labelled as *"not drilled."* Even if the extracted sand does not expose the shale layer directly, aerated oxidizing water from Sio Silica extraction operations would easily penetrate through a porous layer of sand to the shale beneath. Reaction of oxygen in the water with sulphide in the shale would create a sink. Dissolved oxygen would move down gradient to the shale ensuring acid release would continue to occur. Thus the data from Table 1 Attachment A establishes that aid formation is likely to occur in the sandstone aquifer from the Sio Silica extraction operations.

The well information reports for Bru 95-2 and 95-3 illustrated in figures 1 and 2, show the drilling extends into the green shale layer below the extractable sand layer. The well information report for Bru 95-2 documents green/white shale with sandstone layer eight feet thick above the green sandstone layer and within the extracted sand layer. Numerous well information reports throughout the Sio Silica 24 year Project area show interbedded shale layers within the extractable sand layer as reported in table 3 of the brief supporting the DLN and WTFMB motions as well as shale immediately below the sand. The shale layer below the extractable sand will be at the bottom of the extraction cavity and exposed to re-injected water containing entrained and dissolved air and exposed to injected air from air-lifting. The interbedded shale layer above the green shale would be extracted with the sand and exposed to oxidizing along the perimeter of the extraction cavity. The shale aquitard containing high levels of selenium would collapse into the extraction cavity adding to the sources of selenium that would dissolve under the oxidizing conditions from extraction. The Arcadis third party technical report and figure 5 of the brief supporting the DLN and WTFMB motion confirms that shale collapse into the extraction cavity is bound to occur. Photographs of extracted sand show clumps of reddish shale consistent with the shale aquitard as illustrated in figures 1 and 2. This evidence contradicts the Sio Silica assertion that shale will not be encountered in the extraction area of the sandstone. Sio Silica gives no drilling reports or evidence to support their assertion that no pyrite or marcasite containing sulphide will be exposed or extracted in their operations.

Acid formation would very likely occur within the extraction cavity from the documented sources of sulphide including the aforementioned shale, concretions, oolite and marcasite and pyrite in the sand. The sand geochemical analysis done by Sio Silica from air and moisture exposed samples is unacceptable as documented by the third party technical report of Hollander and Woodbury.

Request:

a) In response to public comments for the Project Sio Silica stated; *"Not all wells were reinjected, as some well water was diverted to surface, and a permit was also issued for this. Re-injected water was treated with chlorination in accordance with CanWhite's application for the re-injection permit. Monitoring data was collected and would be made available to regulatory authorities upon their request."* How much total chorine was re-injected in injection well Bru 92-8 and all other utilized injection wells? What was the concentration the chlorine in the re-injected water of well Bru 92-8 and all other utilized injection wells? Give detailed descriptions of the chlorine delivery system. Name all the wells where chlorine was used in re-injection and give the dates and duration of re-injection and chlorination.

b) The well injection permits we have obtained from Manitoba Groundwater do not specify chlorine use. Document the permission obtained from Manitoba regulators for the use of chlorine in the re-injected water.

c) Does Sio Silica plan to chlorinate the re-injected water during production? If so give the planned chlorine concentrations in the re-injected water and describe in detail the chlorine delivery process for production. What deleterious or unwanted effects would chlorine in re-injected have on aquifer drinking water quality during production?

d) If Bru 92-8 and perhaps wells Bru 95-2 and 95-3 were the only instances of water return to the aquifer in all of numerous instances of silica sand extraction by Sio

Silica over a period of five years or more, all the excess process water was discharged to the land surface. The temporary authorization permits to divert water do not authorize chlorination or suspended fine sand, heavy metals acid or selenium. Was all this process wastewater water diverted to the surface chlorinated?

e) It has been established that the process wastewater carries large amounts of suspend fine sand and selenium and potentially, heavy metals and acid. What was the detriment associated with discharging the large amount of to the land surface since the commencement of Sio Silica's operations. What was the total amount of water discharged to the land surface? Give the dates, locations and the amount discharged at each location and any measured data on the characterization of this water.

f) The Waste Characterization and Management Plan describes geochemical field testing of wastes including PAG potential and kinetic tests from the till, carbonate and shale but not from the sandstone. Wastes from the sandstone including concretions, oolite, interbedded shale and the sand are documented to contain heavy metals and sulphide that is potential acid generating. Describe the geochemical testing that Sio Silica will perform prior to and during production on all the wastes from the sandstone and on selected silica sand samples. Sio Silica may consider these tests unnecessary since geochemical testing for the EAP gave non PAG results for the sand samples. However the sand sampling procedures from stockpiles and older wells has been declared unacceptable by the third party technical report of Hollander and Woodbury. The flasks test results of the EAP show selenium above guidelines in the sandstone samples. This evidence establishes that geochemical testing of the sandstone is required. To reassure residents and to maintain credibility geochemical testing of the sandstone is necessary. Will Sio Silica commit to comprehensive geochemical testing of all wastes and process water from the sandstone?

g) The condition of the injection well permits issued to CWS/SS includes; *The injection well will be continuously monitored to ensure the formation is not over-pressured.* In accordance with the fulfillment of this condition provide, the water pressure in the sandstone and carbonate during injection as a function of distance from the well, depth and time, analysis of the damage to the aquitard and the formation for all Sio Silica well injections that has occurred to date.

h) The condition of the injection well permits includes; *"The use of the injection well must cease immediately if any local water supplies are negatively impacted as the result of the use of the injection well."* In accordance with fulfillment of this condition provide analysis of contaminants in water injected, analysis of entrained and dissolved air during injection including measurements of organics, and other contaminants and microbes in the air injected during airlift extraction for all extraction operations, concentration of chlorine in injected water, baseline measurement of organics, and other contaminants and microbes in the air around the compressor during airlift extraction for all extraction operations, description of method of chlorine administration and rate, and the concentration of all microbes including iron bacteria in the injected water. Provide this data for all Sio Silica well injection that has occurred to date. If the requested data is not available from previous Sio Silica sand extraction operations provide the measured data from new test sand extraction operations conducted to supply this essential data for the Hearing.

i) Document #1 – Silica Extraction Method of CWS/SS, June 2, 2022 states that the production tubes will be removed after use. For those wells where the production tube was removed provide data on the name and location of the well, the well information report from MB Groundwater, the driller installation information and sealing reports, the total amount of sand withdrawn during extraction, the total amount of water re-injected, the duration of the re-injection and sand extraction, the time and date of installation of the production tube, the rate of sand and water extraction as a function of extraction time, that the rate of water re-injection as a function of extraction time, the time and date of removal of the production tubes, data on the depth of the production tubes and the depth of penetration into the sandstone as a function of sand extraction time.

j) Please provide the name of and location of all the permitted injection wells, permit numbers, conditions of each permit, the water injection dates, well names, duration of injection, rate of injection and the water injection, the water pressure in the sandstone and carbonate during injection as a function of distance from the well, depth and time, analysis of the damage to the shale aquitard and the formation during injection, analysis of contaminants in water injected, analysis of entrained and dissolved air during injection, concentration of chlorine in injected water, description of method of chlorine administration and rate, the concentration of all microbes including iron bacteria in the injected water.

k) Given the background information provided here give evidence that the gravity driven re-injection of water into the sandstone through the outer casing can keep pace with the withdrawal of water with the sand from the production tube.

l) Has Sio Silica provided the Hearing in Supplementary Information Extraction Method of June 2, 2022 simply a drawing of the re-injection method with no field test data or evidence of any kind to establish that the method is viable? Please provide the test data and evidence that the gravity re-injection method is viable.

m) Provide data on the total amount of water that will be withdrawn with the sand in a full production year of 1.36 million tonnes of sand and the total amount of water that would be re-injected to the aquifer. Provide a detailed accounting of the amount and location of all water withdrawn that is not returned to the aquifer including loss by evaporation in the sand stockpiles and the total amount of water entrained in all waste streams including fines/ overs and filtrate from the UV filtration system and sand drying beds.

n) For the total amount of water not returned to the aquifer provide a regional scale aquifer determination of the sustainability of the draw on the aquifer by Sio Silica operations including all other draws on the total of the Sandilands sandstone aquifer.

o) The Arcadis technical report states; *"Borehole logs for boreholes BH10-17, BRU 121-1, BRU146-1, DEN 216-1, BRU 96-1, BRU 96-2, and BRU 95-6 to 95-9 as advanced by Norwest Corporation, Stantec and AECOM."* Please provide the borehole logs for Bru 121-1 and Bru 146-1. Provide information on how the core samples were stored and handled after extraction for Bru 121-1 and Bru 146-1 up to the time of geochemical analysis in November of 2020. Provide detailed information on how the sand samples from Bru 121-1 and Bru 146-1 were extracted, stored, handled, and prepared for geochemical analysis performed in November of 2020. Provide the chain of custody documentation of the core and sand samples from Bru 121-1 and Bru 146-1 from extraction to geochemical analysis in November of 2020.

p) Considering the evidence and to maintain credibility will Sio Silica institute geochemical testing of the sandstone samples prior to and during production? If so describe in detail the geochemical sampling and testing methods and frequency that will be performed on the wastes from the sandstone and on silica sand samples.

q) Considering the evidence in the third party technical reports and in the public comments that geochemical analysis was insufficient will Sio Silica perform comprehensive geochemical sampling and testing throughout the entire 24 year project area? At least 40 samples from the carbonate, shale aquitard and sandstone should be taken at representative sites throughout the 24 year project area. Ensure that many samples are taken and analyzed in the sandstone of interbedded shale, oolite and concretions.

References:

a) PH of CO2 saturated water and CO2 saturated brines: Experimental measurements and modelling, Haghi, RK, Chapoy, A, Peirera, LMC, Yang, J & Tohidi, B 2017, , International Journal of Greenhouse Gas Control, vol. 66, pp. 190-203. https://doi.org/10.1016/j.ijggc.2017.10.001 https://pure.hw.ac.uk/ws/portalfiles/portal/16060209/pH_of_CO2_saturated_water_and_CO2_saturated_brines.pdf

b) Chemical Aid, tools, equation balancer https://en.intl.chemicalaid.com/tools/equationbalancer.php?equation=FeS2+%2B+O2+%2B+CaCO3+%3D+Fe2O3+%2B+CaSO4+%2B+CO2

c) Air Removal from Hydronic Systems, PHCP Pros, March 1, 2022, https://www.phcppros.com/articles/15040-air-removal-from-hydronic-systems

d) Mathematical simulation of hydrocyclones K. A. Pericleous CHAM Limited, Bakery House, Wimbledon, London, SW19 SAU, UK (Received February 1986; revised November 1986) 242 Appl. Math. Modelling, 1987, Vol. 11, August, PII: 0307-904X(87)90139-9 https://www.researchgate.net/publication/222882948_Mathematical_Simulation_of_Hydrocyclones

e) Study on screening performance and parameter optimization of vibrating-dewatering screen, Zhanfu Li, Peiyu Jia, Kunyuan Li, Xin Tong, and Zhihong Wu, Advances in Mechanical Engineering, 2021, Vol.13(9) 1–15 https://www.researchgate.net/publication/354788728_Study_on_screening_performance_and_parameter_optimization_of_vibrating-dewatering_screen [accessed Feb 10 2022].

f) Bubble formation and scale dependence in free-surface air entrainment, Wangru Wei, Weilin Xu, Jun Deng, Zhong Tian, and Faxing Zhang, Sci Rep. 2019; 9: 11008. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC6662671/

g) Economic Geology Report ER84-2 Silica in Manitoba By D.M. Watson Manitoba Energy and Mines Geological Services Report, 1985 https://www.manitoba.ca/iem/info/libmin/ER84-2.pdf

h) Pyrite and Marcasite Coated Grains in the Ordovician Winnipeg Formation, Canada: an intertwined record of surface conditions, stratigraphic condensation, geochemical ‘‘reworking,’’ and microbial activity, Jurgen Schieber and Lee Riciputi, Journal of Sedimentary Research, 2005, v. 75, 907–920, https://www.semanticscholar.org/paper/Pyrite-and-Marcasite-Coated-Grains-in-the-Winnipeg-Schieber-Riciputi/c7260c14eefc435745019d169ed8f741ed4da6df

Response:

a) The use of chlorine in water wells is a commonly accepted practice in well maintenance and installation. Sio proposed to utilize chlorine for re-injection in its injection permit applications for testing purposes. Sio followed *the Groundwater and Water Well Act* – Well Standards Regulation Section9(2) b, which provides that the source of water for construction, sealing, etc must: "*contain a minimum 10 mg/L free chlorine at all times, except for monitoring wells where chlorine will interfere with water quality analysis or remediation"*.

Sio Silica declines to answer the remaining questions based on lack of relevancy to its extraction proposal.

b) Chlorine usage was documented in the Sio application for injection, see response to DLN-IR-002(a).

c) No.

d) No, any water discharged on surface was not chlorinated.

e) Sio disagrees with the premise of the question regarding the quality of process wastewater, which is contrary to Sio's evidence. Sio discharged all water in accordance with the permissions granted to discharge by the Water Rights Branch under a Temporary Authorization.

There is no recorded or known adverse impact associated with Sio's water discharges.

Sio Silica declines to answer the remaining questions based on lack of relevancy to its extraction proposal.

f) Sio disagrees with many of the statements in the preamble to this question. Sio's testing protocols and requirements will be outlined in the Waste Characterization and Management Plan that will be issued in draft form prior to the CEC Hearing. In addition, it is standard practice to test water before, during and after activities, and this practice is reflected in Sio's proposal.

g) Water injected by Sio will not be re-injected under any pressure. Water will be returned to the aquifer on open gravity feed to a well that is actively producing. As a result, while Sio will continually monitor its wells, there is no need to test the pressure in the aquifer.

h) Sio is not aware of any impacts to local water supplies associated with its testing to date. Sio similarly does not expect any adverse impacts on local water supplies from extraction activities, but it has proposed monitoring and mitigation measures to ensure that, in the unlikely event that a local water well is impacted by the extraction, those impacts are appropriately addressed. See Sio's response to CEC-IR-003.

i) Sio declines to answer this question based on relevancy. The production tube is temporary, and therefore not a permanent fixture, which is why it does not appear on the construction or abandonment reports. The information requested would be onerous to produce and is irrelevant to the impacts associated with Sio's proposed extraction activities.

j) Based on the preamble to this IR, it is clear that the author already has much of the requested information. The remainder of the information requested either does not exist or is irrelevant to the impacts associated with Sio's proposed extraction activities. As a result, Sio declines to provide the requested information.

k) The re-injection occurs simultaneously with the extraction. As has been previously described in the Supplemental Filings #1 - Extraction Method, water is returned down the annular space between the cemented well casing that is permanent (which appears on the construction report) and the production pipe that is removable (which does not appear on the construction report as it is not permanent). The sand is extracted through the production pipe. Using these methods, the volume of water being re-injected would more or less match the volume of water being pumped out.

l) Sio Silica’s Bru 92-8 well was successfully tested with all produced water returned to the well and no discharge on surface.

m) As a point of clarification, 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.

It is assumed that there will be some water loss in the system from evaporation from the stockpiles. Stockpiled sand is deposited at approximately 15% moisture content and will drain or evaporate down to approximately 7% or less moisture content, which is the optimal moisture content for the dryer. As the stockpiles must remain damp, a small amount of water will be diverted from the process to keep the stockpiles damp in the summer months. The evaporation or need for a small amount of additional water on the stockpiles is not expected to create an additional draw on the system as there is a small amount of surplus water that will come from the wet sand entering the slurry line. As outlined in the EAP Section 2.2.4 Sand Slurry Conveyance to Processing Facility, the slurry line will contain 15% sand up to 35% sand to allow for operational changes and fluctuations. This lower sand concentration allows for the slurry line to be stopped and restarted without having the clean or drain the line.

n) Please refer to the 50% reinjection scenario in the Hydrogeology and Geochemistry Assessment Report – Section 6.10 Predictive Scenarios.

o) According to the preamble to this IR, it is clear that the author already has a copy of the requested log. Further, the information requested is irrelevant to the impacts associated with Sio’s proposed extraction activities. As a result, Sio declines to provide the requested information.

p) See the response to DLN-IR-002(f).

q) See the response to DLN-IR-002(f).

IR Number: **DLN-IR-003**

Submitted by: DLN

Date Submitted: November 23, 2022

Subject Matter: Slurry Line Contamination

Reference Documents:

(i) Table 4-2, 4-3 and 4-4 of the Sio Silica Hydrogeology and Geochemistry Assessment Report

(ii) Section 2.2.4 Sand Slurry Conveyance to Processing Facility

(iii) 6.9 Accidents and Malfunctions - 6.9.2 Spills and Leaks Appendix H. Production Schedule

(iv) 7.4 Prediction Confidence and Uncertainty

Preamble: Selected heavy metal concentrations in sandstone samples taken from Table 4-3 total recoverable constituents from core samples given in the Sio Silica Hydrogeology and Geochemistry Assessment Report and from results from a concerned citizen's group, OLS, are given in table 1. Concerned citizens (OLS) gathered sand samples from unsecured Sio Silica stockpiles south of Vivian in the summer of 2020 and submitted the samples to ALS laboratory in Vancouver on June 29, 2020.

Table1. Selected Heavy Metal Concentration in Vivian Silica Sand

Element	Bru 95-3 ppm	Bru 121-1 ppm	Bru 146 ppm	OLS ppm
Arsenic	0.9	1.5	0.2	0.9
Chromium	2	3	2	5
Uranium	0.14	0.16	0.14	0.5
Barium	<10	<10	<10	10
Selenium	<0.2	3.2	<0.2	1

The groundwater samples taken from sandstone given in Table 4-7, Groundwater Quality Analytical Results Discharge to Groundwater in the Sio Silica Hydrogeology and Geochemistry Assessment Report give concentration of about 0.09 mg/L for barium. The maximum allowable concentration of barium in drinking water from table 4-7 is 1.0 mg/L

The concentration of heavy metals of concern, are relatively low in the sandstone but can accumulate in slurry line water upon leaching by acid in the water.

The acid base accounting for the sandstone samples from Table 4-4 is summarized below

Sample ID	Total S wt%	CaCO3 equivalent tCaCO3/kt sand	Acid generation potential tCaCO3/kt sand	Mod. ABA Neutralization Potential tCaCO3/kt	Neutralization Potential ratio
Bru 95-3	0.02	7.5	0.6	6	10.0
Bru 121-1	0.01	7.5	0.3	3	10.0
Bru 146	<0.01	4.17	<0.3	4	>13.3
OLS	0.02	0	0.6	0	-

All samples from the sandstone were exposed to air. The Bru 95-3 samples were taken from a stockpile that experienced weathering from Jun 2019 until sampling in Nov. 2020. The borehole results obtained from Manitoba Mines show that Bru 146 completed in November of 2018 did not penetrate to the sandstone. The storage location, sampling methods, chain of custody after extraction, sample protection methods are not documented for Bru 121-1 and Bru 146 samples. The results are likely to be an underestimate of both heavy metal and sulphide content due to exposure to air and moisture. Even though the sand samples were compromised, two samples Bru 95-3 and Bru 121-1 showed sulphide content. Bru 146 results are unacceptable since the borehole did not penetrate to the sandstone as shown in figure 1.

Drilling commenced on the 21st of November 2018. A DR-24 rig was used to drill 8" casing

Hole ID	From (ft)	To (ft)	Lithology	Date Drilled
Bru 146-1	0	114	Quaternary	21-Nov-18
	114	160	Limestone	23-Nov-18
	160	165	Shale	

TABLE 1: BRU 146-1 LOGGED SECTION

Figure 1. Borehole record for Bru 146 obtained from the online borehole data base of Manitoba Mines
https://web33.gov.mb.ca/imaqs/page/viewer/assessmentSearchForm.jsf?%20keepSyncToken=keepSyncToken&ts=1648670380265

The XRD results showed no $CaCO_3$ for Bru 121-1 and 0.9 wt% siderite $FeCO_3$. Siderite is not neutralizing for acid production. The modified ABA results take into account the non acid generating carbonate such as siderite however for Bru 121-1 the neutralization potential was reduced only from 7.5 to 3 $tCaCO_3/kt$. Considering no calcite was in the Bru 121-1 sample, only non neutralizing siderite, the neutralization potential should have been zero.

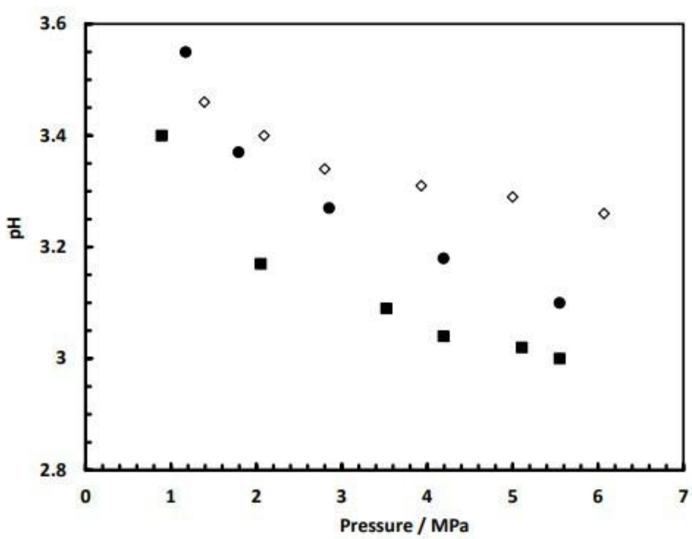
The calcite in the Bru 95-3 sample could be from contamination. Tire tracks from all terrain vehicles were visible on the stockpiles from which the Bru 95-3 samples were taken. The stockpiles were moved during road building operations. The Bru 121-1 and Bru 95-3 results showed enough $CaCO_3$ to neutralize acid formation however as shown below neutralization of sulphuric acid by calcium carbonate produces carbon dioxide. Note that the results of the sulphide content in the sand from OLS and Sio Silica agree. The CO_2 in a closed system such as the slurry line would dissolve and some would form carbonic acid. Thus acid formation in the slurry line cannot be avoided.

The reactions of FeS_2 (pyrite or marcasite) and H_2SO_4 (sulphuric acid) with $CaCO_3$ (calcium carbonate) are;[1]

$4FeS_2 + 15O_2 + 8CaCO_3 \rightarrow 2Fe_2O_3 + 8CaSO_4 + 8CO_2$

$CaCO_3 + H_2SO_4 \rightarrow CaSO_4 + H_2O + CO_2$.

Thus the above reactions generate CO_2 which would dissolve and form acid in the slurry line. Figure 2 shows the pH of water in equilibrium with dissolved CO_2.



. pH of CO_2 saturated solutions as a function of pressure in the CO_2-H_2O-NaCl system. Filled symbols represent experimental data measured in this work using spectroscopic technique ($m = 2\ mol\cdot kg^{-1}$): T = 293.15K (■) and T = 323.15 K (●). Empty symbols represent the data measured using the electrometric technique by Schaef et al. (2003), ($m = 2.11\ mol\cdot kg^{-1}$): T = 295.15 K (◇).

Figure 2. pH of carbonic acid in water from CO2 dissolved to saturation[2]

Note that according to the geochemical results at full production 0.6 tCaCO3/kt x 1.36 x10^3 kt sand would use 816 tonnes of CaCO3 to neutralize the sulphide in the sand and produce 326.4 tonnes of CO2 per year upon complete reaction. The accumulation of CO2 in the slurry line would depend on the reaction rate, the transit time of the sand in the line and the amount of CO2 that could vent in the clarifier tank and sand removal operations.

The pressure in the slurry line is unknown. However from the figure 2 even at atmospheric pressure CO2 dissolved to saturation can form a strong acid.

The slurry line water would become acidic even with neutralization by CaCO3 depending on the amount of CO2 that would vent in the slurry line operation. The acid is known to leach the heavy metals in the extracted sand that would accumulate in the slurry line. The heavy metals would not only be formed the sand in the slurry line but also from shale, oolite and concretion fragments of similar size to the sand that would not have been screened out. H2SO4 may also form depending on the amount of CaCO3 available for neutralization.

H2SO4 would not vent and accumulate in the line. In the slurry loop either sulphuric acid or carbonic acid or both will form from the sulphide and carbonate in the sand.

The accident and malfunction section of the EAP states;

"Slurry and water return line will be inspected on a daily basis, and after extreme weather events, to check for leaks and/or breaks in the line. If leaks or breaks in the line are detected, appropriate spill containment and clean-up measures will be applied as soon as feasible and the line will be repaired or replaced"

The brief of Oct. 20, 2020 supporting the motions submitted by DLN and WTFMB documents the accumulation of selenium and acrylamide to above allowed limits in the slurry line. The illustration of the results is repeated in figure 3 and figure 4.

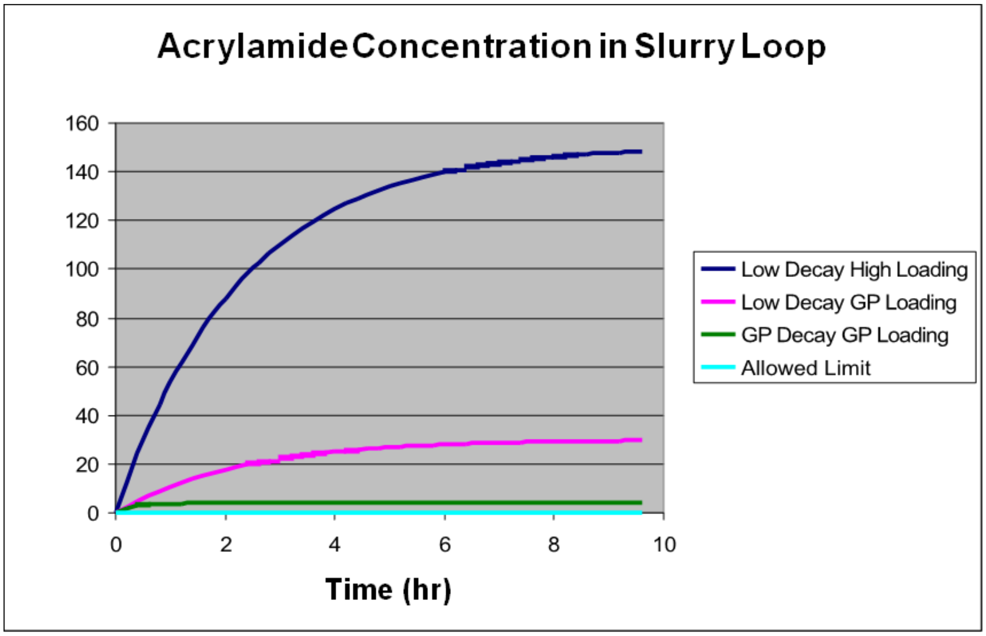


Figure 3. Acrylamide accumulation in Sio Silica Slurry loop. *The illustration was produced by D.M. LeNeveu from model results documented in the DLN WTFM motion brief.*

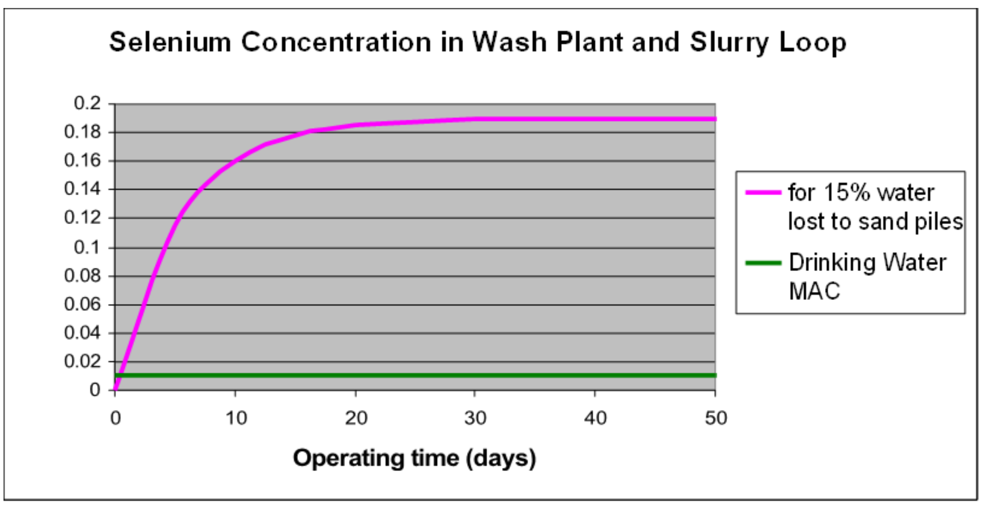


Figure 4. Selenium accumulation in Sio Silica Slurry loop. *The illustration was produced by D.M. LeNeveu from model results documented in the DLN WTFM motion brief.*

The EAP does not consider slurry line contamination from heavy metals, acid selenium, and acrylamide and the effects of spills or slurry line malfunctions on the environment. Selenium does not require acid for release only oxidizing conditions that would occur in the sandstone aquifer from the re-injected water and air injection operations. The selenium release from all formations was demonstrated in the geochemical shake flask tests of the Hydrogeological Report.

The EAP gives no detail on the interconnection of the slurry line loop with the water to be re-injected into the aquifer. There is no discussion about a malfunction of this connection such that contaminated water from the slurry line could enter the water for re-injection and thereby add to aquifer contamination by Si Silica operations.

Request:

a) Give detailed information on the connection between the slurry line and the water re-injection system. Evaluate the potential for malfunction of this connection leading to toxins accumulated in the slurry line entering the water to be re-injected into the aquifer. Give mitigation measures to minimize such malfunctions.

b) Since it has been established that toxins and acid can accumulate in the slurry line loop give a schedule for the measurement of the toxins and pH in the slurry line. Give a description of the means to remove the toxins and acid from the slurry line when they increase beyond acceptable levels. Give a description of the waste management measures required for the removed toxins. Specify the method and location of disposal together with a determination of the amount of such waste generated.

c) Describe methods to mitigate against leaks and breakage of the slurry line including use of automated pressure sensors and shut off valves, and installation of double walled slurry pipes with leak detectors in the outer wall.

d) Determine and report the amount of routine spillage that would occur in moving and emptying of the feeder slurry lines as new wells are drilled and during end of the year voidance of the lines.

e) Describe in detail slurry line spill clean up methods.

f) Describe methods to prevent toxic slurry line spillage into the municipal drain systems from reaching fish bearing water courses such as the Brokenhead River and Cook's Creek.

g) Document consultations and established permission with the City of Winnipeg regarding the eventual required slurry line crossing of the Winnipeg Aqueduct.

h) Describe methods to ensure that spillage of toxins and acid from the slurry line do not enter the Winnipeg aqueduct. Include assessment of subsidence malfunction near the aqueduct that could lead to pathways of toxins to enter the aqueduct.

i) Describe the measures used to inspect and determine damage to pumps and other slurry line equipment from acid build up in the slurry line. Describe the required shut down time, Project cost and maintenance required to fix such damage.

j) The extraction EAP states 10 US gallons of process water per minute per cluster will be routed to the closed loop slurry line. At a maximum of 7 clusters operating simultaneously as specified in the EAP, the maximum rate of water entering the slurry line would be 4200 US gallons or 15.9 cubic meters per hour. The EAP states the stockpiles at the processing facility would contain 15% water. For 1.36 million tonnes of sand per year using a sand density of 1.65 t/m^3, and the yearly operating time of 224 days given in Appendix H of the extraction EAP, the rate of water loss to the stockpiles would be 23 cubic meters per hour. For water balance in the slurry line the water lost to the stockpiles must on average equal the water entering the line at the extraction site. According to the data given by the Sio Silica EAPs the rate of water entering the slurry loop and the water leaving to the stock piles do not match. Explain and resolve this discrepancy. The amount of water entering/leaving the slurry line is necessary to model the concentration of accumulated toxins in the slurry line as described in the brief supporting the DLN and WTFMB motions and in the Great Plains Silica Sand Processing Plant memorandum. [3]

k) Model the concentration of acrylamide and selenium accumulation in the slurry line as per the methods described in the Great Plains Silica Sand Processing Plant memorandum[3] and the brief supporting the DLN and WTFMB motions or by any other appropriate methods. By these methods or other methods considering the amount of CO2 and SO2 released to the slurry line from the dissolution of sulphide in the sand, and in concretions, oolite and shale fragments in the slurry line, model the acid concentration, pH, and heavy metal accumulation in the slurry line.

l) Appendix H gives a production schedule and water re-injection rate for the well clusters. Only one well name per line is given in the schedule however 7 wells per cluster are specified. The average well pumping rate of solids plus water is given as an average of 540 US gallons per minute (2.044 cubic meters per minute) for 224 operating days, 24 hours per day, 7 days per week at ~50% water. This production rate and operating time for a well using a density of sand of 1.65 t/m^3 gives 0.544 million tonnes of sand per year. Assuming the rate of 540 gpm (270 gpm sand) applies to one well, to achieve the production target of 1.36 million tonnes per year, on average 2.5 wells would operate simultaneously. This small simultaneous number would exacerbate the discrepancy between the amount of water entering the slurry line and leaving to the sand stockpiles. The revised cluster design specifies 5 wells per cluster rather than 7. To achieve the production target of 1.36 million tonnes of sand per year give a revised well pumping schedule pertaining to 5 wells per cluster. Specify the number of wells and clusters operating simultaneously as a function of time. Resolve any discrepancy between the amount of water entering the slurry line at 10 US gallons per minute per cluster and leaving to the sand stockpiles at 15% water in the sand. Document the measurement and tests used to determine the 10 US gallons per minute of water per cluster entering the slurry line loop.

m) Section 7.4 Prediction Confidence and Uncertainty states; *"the ability to re-inject the majority of groundwater into extraction wells has not been tested for full scale operations, and pumping rates and reinjection efficiency may vary over time."* Include measured data on the variation over pumping time of the water to sand ratio on the extracted water. Use this data to determine the time average water content of the sand/water extraction rather than the unsupported value of 50% water of Appendix H. Include in the revised well pumping schedule the time average rate of water and sand withdrawn per well and total amount of water in one production year transported to the slurry line to the sand stockpiles. Rationalize with respect to water balance the amount of water transported to the slurry line with the amount of water withdrawn from the slurry line as entrainment in the sand stockpiles. Specify the total amount of water that would be re-injected into the aquifer in one full production year.

n) A French drain type system is described in a notice of alteration for the Vivian Sand Facility Project February 16, 2021.[4] Run off from the sand stockpiles is specified to be collected by the French drain system and discharged into the slurry loop. The public comments on the Notice of Alteration for the French drain documents that a large precipitation event will overwhelm the slurry loop capacity.[4] To accept the extra water the slurry line flow rate must increase well beyond design limits. The detention time in the clarifier would decrease to an inoperable level. Document design features and calculations and measures required for the slurry line loop to accept short duration large inputs to the line from French drain discharge following a large precipitation event.

o) If spillage of the run off water is required or could result from a malfunction specify the magnitude of the discharge of slurry line water and sand to the environment that could result.

p) Specify what measures would be taken to prevent a large spillage from the French drain during large precipitation event and spring run-off.

q) Quantify the amount of run off that could maximally be collected by the French drain system.

r) Give data on event duration and total collected run off for various scenarios based on historical data and taking into account the effect of climate change for future predictions.

References:

1. Chemical Aid, tools, equation balancer https://en.intl.chemicalaid.com/tools/equationbalancer.php?%20equation=FeS2+%2B+O2+%2B+CaCO3+%3D+Fe2O3+%2B+CaSO4+%2B+CO2

2. pH of CO2 saturated water and CO2 saturated brines: Experimental measurements and modelling, Haghi, RK, Chapoy, A, Peirera, LMC, Yang, J & Tohidi, B 2017, , International Journal of Greenhouse Gas Control, vol. 66, pp. 190-203. https://doi.org/10.1016/j.ijggc.2017.10.001

https://pure.hw.ac.uk/ws/portalfiles/portal/16060209/pH_of_CO2_saturated_water_and_CO2_saturated__brines.pdf

3. Technical Memorandum, Great Plains Sand, T.Holstrom, March 9,2012 https://www.scottcountymn.gov/DocumentCenter/View/880/Exhibit-M-PDF?bidId

4. Environment, Climate and Parks,Public Registry 6057.00,Vivian Sand Processing Facility Sio Silica Corporation (formerly CanWhite Sands) https://www.gov.mb.ca/sd/eal/registries/6057canwhite/index.html

Response:

a) The slurry loop and the extraction, dewatering and UV system are completely independent of each other.

b) Sio disagrees with the factual statements in the request and the premise of the question. As a result, Sio declines to respond.

c) The outline of the slurry line leak detector is found in Key Issue / Question # 93 in Sio's Responses to the Public, which states:

"Project operations will not involve the use of, or discharge to, any surface waterbody of any kind. Therefore, there will be no overland flooding due to effluent discharge or potential for discharge to waterways /waterbodies.

As indicated in the EAP, Section 4.3.1 (Surface Water and Drainage), there are no natural lakes, rivers, or streams within the Project Site and therefore no potential for fish habitat.

Section 6.9.2 of the EAP (Spills and Leaks) describes the standard procedures that will be implemented to prevent spills and leaks from occurring during Project activities. The slurry line connecting the extraction sites with the Processing Facility will only contain a sand/water slurry and a residual amount of a non-toxic biodegradable flocculant (from recycled water as described in the Facility project EAP). The quality of the water within the slurry line will be of similar quality to the groundwater removed form the aquifer during extraction, as no toxic chemicals or other harmful contaminants are introduced into the slurry line during the extraction process. Therefore, there is no risk of toxic chemical or heavy metal contamination associated with the accidental release of water to a surface water body from the slurry line.

The slurry line will be inspected on a daily basis, and after extreme weather events, to check for leaks and/or breaks in the line. Additionally, an automated pressure transducer for leak detection will be installed along the slurry line. If any leaks or breaks in the line that require repair are detected, flow to the line will be shut down, and appropriate spill *containment and clean-up measures will be applied, and the line will be repaired or replaced. Segmentation of the line will allow for each section to be isolated so repairs can be done easily and quickly.*

As indicated in Section 8.5, an Erosion and Sediment Control Plan will also be implemented for the Project to mitigate sediment introduction to low-lying areas such as ditches. Additional mitigation measures to avoid or minimize potential effects on surface water quality, such as establishing drainage ditches and required to direct runoff from rain and snow are described in the EAP, Section 6.4.1 (Surface Water).

An Environmental Emergency Response Plan (EERP) will outline the general procedures to be followed for environmental emergency situations and incidents (e.g. leak or spill) that could occur as a result of Project activities, equipment failure, human error, or natural causes. A copy of the ERPP will be maintained on-site during all phases of the Project."

d) A vacuum truck will be utilized to clear lines during movement. As a result, there will be no "routine spillage".

e) Should a spill occur, the sand would need to be cleaned up with a vacuum truck, however the water does not contain any harmful chemicals. Soil conditions would be assessed to confirm no impacts.

f) Sio disagrees with the factual statements in the request and the premise of the question. There are no "toxic slurry lines". See the response to DLN-IR-003(c).

g) This is outside the scope of the Environment Act Proposal, and, as such, Sio declines to respond.

h) Sio disagrees with the factual statements in the request and the premise of the question. See the response to DLN-IR-003(c).

i) Sio disagrees with the factual statements in the request and the premise of the question. There will be no "acid build up" in the slurry line. As a result, Sio declines to respond.

j) Sio disagrees with the factual statements in the request and the premise of the question. There will not be "accumulated toxins" in the slurry line. As a result, Sio declines to respond.

k) Sio disagrees with the factual statements in the request and the premise of the question. There will not be accumulations of acrylamide and selenium in the slurry line. As a result, Sio declines to respond.

l) At the time of field testing, Sio saw production rates with sand (solids) as high as 90% sand concentration. 10 US gpm was an estimated value based on field monitoring results. This number may fluctuate, and this variance is accounted for in the modelled a 0% re-injection scenario.

As stated in the EAP Section 2.2.4 Sand Slurry Conveyance to Processing Facility, the 15% moisture content in the slurry line is a value that was selected to allow for operational changes in flow (i.e. starting and stopping the slurry line).

With the issuance of new Geotechnical recommendations as seen in the responses to public comments for the EAP in attachment A, a revised extraction plan will be filed with the Approvals Branch and the CEC prior to the hearing as a project update letter to address updated information.

m) As a point of clarification, 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.

With the issuance of new Geotechnical recommendations as seen in the responses to public comments for the EAP in attachment A, a revised extraction plan will be filed with the Approvals Branch and the CEC prior to the hearing as a project update letter to address updated information.

n) The French drain system is not part of the Extraction Project - Environment Act Proposal and is therefore outside the scope of the CEC process. Sio notes, however, that the French drain system will not drain into the slurry loop, contrary to the premise in the question.

o) See the response to DLN-IR-003(n).

p) See the response to DLN-IR-003(n).

q) See the response to DLN-IR-003(n).

r) See the response to DLN-IR-003(n).

IR Number: **DLN-IR-004**

Submitted by: DLN

Date Submitted: November 23, 2022

Subject Matter: Design specifications and drawings

Reference Documents:

(i) 2.1 Components and Activities

(ii) Figure 2-1: Sand Extraction Circuit Process Figure 2-4: UV Water Treatment

(iii) 2.4.3 Dewatering and Pumping Stations

(iv) Figure 2-5: General layout of Mobile Slurry and Water Lines and Temporary Access Trails

(v) 2.4 Ancillary Components

Preamble: N/A

Request: Please provide detailed engineering specifications, drawings measurements and data including volumes of all the vessels and tanks, pumps, hydrocyclones, etc. for;

a) the wash plant,

b) dewatering plant,

c) connection of the wash plant and dewatering plant to the recycling slurry loop,

d) French drain system at the processing plant and connection to recycle slurry loop,

e) Drainage system to collect runoff from sand stockpiles at the extraction site,

f) leak detection systems for the slurry loop,

g) CN approved specifications for the CWS/SS railway loop,

h) processes for removal of accumulated dissolved contaminants in the recycle slurry loop,

i) solid waste management facilities,

j) waste storage buildings,

k) the over winter slurry loop water storage tank including insulation and heating, and

l) the UV radiation system and UV filtration system including hydrocyclones, grit removal system, clarifier tanks, filters, the sand bed drainage facility and subterranean water collection for the UV radiation system.

Response: As a point of clarification, 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.

Further, as Sio's detailed designs are still being finalized, Sio declines to release any additional details of its designs at this time. Many of the technical components of the extraction proposal are being negotiated with arm's length third parties and disclosure of additional information could prejudice Sio's negotiations with these parties. Sio also maintains that details of technical components that have not yet been finalized are not relevant to the CEC's review of the extraction proposal, and Sio has already filed sufficient information to allow the CEC and participants to fully review the merits and possible environmental impacts of the project.

a) In addition to the above, this component is outside the scope of this Environment Act Proposal and the CEC process.

b) In addition to the above, this component is outside the scope of this Environment Act Proposal and the CEC process.

c) In addition to the above, this component is outside the scope of this Environment Act Proposal and the CEC process.

d) In addition to the above, this component is outside the scope of this Environment Act Proposal and the CEC process.

e) The extraction proposal does not include stockpiles at the extraction site.

f) In addition to the above, please refer to response DLN IR-003(c).

g) In addition to the above, this component is outside the scope of this Environment Act Proposal and the CEC process.

h) In addition to the above, see the response to DLN-IR-003.

i) In addition to the above, this component is outside the scope of this Environment Act Proposal and the CEC process.

As stated in the response to CEC-IR-008(a):

"*When overs are captured, they will be stored in covered, open to atmosphere tankage. The coverage reduces rainwater collection in the tankage. These overs will be taken to a licensed landfill facility for disposal or used in reclamation activities as they are not considered harmful.*

In addition, fines, which are estimated at about 1.9% of total extracted material, will be collected at the extraction site and pressed into a filter cake similarly to the fines captured at the Facility. The filter cake fines are damp. Fines will be stored in enclosed tankage before they are taken away from the Project site. The fines are largely kaolinite clay material and are therefore a salable material to industries such as paper, porcelain, paint, cement filler, cosmetics, medical and others. Sio plans to sell these fines to markets as listed, otherwise they will be disposed of at a licensed landfill."

j) In addition to the above, this component is outside the scope of this Environment Act Proposal and the CEC process.

k) In addition to the above, this component is outside the scope of this Environment Act Proposal and the CEC process.

l) As a point of clarification, a UV filtration system has never been proposed by Sio. A UV disinfection system is proposed to follow the filtration as a precaution. Other equipment listed in this question is based on speculation of the author as Sio has not finalized the filtration and UV system design.

As stated in the Reponses to the Technical Expert Reports – Geotechnical, filed November 29, 2022, issue 7:

"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/cm^2 is typical for wastewater 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."

IR Number: **DLN-IR-005**

Submitted by: DLN

Date Submitted: November 23, 2022

Subject Matter: Waste management information for exploration activities

Reference Documents:

(i) 2.2.3 Sand Slurry Pre-Screening and Overs/Fines Temporary Stockpiling

(ii) 2.3 Waste Management.

(iii) 8.1 Waste Characterization and Management Plan

Preamble: N/A

Request:

a) Please provide information on the volume, density and mass of overs/fines and other wastes such as sediments and concretions separated from the sand during all sand extraction operations conducted by Sio Silica prior to the hearings.

b) Specify the method of separation, the dates of separation, and destination of the waste products.

c) Specify the ratio of the volume of the waste products per tonne of extracted sand including concretions, overs, fines and drill cuttings for all advanced exploration activities completed to date.

d) Give a detailed description and drawing of all waste separation methods employed, tested and evaluated such as screening, hydrocyclones, filtration, settling tanks, and gravity separation.

e) Specify the waste separation methods selected for production activities together with detailed drawings.

f) Provide all information on geochemical and waste characterization tests completed on all wastes to date.

Response:

a) As stated in the response to CEC-IR-008(a):

> "*Sio has identified very limited amounts of overs in the sieve analysis work that has been conducted for the Project. Overs are any size fraction greater than 20 mesh (841µm) such as larger hard compacted sand material (concretions) or other small rocks (that are sometimes leftover from the drilling process).*
>
> *Sio is unclear where the 5% referenced in the request came from. In Key Issue / Question # 190 in Sio's Responses to the Public it states: "Mine waste (e.g., overs) is estimated to range from 0.1% to 0.8% of the extracted material."*

When overs are captured, they will be stored in covered, open to atmosphere tankage. The coverage reduces rainwater collection in the tankage. These overs will be taken to a licensed landfill facility for disposal or used in reclamation activities as they are not considered harmful.

In addition, fines, which are estimated at about 1.9% of total extracted material, will be collected at the extraction site and pressed into a filter cake similarly to the fines captured at the Facility. The filter cake fines are damp. Fines will be stored in enclosed tankage before they are taken away from the Project site. The fines are largely kaolinite clay material and are therefore a salable material to industries such as paper, porcelain, paint, cement filler, cosmetics, medical and others. Sio plans to sell these fines to markets as listed, otherwise they will be disposed of at a licensed landfill."

b) Please refer to the description of the pre-screen and sand slurry systems in in the EAP filing in Section 2.2.3 and Section 2.2.4. Also refer to the response to DLN-IR-005(a).

c) Please refer to the response to DLN-IR-005(a). Drill cuttings were not measured during test wells as this is not a requirement of regular water well drilling activities. Sio has proposed to capture these cuttings upon approval of an EAL as is outlined in Section 2.3.2 and 2.3.3 of the Extraction EAP. Samples were taken as a part of the hydrogeology and geochemistry study and analysis of results can be found in Section 4.1.5 of the Hydrogeology and Geochemistry Assessment Report. It is important to note that regular everyday water well drilling practice has not captured drill cuttings in the 100+ years that water wells have been drilled in Manitoba, unless they are being used as native material for well sealing/abandonment activities.

d) As a point of clarification, 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. Further, see the response to DLN-IR-004. For these reasons, Sio declines to provide the requested information.

e) As a point of clarification, 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. Further, see the response to DLN-IR-004. For these reasons, Sio declines to provide the requested information.

f) Refer to the response to DLN-IR-005(c).

IR Number: **DLN-IR-006**

Submitted by: DLN

Date Submitted: November 23, 2022

Subject Matter: High Purity Sand

Reference Documents: Executive Summary

(i) 1.1 Project Overview

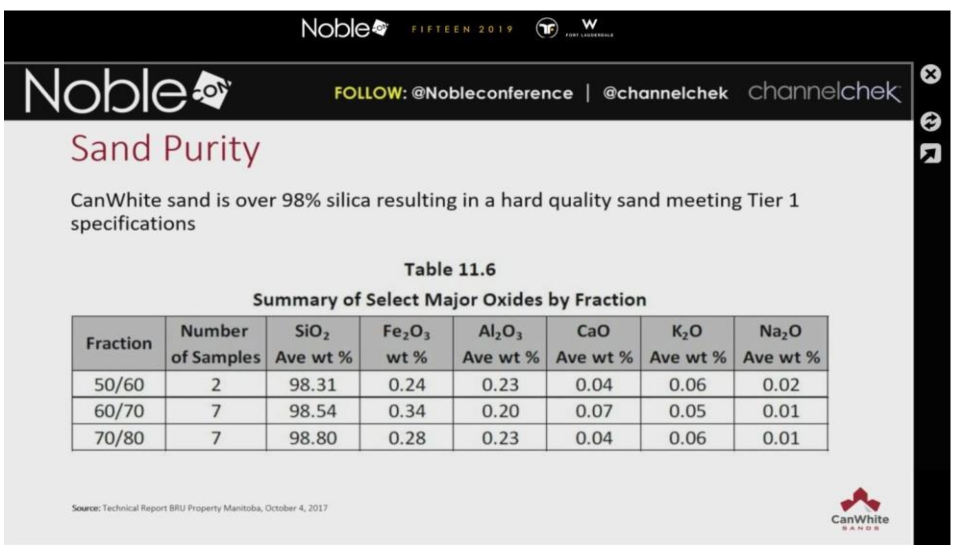
(ii) 1.3 Company Profile

Preamble: Section 1.3 of the extraction EAP states

"The purity of the sand resource, averaging 99.85%, is within international standards for high purity silica use. This positions southeastern Manitoba as a viable supplier of high purity silica sand utilized in green and renewable energy businesses as well as electronics, specialty/medical glass, and other industries supplied by high purity silica."

The EAP contains no geochemical tests or laboratory data on the characterization of the sand with respect to purity.

Below is a slide from Noble Con investment convention Florida 2019 - "Source: Technical Report BRU Property Manitoba October 4, 2017.



Fraction	Number of Samples	SiO_2 Ave wt %	Fe_2O_3 wt %	Al_2O_3 Ave wt %	CaO Ave wt %	K_2O Ave wt %	Na_2O Ave wt %
50/60	2	98.31	0.24	0.23	0.04	0.06	0.02
60/70	7	98.54	0.34	0.20	0.07	0.05	0.01
70/80	7	98.80	0.28	0.23	0.04	0.06	0.01

Figure 1. Vivian sand purity from Noble Investment Convention Florida 2019

The purity values for the Vivian sand given at the Noble conference are lower than the Sio Silica stated value of 99.85% for high purity use.

Request:

a) Give the references and literature that establishes 99.85% as the international standard for high purity silica sand.

b) Provide the laboratory data for the sand characterization that establishes and characterizes the purity of Vivian silica sand.

c) State the Sio Silica purity targets in the terms of maximum allowed weight percent of iron, aluminum, calcium oxide, feldspar and other impurities.

d) Provide detailed information of the methods that will be used to achieve high purity for the Vivian sand such as screening, bumping tables, magnetic separation and acid wash. Provide a description and data on the volume, handling, and destination of wastes including acid wastes that would be produced from the purification procedures per tonne of sand produced.

e) Document all tests that have been done to date to achieve the required purity.

f) Provide the 2017 Technical Report on the sand presented to investors at the Noble conference.

g) Explain why the test results given at the Noble conference are of lower purity than the stated average purity of 99.85% in the EAP.

h) Since the only available evidence shown in figure 1, establishes that the Vivian sand is below international standards for high purity sand, explain why and how the Vivian sand can be used for high purity applications.

i) Identify and name all the markets that Sio Silica has established for the Vivian high purity sand including details such as customer company names and locations.

j) Identify all current suppliers of the high purity sand market in North America including location, company name and source of the silica. Differentiate the current sources of high purity silica distinguishing between silica sand and hard crystalline quartzite type silica deposits.

Response:

a) Although this is not applicable to the Extraction EAP, the standard for high purity silica is application specific, as it differs depending on the market. Sio's sand meets the specific market requirements of our target industries and purity as defined and requested by clients. In addition, Sio notes that the Manitoba Geologic Survey states that the Winnipeg Formation is a high purity silica sand deposit multiple times dating back to 1985 (Watson, 1985).

Examples of this include:

1. Waston, D.M., 1985, Silica in Manitoba, Manitoba Energy and Mines, Geological Services, Economic Geology Report ER84-2, 35pAccessed at: https://www.manitoba.ca/iem/info/libmin/ER84-2.pdf

2. Lapenskie, K, 2017, Update on Investigations of Industrial Commodities: Gypsum and High Purity Silica Sand. Manitoba Growth, Enterprise and Trade, Manitoba Geological Survey. Accessed at: https://www.manitoba.ca/iem/geo/techposters/2017/t15.pdf

3. Industrial Minerals – Commodity Summaries: silica Sand. Manitoba Natural Resources and Northern Development. Accessed at: https://www.manitoba.ca/iem/geo/industrial/silica.html

b) Sio considers this to be outside the scope of this Environment Act Proposal and the CEC process, however, Sio has provided 3 sample results in **Appendix A.** These samples are representative of the 24 year mine life area.

c) Although this is not applicable to the Extraction EAP, Sio Silica's purity target is >99.85% SiO_2. Other impurity targets are industry specific and specified by individual clients, which is confidential.

d) This is outside the scope of this Environment Act Proposal and the CEC process. As a result, Sio declines to respond.

e) This is not applicable to the Extraction EAP. This is also confidential information. As a result, Sio declines to respond.

f) This is not applicable to the Extraction EAP. As a result, Sio declines to provide this report. In addition, Sio notes that the 2017 report and results were targeted at a different industry than Sio is targeting now. At the time of this conference, Sio had not yet discovered that the silica was pure enough for the high purity industry. As has been clarified many times, Sio is no longer focused on the energy industry as a market for its silica sand as was the case in 2017.

g) This is not applicable to the Extraction EAP. Also see the response to DLN-IR-006(f).

h) See the response to DLN-IR-006(a). In addition, it should be noted that purity of silica sand can be increased by very simple methods such as water washing and application of the correct laboratory testing for purity.

i) This is not applicable to the Extraction EAP and is highly confidential. As a result, Sio declines to provide the specific information requested. However, Sio has successfully undergone and passed testing with several consumers of high purity silica around the globe. Those consumers utilize high purity silica for markets such as silicon metal, silicon carbide, photovoltaic glass, medical glass, smart glass, semiconductors, coatings, ceramics and others.

j) This is not applicable to the Extraction EAP, however, the two main suppliers of high purity silica sand in North America are US Silica and Covia. The two main suppliers of high purity quartz in North America are Sibelco and Quartz Corp.

IR Number: **DLN-IR-007**

Submitted by: DLN

Date Submitted: November 23, 2022

Subject Matter: Process Water Treatment Options

Reference Documents:

(i) 2.1 Components and Activities

(ii) Figure 2-4: UV Water Treatment Process Wastewater Treatment Options Technical Memorandum Sio Silica Corp. June 2022

Preamble: On June 29, 2022, Sio Silica submitted to the CEC a technical memorandum on the Process Water Treatment Options. The covering letter for the submission states;

"*At this time, a final design has not been completed. Prior to any operations, the final design and outputs will be provided for review and approval to the Environmental Assessment and Licensing Branch.*"

To date the final design and outputs has not been provided by Sio Silica. The Process Water Treatment Options technical memorandum states;

"*The raw process wastewater is expected to have a solids concentration of 18,500 mg TSS/L, which will then be reduced to approximately 10,000 mg/L and directed for treatment. This is a relatively high concentration. The flow is expected to range from 1,100 m^3/d to a peak of approximately 6,000 m^3/d.*"

Appendix H of the Hydrogeological report gives the average water to sand extraction ratio as 50% and the extraction time at full production of 1.36 million tones of dry sand as 224 days. The average water flow rate assuming a dry density of sand of 1.65 t/m^3 would be 1.36×10^6 t/1.65t/m^3/224d = 3,679 m^3/d which is within the range of 1,100 m^3/d to 6,000 m^3/d given in the technical memorandum. The concentration of solids for treatment of 10,000 mg/L is equivalent to 10 kg/m^3. Using a water flow rate of 3,679 m^3/d, the solids to be removed before UV treatment would be an expected maximum 10kg/m^3 x 3679 m^3/d = 36,790 kg/d. For 224 extraction days 8,241 tonnes of solid sludge per year would be required to be removed prior to UV filtration.

The removed solids are to be spread on drying beds as is conventionally done to dry municipal wastewater sludge as illustrated below.[1]

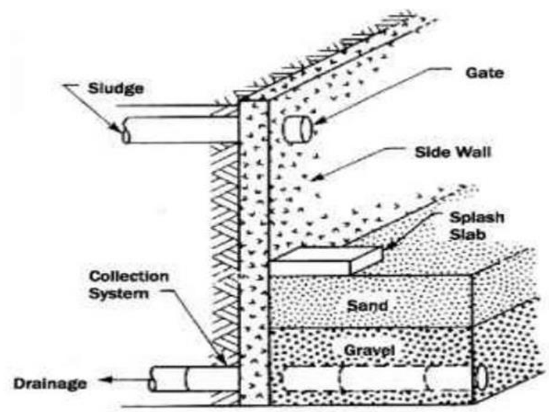


Figure 1. Cross section of a sand drying bed.[1]

Presumably the drying bed area will be reused several times per year. The total mass of solids spread on the drying bed for each drying cycle can be determined from the total mass of solids per year divided by the number of drying cycles per year. The number of drying cycles can be determined from the total number of drying days per year divided by the average recycling time for the drying bed. The average recycling time would include the bed drying time, the spreading time and the solid sludge removal time. If two beds of the same size are used one bed can be prepared during the drying time of 3 to 4 days given in the technical memorandum. The process water treatment options memorandum states;

"Draining time is typically 3 to 4 days. Applied sludge depth should be 200 mm to 750 mm for coagulant sludges."

Using a recycling time of 4 days for one of the beds, 56 cycling periods would be required in 224 days of sand extraction. The mass of solids per bed would be 8241t/56=147.2 tonnes. The actual total mass of solids could be larger than 8241 tonnes depending on the amount of water extracted with the sand for which CWS/SS has not provided measured data. The number of drying bed cycles would be considerably less that 56 due to rainfall. Using the solid loading rate of 2.4kg/m2 from the technical memorandum, the area of each bed would be 147200kg/2.4kg/m2 = 61,333 m^2 or 6.1 hectares. For two beds the area would be 12.2 hectares.

The drying beds are typically constructed with impermeable sides and bottom with layer of gravel containing drainage pipes with a layer of sand about 0.3 meters thick on top.[2] The mass of dry sand required for one drying bed at 1.65 t/m^3 density would be $61{,}333m^2$ x 0.3m x $1.65t/m^3$ = 30,360 tonnes. Some of this sand would be removed with the fine silica sand sludge on top. About 2.5 to 5 cm of sand would be removed along with the solids sludge when the bed is cleaned for the next drying cycle.[2] Using 3 cm of underlying sand removed for 56 drying cycles another $61{,}333m^2$ x 0.03m x $1.65t/m^3$ x 56 = 554,400 tonnes of sand would be required per year for a total of 170,015 tonnes of sand to be disposed of per year which is 12.5 % of the total amount of silica sand extracted per year. The size of the drying beds required according to the example calculation and the amount of sand disposed of and replenished for the drying beds per year is clearly unfeasible.

The example analysis performed here for drying bed size assumes optimal drying conditions. Periods of rain and lower evaporation rates in the cool weather of spring and fall would increase drying times, decrease available drying days and increase the required size of the drying beds and the amount of underlying sand disposed of. Measurements of the actual amount of water withdrawn with the sand have never been documented by Sio Silica. An increase of the average water content withdrawn with the sand over 50% would also increase the size of the beds and amount of underlying waste sand. The example calculations given here are an underestimate of the resources required for the drying beds. Clearly the drying bed requirements are unfeasible.

Request:

a) Please complete a comprehensive analysis to determine the optimal drying bed area, total volume of sand and gravel required for the beds, the cost to construct the beds, remove the solids and maintain the beds per year for the CWS full production of 1.36 tonnes of sand extracted per year.

b) Please include drawings and engineering specifications for the drying bed analysis.

c) Determine the total of the water retained in the solids and evaporated from the sand drying beds and the total amount of water lost from the sandstone aquifer per year from this process.

d) Specify where the drying beds will be located and the movement of the location for every new extraction year.

e) Specify the transportation requirements for movement of silica sand sludge to the drying beds and the sludge and underlying sand removal to the disposal location including number, size and frequency of trucks required, the routes and the traffic impact.

f) Specify the location and name of the disposal location for the waste drying bed material and the total amount of drying bed waste per year.

g) Commit to perform and report the results from geochemical anlysis of the waste material from the drying bed including acid base accounting results, heavy metal and selenium content, and content of chitosan monomer (glucosamine).

h) Specify the cost of rehabilitation and operation of the drying beds per year.

i) Commit to perform and report results from PM10 and PM2.5 airborne respirable silica dust monitoring at regular time and spatial intervals from the drying beds and to make the data publicly available.

j) Provide a complete air quality modelling of the drying bed operations. Document the source term for the modeling taking into account the silica sand sludge spread on the drying beds would contain a much higher concentration of respirable silica dust than raw sand. Ensure the modeling is for the worst case situation of dry silica sand on the bed at the end of the drying cycle. Ensure the modeling reports exposure of respirable silica dust to drying beds workers.

k) Through air quality modeling and direct measurement determine an exclusion zone for the public and habitation around the drying beds.

l) Perform and report results from personnel respirable silica dust monitors from all drying bed workers and personnel involved in the pilot testing of the sand extraction and UV filtration system.

m) Establish and report a comprehensive worker protection plan for silica dust exposure including personnel monitoring of silica dust, respirator protection program, protective clothing and change room area, and staffing of safety personnel and industrial safety hygienists.

n) Specify what will be done with rainwater collected from the drying beds. For example, a deluge of 10 cm of rain covering the at least 12 hectares of the drying beds would result in about 12,000 cubic meters of rain to be returned to the dewatering station if all were collected. The peak flow rate is given in the technical memorandum as 6000 m^3/d (250 m^3/h). If for instance the rainfall duration was one hour the rate of water collected from the drying beds sent back to the dewatering station would be 48 times the peak flow rate for the dewatering /UV filtration system. All the tanks in the dewatering station, the hydrocyclones, gravity clarifiers and other vessels would be near capacity during operation. Specify where the large amount of collected rain water would be stored and how it would be returned to the dewatering station.

o) Describe how a water collection system for the drying beds would be designed to collect the largest possible deluge without overflow of excess water to the environment.

p) Provide examples of where such a collection system for the drying beds has been demonstrated with no discharge or loss of drained water to the environment.

q) Based on rainfall records and projections of more and larger climate change driven rainfall events, determine the maximum amount of collected rain from the drying beds per year over the lifetime of the project and the fate of all this water.

r) Determine how much collected rain water and snow melt would be returned to the aquifer in the process wastewater system. Compare the total precipitation amount returned to the aquifer to the total amount of water withdrawn from the aquifer in all waste streams and in the 15% water in the sand stockpiles at the processing plant.

s) Include estimates rainfall, seasonal temperatures and climate change on the size and material required for the drying beds.

t) Schedule a trial sand extraction and pilot demonstration of the drying bed system and present all the relevant data and information to the regulators and the public.

u) Based on all the drying bed analysis information and the drying bed pilot tests determine the feasibility of drying beds for the filtration of the process water.

v) If the drying beds implementation for full production is not feasible specify alternative procedures for processing of the large amount of filtrate, predominately fine suspended silica sand, required to be removed in the UV filtration process.

w) Specify the total volume of all vessels in the dewatering station and sand filtration system for UV such as hydrocyclones, vortex grit removal, gravity settler, and feed water tank, frac tanks of the CESF package used to dewater and filter the solids for the drying beds.

x) Specify the detention time for a gravity settler and all other large tanks.

y) Explain what will be done with the water from all these vessels at the end of each production year.

z) Give comprehensive results of geochemical tests for all contaminants in the vessel water.

aa) The technical memorandum suggests an option for filtration would use a lamella clarifier however the memorandum states, "*According to the manufacturer fully treating the raw water without any chemicals is not possible. For aggregate type applications which this is similar, it could be normally possible to reduce the TSS concentration to around 100 mg/l with coagulation chemicals*." The coagulation chemicals are not specified however the technical memorandum states; *"This Technical Memorandum assumes that the expected treatment objectives include the removal of TSS and disinfection according to limits presented below. Additionally, chemicals aiding in the treatment process used commonly for coagulation and flocculation of solids are not allowed."* Thus coagulation chemicals for the lamella clarifier cannot be used. Please perform a test on the effectiveness of a CESF clarifier without coagulation chemicals and present the results to the hearings.

bb) Determine the quantity and disposal destination of all the filters described in the CESF package and the entire filtration system.

cc) Specify the disposal requirements and waste volume for the Chitosan, linear polysaccharide used in the CESF package.

dd) Specify the quantity of the linear polysaccharide Chitosan would degrade into soluble glucosamine monomers that would be in the water returned to the aquifer per year and the concentration in the water.

ee) Determine the potential for the soluble glucosamine monomers degraded from the Chitosan to promote bacterial and harmful microbial growth in the aquifer.

ff) Degradation of glucosamine monomers would be expected to generate ammonia and carbon dioxide and/ or methane. Identify the degradation products and their amounts that could form in the aquifer per year and specify the effect on water quality.

gg) Chitosan is soluble at below pH 6.3 that could result from oxidation of sulphide in the sand and shale fragments in the solids.[3] Measure the pH of process water and the concentration of dissolved chitosan in process water after the chitosan filtration.

hh) Provide all historical measured data on the pH and geochemical analysis of the process water that has been withdrawn with the extracted sand in all on Sio Silica's advanced exploration activities. Provide the name and location of the extraction wells and the amount, date and duration of sand and water extraction from the sandstone aquifer.

ii) Determine if UV light would degrade any residual or soluble Chitosan reaching the UV radiation system Identify the degradation products and their potential effect on water quality.

jj) Determine how residual dissolved Chitosan and Chitosan soluble glucosamine monomers affect the taste and water quality of re-injected water.

kk) Specify what will be done with the water in all the dewatering tank and filtration tank vessels at the end of the extraction year. Will the water be recycled through the water and solid removal process and UV radiation system and eventually returned to the aquifer? If so how long will this take?

ll) Will this end recycling process of vessel tank water shorten the sand extraction time requiring faster overall sand extraction rates?

mm) Specify what will be done with all the water in the storage tanks, pipes, and vessels of the dewatering station and the UV filtration system at the end of the extraction season. Will the water be stored over winter as is to be done for the vessel water in the processing plant? If so what is the required size of the overwinter water storage tank(s) at the extraction site? Will the storage tanks be moved every year as the location of extraction changes?

nn) Specify the cleaning and maintenance requirements for all the vessels and equipment for screening, water collection, dewatering and UV filtration systems at the end of the extraction year. Specify the nature and quantity of all the cleaning wastes, the geochemical waste characterization analysis methods and the location of the waste disposal sites.

oo) Note that the Wastewater Treatment Options technical memorandum states, "*Due to uncertainty in the settling ability of the solids and unique characteristic of the wastewater it is recommended to pilot some of the recommended treatment options in order to assess the efficiency of the equipment treating the process water before proceeding with final equipment selection. It is especially recommended to pilot trial test the hydrocyclones and mobile/lamella clarifiers.*" This demonstrates that the pilot trials must be done based on the expert advice. Give a schedule for the pilot test trials.

pp) Determine the contaminant content including all trace metals, residual Chitosan, dissolved sugars arsenic, selenium, pH, and results of acid base accounting in the pilot tests for the water from the UV system to be returned to the aquifer.

qq) Ensure the pilot test drainage beds be subject to at least one large rainfall and demonstrate the feasibility of the collection process from sand drying beds and the routing process for rain water.

rr) Provide to the CEC Hearing modeling of the discharge amount from the sand drying beds and transfer of the collected amount to the process water system for large rainfall events. Determine and provide the data for the rainfall events including the effect of climate change on the projected rainfall. Include detailed calculations use to determine the size of the drying beds.

ss) Once all studies on the wastewater treatment option are completed, post a notice of alteration on the project registry specifying the wastewater treatment and UV filtration process. Summit a modified EAP that includes an assessment of the environmental risks and mitigation plans and worker and public safety measures for the wastewater treatment and UV filtration process. Respond to TAC and public comments for the plan. Commit to issuing a major project alteration with the revised cluster design and yearly project footprint. Commit to delay in licensing and production until the completion of all activities specified here. Sio Silica and AECOM must act responsibly by implementing this delay unilaterally without being required to do so by the Provincial Approvals process.

References:

1. Climate Policy Watcher, The Main Advantages of Sludge Drying Beds, 14 Nov 2022, https://www.climate-policy-watcher.org/wastewater-sludge/drying-beds.html

2. Innovative Sludge Drying Bed Design, Case Study, GWLS GeoWeb, https://2y2qpw2op3o93ygu164frm9z-wpengine.netdna-ssl.com/wp-content/uploads/2016/10/GWLS- Geoweb-Sludge-Drying-Bed.pdf

3. Stability of Chitosan—A Challenge for Pharmaceutical and Biomedical Applications, Emilia Szymańska and Katarzyna Winnicka, Mar Drugs 2015 Apr; 13(4)

Response: This Information Request is based on an assumption made by the author that drying beds will be used for the extraction activities. Drying beds were listed as an example for sludge management in the Supplemental filing #4 – Process Wastewater Treatment Options, however Sio is also exploring other options such as a filter press which have a far smaller footprint.

The volumes of water used in the author's calculations are also assumptions. As has been previously stated, in DLN-IR-003 (l) and the Hydrogeology and Geochemistry Assessment Report - Section 2.4 Groundwater use During Extraction, sand/water ratios fluctuate. The sand water ratios can be as high as 90% sand, 10% water.

As it has been noted in other IR responses, 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 water and wastewater treatment specialists to determine appropriate equipment selection for management of process water waste material.

a) Sio declines to respond to this request as per the comments provided above.

b) Sio declines to respond to this request as per the comments provided above.

c) Sio declines to respond to this request as per the comments provided above.

d) Sio declines to respond to this request as per the comments provided above.

e) Sio declines to respond to this request as per the comments provided above.

f) Sio declines to respond to this request as per the comments provided above.

g) Sio Silica will commit to conducting geochemical analysis of the waste material output. The details of this will be defined in the Waste Characterization and Management Plan.

h) Sio declines to respond to this request as per the comments provided above.

i) Sio declines to respond to this request as per the comments provided above.

j) Sio declines to respond to this request as per the comments provided above.

k) Sio declines to respond to this request as per the comments provided above.

l) Sio declines to respond to this request as per the comments provided above.

m) Fines from the waste system will be stored in enclosed tankage before they are taken away from the Project site. Fines are damp when they enter the containment. The fines are largely kaolinite clay material and are therefore a salable material to industries such as paper, porcelain, paint, cement filler, cosmetics, medical and others. Sio plans to sell these fines to markets as listed, otherwise they will be disposed of at a licensed landfill.

n) Sio declines to respond to this request as per the comments provided above.

o) Sio declines to respond to this request as per the comments provided above.

p) Sio declines to respond to this request as per the comments provided above.

q) Sio declines to respond to this request as per the comments provided above.

r) Sio declines to respond to this request as per the comments provided above.

s) Sio declines to respond to this request as per the comments provided above.

t) Sio declines to respond to this request as per the comments provided above.

u) Sio declines to respond to this request as per the comments provided above.

v) As stated above, Sio is also exploring other options such as a filter press which have a far smaller footprint as an alternative to drying beds.

w) Sio declines to respond to this request as per the comments provided above.

x) Sio declines to respond to this request as per the comments provided above.

y) Sio declines to respond to this request as per the comments provided above.

z) Sio declines to respond to this request as per the comments provided above.

aa) As a point of calcification, chemicals required for a lamella clarifier are not the same as what is required for the Chitosan Enhanced Sand Filtration (CESF) system. A lamella clarifier is also not the same as the CESF system which is more then 1 step. The CESF system is a good option as the chitosan used in the system is safe and non-toxic. This system is used in many places in Canada and discharges cleaned water into rivers and streams regularly.

The concentration for the dosage of the chitosan system based on testing of the extraction water to date is in the low range of typical dosages. Treated water from the CESF system would not have any chitosan remaining after treatment. In addition, if there was any small amount of residual, it is biodegradable.

bb) Sio declines to respond to this request as per the comments provided above.

cc) The CESF system is deployed in many locations in Canada and the US. Disposal of the waste material is managed by a 3rd party using a vacuum truck to take waste to a licensed facility.

dd) Please refer to response DLN-IR-007(aa) above. There is no residual chitosan in the discharged water.

ee) See the response to DLN-IR-007(aa). There is no residual chitosan in the water that is discharged from the CESF system.

If there were any residual chitosan, this residual would be extremely limited, biodegradable, and in order to degrade, the presence of an enzyme would be required, of which there is none.

ff) See the response to DLN-IR-007(aa) and (ee). There is no residual chitosan in the water that is discharged from the CESF system.

gg) See the response to DLN-IR-007(aa). There is no residual chitosan in the water that is discharged from the CESF system. Additionally, the pH of the water would not approach these levels.

hh) Sio declines to provide this information as this is proprietary.

ii) Refer to DLN-IR-007 (aa). The UV light that would be used for disinfection will not have sufficient intensity to degrade chitosan molecules.

jj) There is no residual chitosan in the water that is discharged from the CESF system. Also see response DLN-IR-007 (ee).

kk) Sio will contract a vacuum truck and pay for water disposal by a 3rd party at the end of each season. This will occur after the operational activities for the season are complete.

ll) Maintenance and management of equipment is worked into the overall timeline of the operations. Major movements of equipment occur during the winter months when extraction is not active.

mm) See response to DLN-IR-007(kk) above.

nn) At this time, maintenance and cleaning standards have not been developed yet.

oo) Sio is working with industry leading water and wastewater treatment specialists to determine appropriate equipment selection for treatment (UV and filtration) and management of process water and waste material.

As a point of clarification, pilot trial tests are underway with some suppliers. The referenced wording in the request states testing of some of the treatment options is recommended, not all. Pilot trial tests do not need to be in the field and can occur by providing samples to suppliers.

pp) No large-scale pilot test is planned, therefore, Sio declines to respond to this request. See response DLN-IR-007(nn) and the preamble to Sio's responses to DLN-IR-007.

qq) No large-scale pilot test is planned, therefore, Sio declines to respond to this request. See response DLN-IR-007(nn) and the preamble to Sio's responses to DLN-IR-007.

rr) Sio declines to respond to this request as per the comments provided above in the preamble.

ss) Sio declines to respond to this request as per the comments provided above in the preamble. However, as a point of calcification, once a final design is reached after the issuance of an EAL, Sio will provide the design to the Approvals Branch for approval.

IR Number: **DLN-IR-008**

Submitted by: DLN

Date Submitted: November 23, 2022

Subject Matter: Extraction Well Cluster Design, Limestone and Sand Pillar Stability

Reference Documents:

(i) 2.2 Silica Sand Extraction Process

(ii) 2.2.2 Layout of Sand Extraction Sites

SIO SILICA SUPPLEMENTAL INFORMATION

(iii) Document #1 – Silica Extraction Method June 2, 2022

(iv) Technical Review Sio Silica Corporation's Environment Act Project Proposal, H. M. Hollander and A. D. Woodbury, Sept. 19, 2022

Preamble

In the public comments for the extraction project WTFMB posted a histogram of the limestone thicknesses obtained from 44 Sio Silica well information reports obtained from Manitoba Groundwater as shown in figure 1 below.

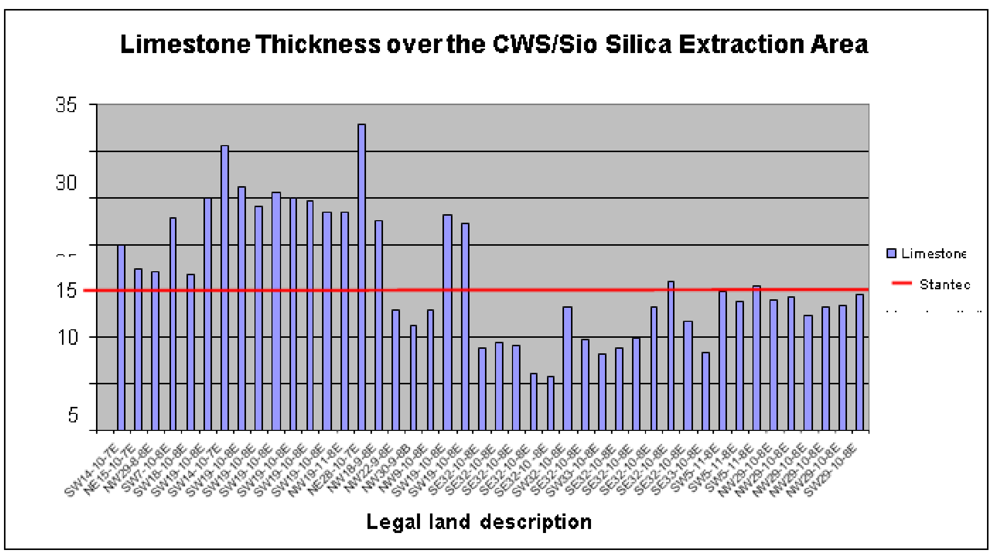


Figure 1. Limestone thickness obtained from 44 Manitoba Groundwater well information reports

Figure 1 illustrates that almost all the limestone thicknesses east of highway 302 are below the minimum thickness of limestone specified by the Stantec geotechnical report as reported in the extraction EAP.

According to this data the Sio Silica extraction locations for the first four years of operation shown in EAP Figure 1-2 are invalid. This critical deficiency was not addressed by Sio Silica in the response to public comments.

In the brief supporting the motions from DLN and WTFMB I used data from the public version of the Stantec geotechnical report of Jan. 14, 2022 posted in the response to public comments to develop equation 1 that predicts the long term maximum extraction cavity span based on the thickness of the limestone and overlying glacial till.

$$S = 1.5(L - 15) - 0.3(O - 25) + 35 \quad (1).$$

Equation 1 applies for limestone thickness greater than or equal to 15 m, the minimum allowable limestone thickness determined by Stantec. *L* is the limestone thickness in meters. *O* is the overburden thickness in meters. The cavity span calculated by equation 1 is compared in figure 2 to the Stantec maximum allowable cavity span from Table 9 in Attachment A of the Sio Silica Responses to Public comments in Project Registry 6119.00.

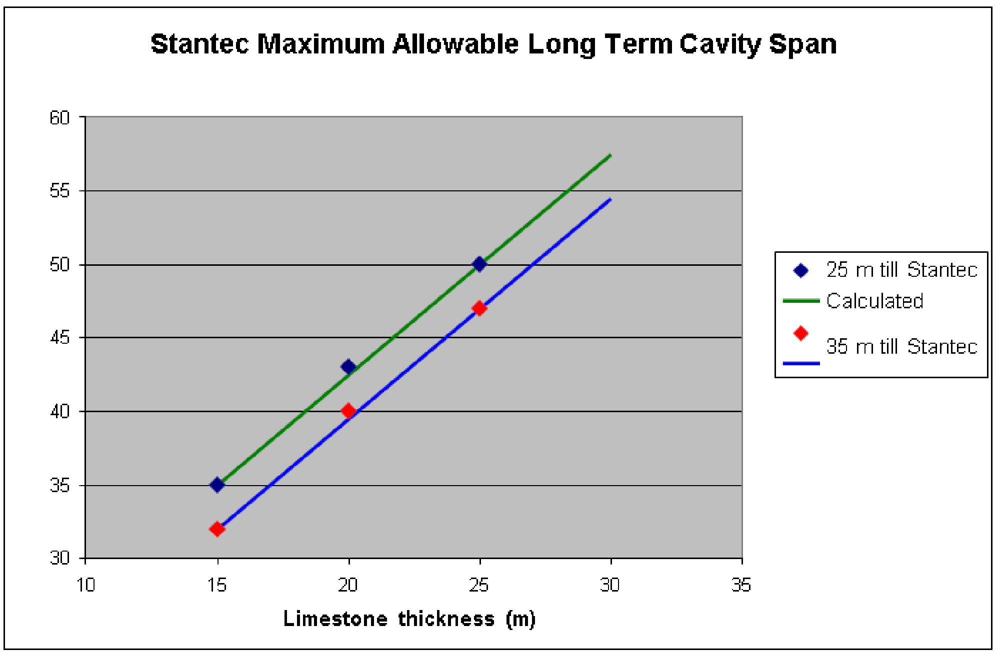


Figure 2. Stantec data for maximum long term allowable silica sand extraction cavity span compared to calculated values from equation 1.

Figure 2 establishes that equation 1 provides accurate values for maximum allowable long term silica sand extraction cavity span for any limestone and glacial till thicknesses within the range of data over the 24-year Sio Silica Project area.

From equation 1 the long term minimum stable cavity span can be determined for any location within the 24- year Sio Silica Project area, given the till and limestone thickness. Using equation 1, I determined the maximum allowable span diameters for the data obtained from the Manitoba Groundwater Section from 44 Sio Silica extraction wells over the 24 year project area as shown in the figure 3 below.

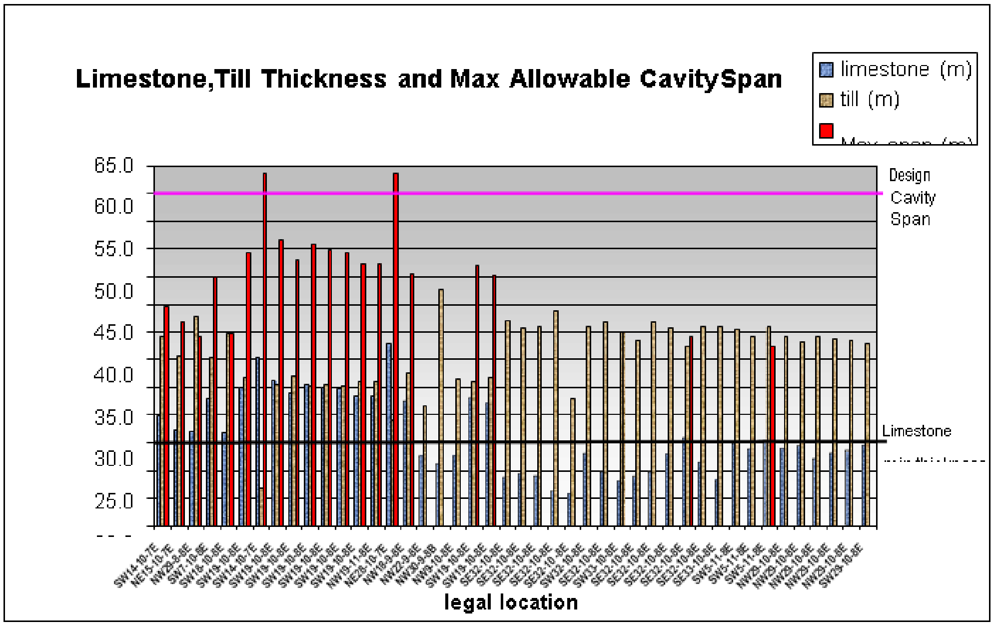


Figure 3. Limestone and till thickness and maximum allowable long-term excavation cavity span over the Sio Silica 24 year project area

For the documented limestone and till thicknesses a long term cavity span of 60 meters given in Document #1 is too large for stability for almost all the wells in the 24-year Project Area. The design cavity span of 60 meters must be reduced considerably for the extraction design to be viable. The maximum allowable extraction cavity span must be determined anew for each extraction cluster location based on the local limestone and till thicknesses.

The conclusion that the design cavity span is too large is obvious from the Stantec data illustrated in figure 2 and the range of till and limestone thicknesses reported for 44 Sio Silica wells in the 24-year project area. Figure 3 confirms that the design cavity span is invalid.

The Stantec geotechnical report did not analyze the slope stability of the sand pillars between well clusters of the dimensions given in document #1. The lack of adequate sand pillar stability anlysis has been corroborated by the third party technical report of Hollander and Woodbury. At each extraction location the allowable cluster separation would have to be determined based on three dimensional geo-mechanical modeling and the local the site specific geo-mechanical properties of the limestone, till and the sandstone.

If a single cluster design were to be used that would apply to all extraction locations from the preliminary information given here, a extraction cavity span of no more than 30 meters would be required for stability at all locations with the provision that no extraction should occur in areas with limestone thickness less than 15 meters as specified by the Stantec analysis. A cluster separation suitable for all locations would have to be determined by comprehensive three dimensional modeling of the sand pillar stability and data for the sandstone, till and limestone geo-mechanical properties obtained at representative locations throughout the 24- year project area.

Request:

a) Revise the well extraction location and schedule to conform to the information from Manitoba well reports that limestone thicknesses east of highway 302 are less than the minimum allowable thickness of 15 meters determined by Stantec.

b) Revise the well cluster design according to the information illustrated in figure 3 on the maximum allowable cavity span based on the data from the 44 Manitoba Groundwater Well Information Reports. According to the analysis from the DLN WFWMB motion brief, the cavity span must be much smaller than the current design specification of 60 meters, of the order of 40 meters or less depending on the local geological and geo-mechanical properties of the extraction location. The long term allowable cluster span for each extraction location must be determined by a new fully three-dimensional geo-mechanical modeling that includes analysis of the sand pillar stability. Local geo-mechanical properties must be measured at each extraction location to perform this analysis.

c) Revise the spacing between well clusters based on a state of the art three dimensional geo-mechanical modeling of the sand pillar stability.

d) Report the experimental methods used and the measured data for the state of the art three dimensional geo-mechanical modeling including the sand geo-mechanical parameter values such as intrinsic angle of friction, cohesion, shear strength, shear and tensile strength of the limestone, limestone layering and rock block sizes, Young’s modulus, Poisson ratio, and all other required geo-mechanical parameters.

e) If a single cluster design is to be used for each extraction location based on information from the 44 Sio Silica well information reports and a detailed three dimensional analysis of the sand pillar stability, determine a cluster design that would be stable for all locations. Provide a report of the analysis and all the data used and methods for obtaining the required data. A single universal design would have a smaller cluster span, of about 30 m in diameter, than might be allowed for a specific location.

f) It is clear that much smaller diameter well clusters are required. The clusters may well be required to be much further apart than in the current well cluster design. The resulting larger yearly footprint for extraction would have major cost and operational implications. Give the increase in Project cost for the required determined larger extraction footprint. Determine the environmental impact of a larger yearly project footprint including increase in clearing for slurry lines, increase in area of Project noise and lighting impacts, increase in disruption of existing infrastructure such as roads, drainage ditches, transmission lines, increase in GHG emissions, and increased impact on and the Winnipeg aqueduct. Determine the viability of maintaining the size of the current 24-year Project area with an increased yearly extraction footprint. Revise the total 24-year Project area with respect to the increased yearly extraction footprint. Determine the viability of the Project with respect to the much larger yearly extraction footprint.

g) If the required geo-mechanical analysis and Project layout revisions cannot be done within the IR time framework give a schedule for completion. Commit to issuing a major project alteration with the revised cluster design and yearly project footprint. Commit to revising the EAP to document all the geotechnical analysis required to support the new Project layout design. Commit to fully respond to all TAC and public comments for the new designs and geo-technical analysis documented in the revised EAP. Commit to delay in licensing and production until the completion of all activities specified here. Sio Silica and AECOM must act responsibly by implementing the EAP and Project revisions unilaterally without being required to do so by the Provincial Approvals process.

Response:

a) As has been previously stated in other IR responses (DLN-IR-003 (l) and (m), CEC-IR-002), the new Geotechnical design recommendations and parameters, have been incorporated into Sio's extraction plans and will be filed with the Approvals Branch and the CEC prior to the hearing as a project update letter to address updated information.

b) Sio disagrees with the factual statements in the request and the premise of the question. Refer to the response to DLN-IR-008(a).

The author is reminded that the allowable cavity spans corresponding to the limestone thickness and till thickness are listed in Table 9 of the Geotechnical Analysis for Sio Silica Extraction Project as was included in the responses to public comments for the Extraction EAP. Sio Silica will be adhering to this design and these parameters as set out in Table 9 by Stantec.

Sio would also like to direct the author to the Arcadis Technical Review of Sio Silica Corporation's Environment Act Project Proposal, where Arcadis agrees with the Stantec approach. This is found in Arcadis Conclusion # 3, Section 5.1 on page 15:"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."*

c) See the response to DLN-IR-008(a) and (b).

d) See the response to DLN-IR-008(b).

e) See the response to DLN-IR-008(a). As a point of clarification, there is no requirement for a cluster design to be universal across all areas.

f) This request is based on many incorrect assumptions by the author. See the response to DLN-IR-008(a).

g) Sio Silica disagrees with the comments in this request. See the response to DLN-IR-008(a).

IR Number: **DLN-IR-009**

Submitted by: DLN

Date Submitted: November 23, 2022

Subject Matter: Extraction Well Cluster Design and Sealing

Reference Documents:

(i) 2.2 Silica Sand Extraction Process

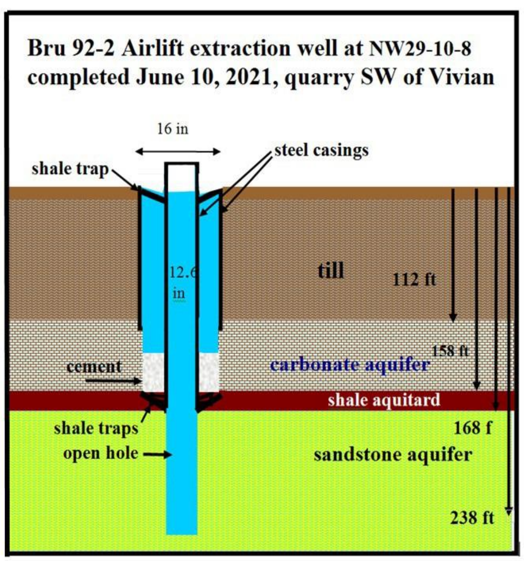
(ii) 8.3 Progressive Well Abandonment Plan

(iii) SIO SILICA SUPPLEMENTAL INFORMATION

(iv) Document #1 – Silica Extraction Method June 2, 2022

(v) Arcadis Technical Review Sio Silica Corporation's Environment Act Project Proposal Results Reported page A-4 13 Sept. 2022

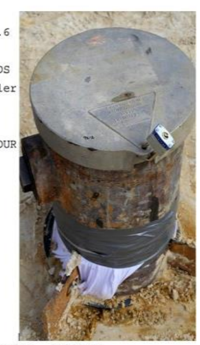
Preamble: In the "*Results Reported*" section of Arcadis technical report three extraction wells are described, Bru 92-2, Bru 92-3 and Bru 92-8. Bru 92-8 was permitted as an injection well. Silica sand extraction occurred in all three wells. A request for information, IR 002 DLN, pertaining to the injection well Bru 92-8 has been made. Figure 1 below illustrates the construction of wells Bru 92-2 and Bru 92-3 based on well information reports obtained from Manitoba Groundwater.



Location: NW29-10-8E
UTMX:681574.4 UTMY:5526460.6
UTMZ:282
Owner: CANWHITE SANDS
Driller: Friesen Driller
Well Name: BRU 92-2
Date Completed: 2021 Jun 10
Well Use: PRODUCTION/SOUR
WATER USE: Other
Well Status: ACTIVE

WELL LOG (Imperial units)

From	To(ft.)	Log
0.0	3	FILL
3.0	20	BROWN TILL
20.0	112	GREY TILL
112.0	158	LIMESTONE
158.0	168	SHALE
168.0	238	SANDSTONE



From	To(ft)	Const.Method	Inside Dia.(in)	Outside Dia.(in)	Material
0.0	115.0	CASING	15.5	16.0	STEEL
0.0	169.0	BOREHOLE	14.8		
0.0	168.0	CASING	12.0	12.6	STEEL
168.0	238.0	OPEN HOLE	11.0		
130.0	158.0	ANNULAR FILL	12.0	14.8	CEMENT
158.0	158.0	ATTACHMENT	12.0		K PACKER
158.0	158.0	ATTACHMENT	12.0		SHALE TRAP
0.0	0.0	ATTACHMENT	16.0		SHALE TRAP
158.0	158.0	ATTACHMENT	12.0		SHALE TRAP

Top of Casing: 2.0 ft above ground

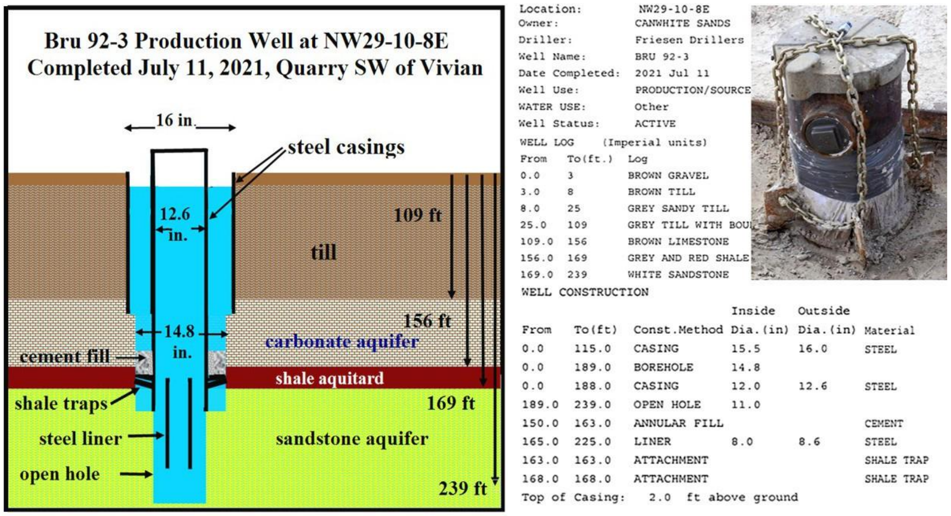


Figure 1 a and b. Extraction wells Bru 92-2 (a) and Bru 92-3 (b) completed at a quarry south west of Vivian. *Illustrations by D.M. LeNeveu was based on the well information report received from Manitoba Groundwater shown on right. Photographs were reproduced with permission of photographer*

These extraction wells do not conform to the well design given in Sio Silica Supplemental Information Document #1 – Silica Extraction Method June 2, 2022 or the earlier design given in figure 2-2 of the extraction EAP. The well design of Bru 92-8 given in IR 002 DLN is reproduced below.

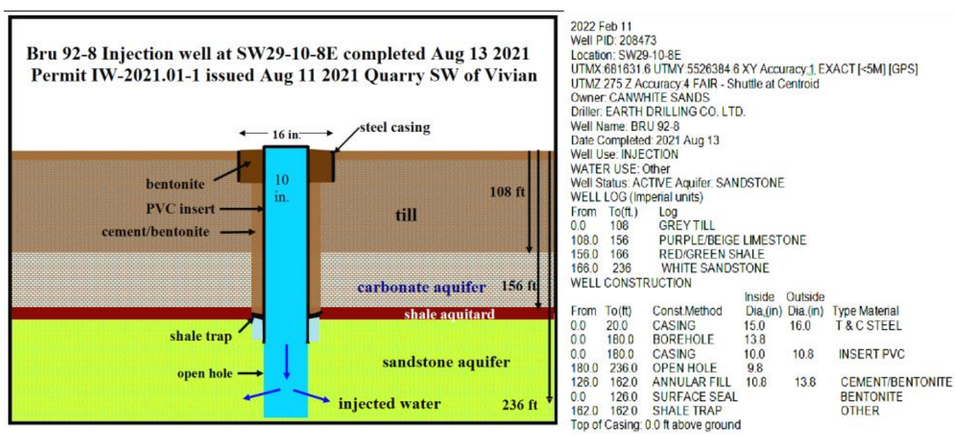
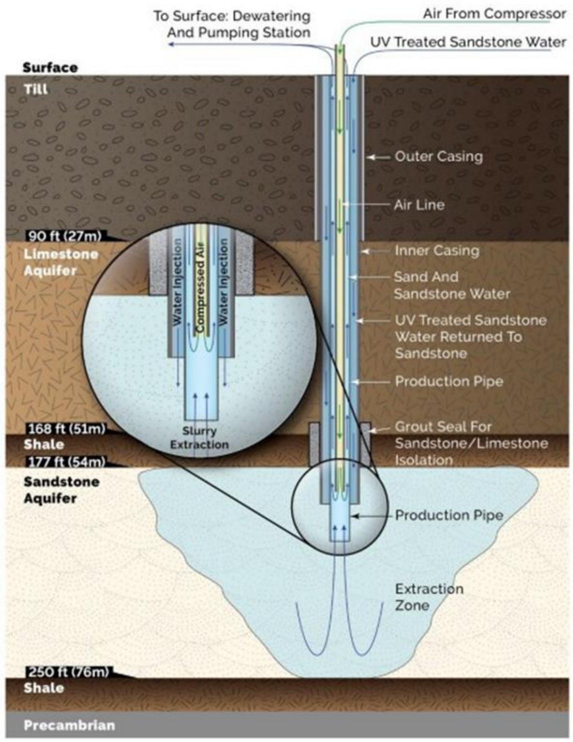


Figure 2. CWS permitted injection well Bru 92-8 at a quarry south west of Vivian 2021.*Illustration is by D. M. LeNeveu. Well information report was from Manitoba Groundwater*

The latest extraction well design is shown in figure 3.

Sio Silica Supplement Information – Document #1 – Silica Extraction Method
Vivian Sand Extraction Project (File # 6119.0)



Example Only

Figure 2 - 3 Extraction method example

Figure 3 . Sio Silica extraction well design. *Illustration was reproduced from Sio Silica Supplement Information – Document #1 – Silica Extraction Method Vivian Sand Extraction Project (File # 6119.0)*

In the Remarks field of the Bru 92-3 well information report the this statement was entered;

"*THREADED PIPE (REMOVABLE) STUCK IN SANDSTONE*"

This remark explains why the central steel liner appears to be unsupported in the illustration in figure 1b.

There is no return route for re-injected water to the sandstone through the outer annulus in Bru 92-2 or Bru 92-3 however there is a return route into the carbonate aquifer. The steel liner of Bru 92-3 extends 56 feet into the sandstone while the open hole extends 70 feet into the sandstone. The steel liner does not extend to the surface therefore cannot be a production tube as illustrated in figure 1b. The remark, "*stuck in the sandstone,*" in the well information report demonstrates that a removable steel liner was likely lowered into the hole during airlifting to prevent sand from collapsing. As described in the CWS patent, the air injection tube would extend below the liner injecting directly into the sandstone to loosen and mobilize the sand. The air injection would be pulsed as described in the patent. Since the inner liner does not penetrate beyond 56 feet into the sandstone, the air tube must have been extended directly into the sandstone below the inner liner to extract sand below. When the pulsed injection is periodically stopped the injected air would move up the steel liner airlifting the sand. The pulsed extraction of sand into the dewatering tank was observed at the quarry by local citizens. Injected air would have entered the sandstone aquifer directly and not have been confined to the inner liner, establishing oxidizing conditions in the sandstone. It appears that in the Bru 92-2 airlift well, a steel liner, if used in construction and airlifting to prevent sand collapse, was successfully removed. Bru 92-2 does not conform to the Sio Silica production well design given in figure 3.

Bru 92-3 like Bru 92-2 has an open outer annular region from the surface directly into the carbonate. The top of the outer casing is at ground level. Any run-off or snow melt would enter the annular region and could carry surface contamination directly into the carbonate aquifer. The shale trap at the top of the annular space of Bru 92-2 is not specified in the well information report for Bru 92-3. The annular region appears to be unsealed and vulnerable to surface contamination in Bru 92-3. The shale trap for well Bru 92-2 would be temporary and not a permanent seal. The picture of Bru 92-3 shows a cloth skirt duct taped onto the inner casing that extends above ground surface. The skirt extends downward mostly obscuring the open outer casing. Flanges attached to the inner casing rest on top of the outer casing. The chains looping through the flanges secure well Bru 92-3 against well tampering. For a well that has been left unsealed, opening directly to the carbonate aquifer, tamper protection would seem rather superfluous. Well Bru 92-2 has a similar cloth skirt duct taped to the outer casing.

The Groundwater and Water Well Act (C.C.S.M. c. G110) Well Standards Regulation 2015 states;[1]

"Manner of construction and sealing 2 A person must not construct or seal a well or test hole other than in a manner which
(b) prevents surface water from entering the well or test hole;"

It would appear that Bru 92-3 violates the groundwater regulation with respect to entry of surface water into the well.

The supplementary filing by Sio Silica states; "*Based on recent refinements aimed at improving efficiency and reducing the Project footprint, Sio is now able to complete sand extraction with five wells or less in a cluster, reducing the number of wells required per year from 467 to 324.*" This statement implies a cluster design with five wells of the design specified was actually tested however there is no reporting of this testing in the supplemental filing. The Extraction EAP was named in the references for the supplemental filing.

No sand was extracted, no water was re-injected and no well clusters were considered in the modeling and well drawdown studies reported in the Sio Silica Hydrogeological Report of the Extraction EAP. According to the information received from Manitoba Water Branch, no injection well permits were issued for the wells used in the hydrogeological studies and no water was re-injected to the aquifer. According to the well information reports received from Manitoba Groundwater, no wells of the design shown in figure 3 were constructed and used for the hydrogeological studies. A modeled 50% re-injection scenario was done by simply reducing the well pumping rate as documented by the following excerpt on page 76 of the Hydrogeological Report;

"The extraction rate assigned to the pumping well in the Scenarios 1 through 3 was scaled according to the injection rate as follows:

- *Scenario 1 (0% re-injection): Pumping Rate = 2,998 m3/day (550 US GPM)*
- *Scenario 2 (50% re-injection): Pumping Rate = 1,526 m3/day (280 US GPM)"*

No re-injection occurred. No injection well was used in the hydrogeological model. Only a single pumping well as stated in the above excerpt was used in the model. Thus no relevant measured testing or modeling for the Sio Silica extraction wells and well clusters with sand withdrawal and water re-injection was documented in the Sio Silica Hydrogeological Report.

Request:

a) Explain why extraction wells Bru 92-2 and Bru 92-3 do not conform to the well extraction design of the supplementary filing of June 2, 2022.

b) Will Bru 92-2 and Bru 92-3 be the well design implemented for production?

c) If the extraction design given in figure 3 of the Supplementary filing of June 2, 2022 is to be used during production please give detailed information on where and when this production well design of figure 3 has been implemented and tested. Give the name of implemented extraction wells, the drillers reports for the wells, the Manitoba groundwater well information reports, ands all the test data for the wells including sand and water extraction amounts, rates, time, duration, water re-injection amount, rate, time and duration, pressure measurements in the formation an all other collected data.

d) Since the latest implemented extraction wells Bru 92-2, 92-3 and Bru 92-8 do not conform to the EAP extraction well design does this not establish that the designs of wells Bru 92-2, Bru 92-3 and Bru 92-8 will be used in production?

e) The Sio Silica revised cluster design was submitted on June 2, 2022 long after the wells Bru 92-2, 92-3 and 92-8 were used for sand extraction and analyzed and reviewed by Stantec and Arcadis. There is no information in the revised cluster design of June 2, 2022 on implemented and tested wells used as a basis for the revised design. Please provide the evidence to support the well extraction design of June 2, 2022.

f) The latest well information reports obtained from Manitoba Groundwater for extraction wells Bru 92-2, 92-3 and 92-8 do not conform to the revised cluster design. Surely Sio Silica would not intentionally specify a production extraction well design that has never been tested and will not be implemented. Please explain the discrepancy in the implemented well designs of Bru 92-2, Bu 92-3 and Bru 92-8 and the specified production well design in Sio Silica Supplement Information – Document #1

g) The extraction cavities for wells Bru 92-2, Bru 92-3 and Bru 92-8 were used by Stantec for their geotechnical analysis. Does this not establish that these are the production well designs that would be implemented? If not why would Stantec analyze a design for geotechnical stability that would not be used including the extraction cavities for Bru 92-3 and 92-8? If Stantec analyzed the incorrect well design does this not mean the analysis is invalid and must be redone? The geotechnical properties of extraction cavities formed with the gravity return re-injection specified in the reference production design of figure 3 may well be significantly different than the cavities formed with the designs for Bru 92-2, Bru 92-3 and Bru 92-8.

h) Arcadis reported on the Bru 92-2, Bru 92-3 and Bru 92-8 wells in their technical report. Surely Arcadis was not given a design that would never be implemented for production for their technical review. If Arcadis has based their geotechnical review on a well design that would not be implemented is not the Arcadis review invalid and must be redone with detailed information from the production design?

i) Why would Sio Silica allow Arcadis to review a design that would not be implemented? That air injection could cause sufficient drawdown for re-injection of water at the nearly same rate as withdrawal as specified in the updated well design is suspect and has not been supported by documented testing or evidence as established in the background information above. Would not a return water rate the same as a withdrawal rate using the same driving force without any added energy for water return constitute perpetual motion? Has Sio Silica provided the CEC Hearing with an unviable extraction well design in the supplemental filing of June 2, 2022 that has never been tested?

j) Will the Bru 92-2, Bru 92-3 and Bru 92-8 well designs be used for production?

k) The Bru 92-2, Bru 92-3 and Bru 92-8 designs entail large amounts of air injected directly into the aquifer which constitutes a major environmental risk to groundwater and a major Project alteration requiring a revised EAP and approval process. There is no outer casing for gravity induced flow of returned water in Bru 92-2, Bru 92-3 and Bru 92-8. The production design of Figure 3 is constructed so that injected air would be confined inside the production casing. Please resolve the discrepancy between the Bru 92-2, Bru 92-3 and Bru 92-8 well designs and the production design of figure 2-3 in the supplemental filing of June 2, 2022 with respect to air injection and water re-injection.

l) What is the purpose of the outer steel casings in well Bru 92-2 and well Bru 92-3 that open into the carbonate?

m) If the purpose of the outer steel annulus opening into the carbonate for Bru 92-2 and Bru 92-3 is for carbonate pressure measurements during extraction please provide the data from the measurements and the data from any other measurements taken.

n) Since the inner steel liner in well Bru 92-3 became stuck and could not be removed would this not demonstrate that many removable production liners as specified in the design for production would become stuck? Would this not invalidate the production design specs for a removable production liner?

o) Please provide information on mitigation and implications of a stuck production liner including potential compromised well seals and damage to the shale aquitard and carbonate aquifer from dislodging operations.

p) Please answer the following questions about sealing of Bru 92-2 and Bru 92-3. Why has the outer annulus of well Bru 92-3 been left unsealed such that surface water could enter the well and have access to the carbonate aquifer?

q) Why has a temporary shale trap been installed at the surface in the outer annulus of well Bru 92-2?

r) Why was the cement outer annular fill in well Bru 92-2 and Bru 92-3 only emplaced in a limited region at the bottom of the carbonate aquifer and not all the way to the surface?

s) What is the purpose of the duct tape and cloth skirt on the outer casing of wells Bru 92-2 and Bru 92-3 as shown in figure 1?

t) Is the open outer annulus with no permanent seal to be used during production even for a limited time during extraction and permanently sealed later?

u) Does the sealing as reported in the well information report for Bru 92-2 violate the Groundwater and Water Well Act Well Standards Regulation given above? If not, why not?

v) If a violation of Groundwater and Water Well Act Well Standards Regulation has occurred will AECOM report the violation as required by the engineering code of ethics?[2] If not, why not?

w) Please give information on the final destination of all the aquifer water extracted with the sand in wells Bru 92-2 and Bru 92-3.

x) Provide detailed information on the rate, time and duration of sand and water withdrawal from wells Bru 92-2 and Bru 92-3. Give the ratio of sand to water at all times during withdrawal and the total amount of sand and water withdrawn. Provide detailed information of any formation fluid pressure measurements made during extraction. Give detailed information on the amount of air injected into the sandstone aquifer, the rate of injection, the injection pressure, the time course of injection including specification of air pulses, the duration of the pulses and the pressure, the time, pressure and amount of the air injection directly into the aquifer not confined by a production pipe. Provide information on a production pipe used during injection and subsequently removed including, the diameter of the pipe, the time of installation, the depth installation, the depth of installation as a function of time if the pipe was moveable, and the position of the air injection tube with respect to the production pipe. Provide any measurements of the contaminants in the injected air. If the extracted water was discharged to the surface what measures were taken to ensure the process wastewater extracted did not seep into the open outer annulus of well Bru 92-3. Was any of the extracted water from Bru 92-2 and Bru 92-3 re-injected into the aquifer? If so, how and where did the water re-injection occur? Provide detailed information on the rate, time and duration of re- injected water.

y) The Groundwater and Water Well Act Well Standards Regulation state; "*9(2) All water used in the construction, sealing, rehabilitation, maintenance or servicing o f a well or test hole not specified in subsection (1) must (b) contain a minimum 10 mg/L free chlorine at all times, except for monitoring wells where chlorine will interfere with water quality analysis or remediation*" Chlorine would form acid under oxidizing conditions that could leach heavy metals.[4] Chlorine would precipitate iron and manganese under reducing conditions.[3] Please specify the effect on aquifer water quality from the use of chlorinated water in the construction of 324 extraction wells per year. One of the advantages of the rural drinking water from the bedrock aquifers of southeast Manitoba is the absence of chlorine. Would not the large amount of chlorine introduced into the aquifer from 324 extraction wells per year adversely affect drinking water quality of domestic well users? Please analyze the effect of chlorination on drinking water quality. Will permission to chlorinate the water of nearby domestic well users be obtained prior to silica sand extraction?

References:

1. The Groundwater and Water Well Act (C.C.S.M. c. G110) Well Standards Regulation 2015, https://web2.gov.mb.ca/laws/regs/current/_pdf-regs.php?reg=215/2015

2. Engineers Geoscientists Manitoba Code of Ethics, The Engineering and Geoscientific Professions Act, https://www.apegm.mb.ca/ActBylawsCode.html#:~:text=Effective%20November%202021)-,Engineers%20Geoscientists%20Manitoba%20Code%20of%20Ethics,when%20dealing%20with%20fellow%20professionals.

3. Effect of Groundwater Iron on Residual Chlorine in Water Treated with Sodium Dichloroisocyanurate Tablets in Rural Bangladesh, A.M. Nasar et al., Am J Trop Med Hyg. 2018 Apr; 98(4): 977–983, https://www.ncbi.nlm.nih.gov/pmc/articles/PMC5928807/

4. Arsenic concentrations after drinking water well installation: time-varying effects on 2 arsenic mobilization, Melinda L. Erickson et al., Science of The Total Environment,Volume 678, 15 August 2019, Pages 681-691 https://www.sciencedirect.com/science/article/pii/S0048969719319059

Response:

a) Sio has tested several different well designs and Bru 92-2 and Bru 92-3 are virtually the same as what is proposed in the supplementary filing – Silica Extraction Method. Figure 2-2 in the filing shows virtually the same design as what was constructed for Bru 92-2 and 92-3. It is not clear what the author understands to be different from the proposed design other than steel casing was used in the Bru 92-2 and Bru 92-3 wells due to availability at the time, whereas PVC casing is proposed. Both steel casing and PVC casing are regularly used in water wells every day all around the world.

b) Yes. This is the intended design at this time. Sio would like to reduce the well casing size as much as possible.

Sio has been working with water well drillers to improve the efficiency of the well design to reduce the materials and time required to drill and construct the wells. The design of any of the previous test wells would all be applicable for extraction as they all follow the requirements under *The Groundwater and Water Well Act.*

c) Bru 92-2 and Bru 92-3 mimic the well design that is shown in the supplemental filing. The author has already demonstrated that he has these logs and reports from the province in the preamble above.

Bru 92-8 was not the same well construction, however the diameter of the production tubing (which is not listed on the report filed to the province as this is not required) was very similar. Bru 92-8 was successfully extracted, and all water was returned to the well as stated in the response to DLN-IR-002(l).

Sio declines to release the testing data, as some of the information is proprietary, not all items in the above list were collected as it was not required by the province, and this information is not relevant to the extraction proposal before the CEC.

d) No. See the responses to DLN-IR-009(a) and (b).

e) The well cluster design revision was based upon total volume of sand to be extracted per well without changing the well cluster footprint. However, this cluster design is no longer valid and will now be revised as previously stated above in DLN-IR-003(l) and (m), DLN-IR-008(a), as well as CEC-IR-002. The well numbers, cluster count and placement has been refined to follow the parameters provided by Stantec Geotechnical Analysis for Sio Silica Extraction Project - Table 9. As previously stated, a revised extraction plan will be filed with the Approvals Branch and the CEC prior to the hearing as a project update letter to address updated information

f) Sio Silica's design and operational plans are based on geotechnical parameters at the time of design and have since be refined.

At this time, the purpose of any full scale test would be to refine the monitoring and efficiency levels of the extraction process, it would not be to assess environmental effects. To date, substantial data has been collected to assess the potential effects of the project. It is not normal practice to build a full scale mine to test before approval. Sio is confident in the current assessments that have been conducted and operations would be confined to the conservative geotechnical model. As is normal practice, the issuance of any licence will set acceptable and safe parameters in addition to what has been set out by Stantec and AECOM's reports. Operating outside of these parameters would not occur.

As with any project, there is a period of ramp up where refinements, efficiencies and monitoring are established. Extraction activities will be gradually increased with monitoring and data collection in place. The usage of the Water Monitoring and Impact Mitigation plan will be critical for the commencement of the project. Data collected will be used to update the hydrogeological model and geotechnical model and confirm assumptions.

g) Wells 92-2, 92-3 and 92-8 were used to collect information for analysis and design. This does not establish that these are the specific designs which would be implemented. Stantec completed multiple analyses to identify a design which provides geotechnical stability. The analyses are valid and have been reviewed by Stantec as well as external independent geotechnical experts. The Sio extraction plan will be implemented to follow geotechnical recommendations to achieve stable designs

Additionally, the extraction production pipe is movable, and the depth of extraction varies during the extraction operation, therefore the permanent well casing is negligible in cavern development.

Sio notes that the depth of the casing will not be exactly the same on every well as the depth of the formation changes.

h) See the responses to DLN-IR-009(a), (b) and (g).

i) Sio disagrees with the statements made within this question. See the responses to DLN-IR-009(a), (b) and (g).

j) See the response to DLN-IR-009(b).

k) The statements in this request are based on the author's assumptions, not the information provided in documents from Sio. Refer to the response to DLN-IR-002(I) and (k), and DLN-IR-009(g).

l) This is a normal well construction design for any well drilled into the sandstone to hold back and maintain till integrity while drilling through the limestone. This is a normal industry accepted practice and based on decades of experience by experienced water well drillers.

m) See the response to DLN-IR-009(l). This outer steel casing has no role in the extraction.

n) This was an isolated occurrence where the production pipe became stuck and was unable to be retrieved. Sio has since refined the design of both the surface parameters/forces applied to the production pipe and the production pipe design itself to address this issue.

o) Sio is investigating other methods to remove stuck production pipe, however, no damage to well seals, shale or carbonate aquifers would be expected as the production pipe is not connected to the well casing. See also the response to DLN-IR-009(n).

p) There is no outer annulus on wells Bru 92-2 and Bru 92-3 as the upper casing was installed using a dual rotary method, which is an accepted practice and normal for experienced water well drillers.

q) There is no outer annulus on Bru 92-2. There is an anulus between the outer and inner casings. Shale traps are sometimes temporarily installed to protect against washout from the extraction testing as well as a safety precaution and to protect from tampering.

r) Cementing or some form of approved sealing material is required to isolate between aquifers in the annular space. Sio was exploring the option to reuse the majority of the casing after the extraction was complete by cementing a lower section between the outer and inner casing, which leaves the upper section of casing removable. This would reduce overall materials left behind in the well.

s) This is a deterrent for sabotage and tampering by others as has been seen on other wells. Sio notes that these wells are located on private property and the property should not be entered without Sio Silica's explicit permission. This has not been the case as is evident from the photos supplied within the preamble which indicate trespassing.

t) A bentonite grout to surface will be utilized in the anulus above the cement plug.

u) Sio declines to provide the requested information because it is not relevant to the extraction proposal before the CEC.

v) Sio declines to respond to this request because it is not relevant to the extraction proposal before the CEC.

w) Sio declines to provide the requested information because it is not relevant to the extraction proposal before the CEC.

x) Sio declines to release testing data, as some of the information is proprietary, not all items in the above list were collected as it was not required by the province, and this information is not relevant to the extraction proposal before the CEC. Sio also disagrees with some of the statements made within this question. When water is discharged on surface, it is discharged first into tankage and then away from the testing area in a trench that ensures it moves away form the active site. See also response DLN-IR-002 (i) and (j).

y) The regulations are set by the Province and Sio and its water well drilling service providers are committed to following the regulations stipulated by the Province for drilling water wells. Sio notes that there are typically more than 800 wells drilled in the province per year. Chlorination and disinfection is used on municipal water supplies everyday.

Furthermore, when water is used to drill a water well, the water is used in combination with an additive, or water is used on its own, all with the purpose of cleaning out the drill cuttings from the wellbore. Therefore, to carry the cuttings to surface, this would mean the water would need to also exit the well, leaving behind little to no drilling fluid and therefore little to no residual chlorine. Chlorinated Water is not freely injected into the aquifer. Water is only used in some zones and circumstances. There are other drilling methods that don’t require water.

For these reasons Sio disagrees with the comments made by the author in the request.

IR Number:	**DLN-IR-010**
Submitted by:	DLN
Date Submitted:	November 23, 2022
Subject Matter:	Indigenous Consultation
Reference Documents:	Executive Summary (i) 4.5 Indigenous Peoples (ii) 5.0 Public and Indigenous Engagement (iii) 6.6.5 Indigenous and Treaty Rights

Preamble: The Executive Summary of the Extraction Project EAP states;

"*Indigenous and Treaty Rights The Project is not expected to adversely impact the exercise of Indigenous or Treaty rights because:*
- *The Project Site consists of private land with private surface rights that do not have public access unless by permission;*
- *No fish or fish habitat will be affected by the Project;*
- *The residual environmental impact of the Project on vegetation beyond the Project site is assessed to be negligible; and*
- *The residual environmental impact of the Project on regional wildlife populations is assessed to be negligible.*"

These reasons are not adequate since slurry lines would cross Crown Lands and traditional lands that are not private. The noise and lights from drilling of up to seven drill rigs operating simultaneously would have an adverse effect on wildlife. Potential subsidence from Project extraction could adversely affect large area including traditional lands and Crown Land. In any case the Hearing Directive states;

"*The provincial consultation process is being led by Manitoba Natural Resources and Northern Development. The Clean Environment Commission plays a role in gathering input relevant to the consultation process; however, the provincial Crown retains ultimate responsibility to ensure that the necessary consultation and accommodation has occurred.*"

It is clear that the CEC plays a role in gathering relevant input from indigenous consultations and must consider such input to the Hearing.

Online guidelines from Osler Law for proponents regarding indigenous consultation state; [1]

"*Despite consultation being a duty owed by government to potentially impacted indigenous communities, project owners will be expected to carry out significant procedural aspects of consultation. The federal or provincial government will supply* *project owners with a list of potentially affected indigenous communities. Consultation can involve the following:*

- *meeting with Indigenous communities to share information about the project*
- *providing reasonable resources for Indigenous communities to participate in consultation {responding to questions and concerns raised by Indigenous communities*
- *maintaining a complete record of all Indigenous consultation activities*
- *discussing any concerns or asserted impacts of the project on Indigenous or treaty rights*

Consultation requirements are circumstance-specific and dependent on the nature of the rights at stake and potential project impacts. The government, not the project owner, determines whether consultation has been adequate. Indigenous communities that believe consultation has been inadequate can have the issue determined by courts, leading to project delay."

Osler Law represents Sio Silica at the Hearing. The CEC should be informed about the Sio Silica indigenous consultation completed at the project planning state.

It would appear from the statement below in the posting that proponent led consultation is a legal requirement that must be carried out;[1]

"Despite consultation being a duty owed by government to potentially impacted indigenous communities, Project owners will be expected to carry out significant procedural aspects of consultation."

Request:

a) Osler Law report a legal opinion on the legal requirement of Sio Silica to complete and document adequate consultation with all indigenous groups whose traditional lands could be affected by the Project. Take into account the environmental effects including disruption from slurry lines that would cross traditional and crown lands, potential subsidence on these lands, wildlife disturbance from noise and lights of drill rigs, the processing plant and the Project rail loop, surface leaks and spillage of process wastewater, and potential contamination of the carbonate and sandstone aquifers over a large area including traditional lands.It is clear from the postings on the Project registry 6057.00 by the Métis on Aug. 25, 2020 and Brokenhead Nation Aug. 24, 2020 that the necessary adequate proponent lead indigenous consultation had not occurred up to those dates. If the consultation with affected aboriginal groups is inadequate at this time, Sio Silica must initiate and complete meaningful and comprehensive remedial indigenous consultations.

b) In conformance with the Osler Law guidelines and/or legal requirements published in "*Doing Business in Canada*"[1], Sio Silica submit to the CEC Hearing a report of all communications and consultations with indigenous groups including meetings of meetings, records of phone calls, records of online meetings, dates, duration and summary or transcripts of the communications including remedial consultations once complete. Summarize the recommendations and concerns of the indigenous groups documented in the consultations.

References: a) Indigenous Consultation, Doing Business in Canada, Osler, Hoskin and Harcourt, LLP, https://www.osler.com/osler/media/Osler/Content/DBIC/PDFs/Indigenous-consultation.pdf?ext=.pdf

Response: a) The author has misinterpreted the Osler publication referenced in the request. Regardless, this is a legal matter and not properly the subject of Information Requests. Sio notes that this matter was recently addressed by the CEC Panel in its Ruling on the author's motion, in which the CEC Panel held that Crown-Indigenous consultation falls outside the responsibilities of the CEC, and consequently the CEC hearing (Reasons for Decision dated November 16, 2022).

b) See response to DLN-IR-010(a). See also the response to CEC-IR-001.

c) See response to DLN-IR-010(a). See also the response to CEC-IR-001.

IR Number: **DLN-IR-011**

Submitted by: DLN

Date Submitted: November 23, 2022

Subject Matter: Shale Aquitard Degradation

Reference Documents:

(i) 4.3.2 Groundwater Quality in Response to Mixing of Waters from Red River Carbonate and Winnipeg Sandstone Aquifers,

(ii) 6.10 Predictive Scenarios,

(iii) 7.2.2 Groundwater Quality,

(iv) Table 4-2, 4-3 and 4-4 of the Sio Silica Hydrogeology and Geochemistry Assessment Report,

(v) Arcadis Technical Review of Sio Silica Corporation's Environment Act Project Proposal Vivian Sand Extraction 5.3 Groundwater Impact Assessment

Preamble: Section 4.3.2 of the Hydrogeological Report states;

"Degradation of the Winnipeg Shale could lead to a more interconnected aquifer system comprising the Red River Carbonate aquifer and the underlying Winnipeg Sandstone aquifer."

Several predictive hydrogeological model scenarios described in Section 6.10 considered the degradation of the shale aquitard. Section 7.2.2 states;

"Project operations may induce changes in oxidation-reduction conditions as a result of reinjectingoxygenated water and increase communication between the Winnipeg Sandstone and the Red River Carbonate aquifers following any degradation of the Winnipeg Shale. PHREEQC geochemical modelling results indicate that degradation of the Winnipeg Shale will have a low to negligible impact on groundwater quality in either aquifer."

The Sio Silica Hydrogeological Reports documents the results of the geochemical modeling software PHREEQU for the oxidizing conditions and mixing of aquifer water that could occur due to re-injection of aerated water. Sio Silica reports that there could be a reduction in the concentration of iron and manganese in the aquifer waters due to oxidizing conditions and portrays this decrease as beneficial. Sio Silica ignores the Groundwater and Water Well Act Well Standards Regulation 3(1) that prohibits mixing of aquifer waters.[1]

Dr. E. Pip in her public comment submission to registry 6119.00 points out that iron and manganese reduction in concentration is caused by precipitation of iron and manganese under oxidizing conditions. Precipitation of iron and manganese causing discoloration and degradation of water quality is well known.[2]

Iron bacteria that can thrive under the newly introduced oxidizing conditions can cause slime and clogging of wells and plumbing.[3] In response to public comments for the Extraction EAP Sio Silica states;

"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."

As usual Sio Silica does not provide any supporting evidence for this statement. A report on the potential use of quartz sand to remove manganese states;[2]

"The quartz sand could adsorb manganese but easily became saturated."[2]

A greensand filter using glauconite and sand can be used to remove iron and manganese.[2,3] The sandstone aquifer does not contain glauconite. The mixing of aquifer waters would result in oxidizing conditions in the carbonate aquifer. Precipitation of iron and manganese would then occur in the carbonate aquifer where there is no silica sand to act as a potential absorbent. The evidence presented here shows the aquifer sand will not effectively absorb manganese and iron precipitates. There would be deterioration of water quality from iron and manganese precipitation in the sandstone aquifer and in the carbonate aquifer following shale aquitard collapse.

Iron bacteria and other potential detrimental organisms, as documented in the submission by Dr. E. Pip, that would thrive under the introduced oxidizing conditions would enter both aquifers by multiple routes especially through the Sio Silica drilling and well casings and air injection.[4,5] The Sio Silica proposed deactivation of microorganisms by UV light would not prevent proliferation of iron bacteria and other microorganisms introduced by Sio Silica drilling and air injection.[4,5] Manitoba well standards regulations do require use of chlorine during well drilling for disinfection.[1] It is very unlikely that such disinfection could totally prevent introduction of iron bacteria for the 324 extraction wells planned per year.[6] The Sio Silica dismissal of the detrimental effect of oxidizing conditions is not credible and not supported by any evidence.

Sio Silica drilling activities would contaminate the aquifers with iron bacteria and other detrimental microorganisms that would thrive in the aerobic environment caused by Sio Silica re-injection of water with entrained and dissolved air and by direct injection of air into the aquifer. The oxidizing conditions and subsequent detrimental effects would occur in the carbonate aquifer upon shale aquitard collapse. The evidence submitted here refutes the Sio Silica dismissal of the detriment of oxidizing conditions to both aquifers created by Sio Silica extraction operations.

The Hydrogeological report does not define what is meant by degradation. The Arcadis third party technical report states;[7]

"Based on the geotechnical information presented, as well as technical discussions with Sio Silica (6 September 2022) it is understood by Arcadis that the shale aquitard has the potential to collapse into the sand extraction."

Arcadis conclusion#5 identifies shale aquitard collapse as a critical failure mode.

Figure 1 shows fragments of shale in the sand piles extracted south of Vivian in the summer of 2019. The clumps of reddish and grey shale are consistent with collapse of the shale aquitard into the excavation cavity. The core log of well Bru 95-8 in the Sio Silica EAP Hydrogeological Report, at the extraction site south of Vivian, legal location SE32-10-8E, documents reddish brown shale in the aquitard consistent with the shale colour of figure 1.

Figure 1. Shale collected by concerned citizens near Vivian from Sio Silica extracted sand piles, spring 2020. *Images used with photographer's permission.*

Figure 1 provides direct evidence that the friable shale aquitard would collapse into the Sio Silica sand extraction cavities.

The geochemical analysis of the Hydrogeological Report identifies the shale aquitard as being uncertain with respect to acid generation and identifies significant selenium and heavy metal content in the shale aquitard. Selected geochemical results from the Hydrogeological Report for shale are summarized table 1

Table 1. Selected Heavy Metal and Acid Base Accounting Results for Shale Aquitard Samples

Data Name	Bru 121-1	Bru 146	Bru 95-8
Selenium (ppm)	13.1	<0.2	0.3
Arsenic (ppm)	30.4	13.3	24.2
Barium (ppm)	30	40	30
Chromium (ppm)	24	42	58
Lead (ppm)	13.1	7.4	4.6
Uranium (ppm)	30	11.65	0.4
Sulphur wt%	0.23	0.07	0.64
Carbonate Equiv. t CaCO3/kt	5.83	4.17	30.0
Acid potential tCaCO3/kt	7.2	2.2	20

Neutralization Potential tCaCO3/kt	10	5	25
NP/AP ratio	1.39	2.27	1.25
Acid generation status	uncertain	Non-PAG	uncertain

Table 1 demonstrates the shale aquitard contains significant amounts of heavy metals and sulphide that could form acid upon exposure to oxidizing conditions. The acid generation status of two shale samples were uncertain meaning that acid could form. These few samples were not taken over the entire 24-year project area. The core shale samples were not protected from air exposure immediately upon extraction and therefore could give an underestimate of the acid producing potential due to oxidation of sulphide. More samples are required over the entire 24-year Project area with strict samples procedures to prevent air exposure for a valid comprehensive geochemical analysis.

The sulphide content of the collapsed shale in the sandstone aquifer would form sulphuric acid when exposed to oxidizing conditions from the Sio Silica extraction operations. The calcium carbonate content may act to neutralize the sulphuric acid but in the confined region of the aquifer, neutralization would form carbon dioxide that could not vent. Some of the carbon dioxide would form carbonic acid lowering the pH and causing subsequent heavy metal release. Thus neutralization of the acid forming sulphide would not prevent heavy metal release from the shale fragments in the aquifer. The scenario of carbonic acid formation is documented in more detail in IR 002 DLN.

Selenium would be released from the shale fragments in the aquifer under oxidizing conditions independent of acid formation as demonstrated by the shake flask results of the geochemical analysis in the Hydrogeological Report. The shake flasks test results gave selenium concentrations above allowed limits in all formations tested.

Shale fragments from the aquitard would be extracted with the silica sand generating selenium, acid and heavy metal release in the water to be re-injected to the aquifer. Shale fragments in the silica sand in the slurry line would cause accumulation of selenium, acid and heavy metals in the in the slurry line loop as documented in IR 003 DLN.

The Sio Silica EAP did not document the detrimental geochemical effects of shale aquitard collapse. This failure to document is a major Project deficiency.

Request:

a) Complete state of the art three-dimensional geo-mechanical modeling of the shale aquitard within the formation. Determine the likelihood of shale aquitard collapse into the excavation cavity as a function of time after sand extraction.

b) Perform field tests of remedial measures to stabilize the shale aquitard above the extraction cavities. Remedial measures may involve grouting of the aquitard over the entire cavity opening.

c) Monitor the effectiveness of remedial measures using side scan sonar and/or test boreholes or other means over a significant time period of at least three months.

d) Determine the cost and the Project viability of remedial measures to stabilize the shale aquitard above the extraction cavities.

e) If the aquitard cannot be stabilized terminate the Project due to violation of Groundwater and Water Well Act Well Standards Regulation 3(1) that prohibits mixing of aquifer waters.

f) As requested in other DLN IRs, complete a comprehensive geochemical analysis involving at least 40 samples from all formations including and especially the sandstone over the entire 24-year project area. The geochemical analysis must include samples of oolite, concretions and interbedded shale occurring in the sandstone aquifer in the 24-year Project area. Strict samples procedures to prevent air and moisture exposure of samples must be implemented. A record of chain of custody from extraction to analysis must be provided.

g) If the aquitard can be stabilized, model the selenium contamination of sandstone aquifer that would occur from leaching of the shale aquitard upon exposure to oxidizing conditions induced by Sio Silica extraction operations. Ensure worst case conditions are modeled. Use the data from new comprehensive geochemical sampling and analysis in the modeling. For example the volume of sand for one cluster at 21000 tonnes of dry sand extraction using a density of 1.65 t/m^3 dry sand would be 12727.3 m^3. Using the sand fraction in the sandstone of 0.75 (0.25 water) the total volume of the extracted cluster would be 16970 m^3. Using the equation for the volume of a cylinder and weight is the product of volume and density, the weight of a 3 meter thick shale aquitard of density 1.8 t/m^3, for a 60 meter diameter cluster, would be 15268 tonnes. Using the Bru 121-1 value 13.1 ppm selenium in the shale if all dissolved the concentration in the excavation cavity would be 15268 x10^9 mg x 13.1 x10^{-6} /16970 m^3 = 11786 mg/ m^3= 11.8 mg/L. According to the extraction EAP, the drinking water standard for selenium is 0.01 mg/L while the allowed concentration for agriculture is 0.001 mg/L. Even if only 0.1% of the selenium dissolved the concentration in the cavity would be above drinking water standards. If the selenium concentration of sandstone aquifer water cannot be demonstrated conclusively to be below allowed limits terminate the Project.

h) If the aquitard can be stabilized, model the concentration of heavy metals in the aquifer that would occur from leaching by sulphuric and/or carbonic acid produced in the sandstone aquifer upon exposure to oxidizing conditions induced by Sio Silica extraction operations. Ensure worst case conditions are modeled. Use the data from new comprehensive geochemical sampling and analysis in the modeling. If the heavy metal concentration of sandstone aquifer water cannot be demonstrated conclusively to be below allowed limits terminate the Project.

i) As requested in other DLN IRs, measure the geochemistry of both aquifers including the concentration of all potential contaminants and harmful microbes before and after sand extraction and water re-injection. This measurement should be part of full-scale field tests of the latest well cluster design and the UV radiation and filtration system. The field tests must be completed before production can begin. If the measured concentration of contaminants and/or microbes, after extraction operations are above allowed limits, terminate the Project.

References:

1. Groundwater and Water Well Act Well Standards Regulation, 2015, https://web2.gov.mb.ca/laws/regs/current/_pdf-regs.php?reg=215/2015

2. Mechanism of Removing Iron and Manganese from Drinking Water Using Manganese Ore Sand and Quartz Sand as Filtering Material, Cai YA, Bi XJ, Zhang JN, He J, Dong Y, Wang HG. Feb 8;40(2):717- 723. Chinese. doi: 10.13227/j.hjkx.201806223. PMID: 30628335. https://pubmed.ncbi.nlm.nih.gov/30628335/

3. North Dakota State University Publications, Iron and Manganese Removal, WQ 1030, May 2019, https://www.ndsu.edu/agriculture/extension/publications/iron-and-manganese-removal

4. Investigation into the Cause of Iron-Related Clogging of Groundwater Bores Used for Viticulture in the Limestone Coast, South Australia by Birte Moser et al., Water 2021, 13(5), 683; https://doi.org/10.3390/w13050683, 3 March 2021 https://www.mdpi.com/2073-4441/13/5/683/htm

5. Controlling Micro-organism Growth in Compressed Air, A White Paper By Mark White Compressed Air Treatment Applications Manager, https://www.parker.com/Literature/IGFG/PDF-Files/WPCMGICA-00-NA-012021_POST.pdf

6. Sio Silica Supplemental Information Document #1 – Silica Extraction Method Vivian Sand Extraction Project June 2, 2022

7. Arcadis Manitoba Clean Environment Commission Technical Review of Sio Silica Corporation’s Environment Act Project Proposal Vivian Sand Extraction

Response:

a) Sio disagrees with the factual statements in the request and the premise of the question. Refer to Responses to the Technical Expert Reports – Geotechnical, filed November 29, 2022 issue 6.

b) Refer to Responses to the Technical Expert Reports – Geotechnical, filed November 29, 2022 issue 6.

c) Refer to Responses to the Technical Expert Reports – Geotechnical, filed November 29, 2022 issue 6.

d) Sio declines to respond to this request on the basis of its Responses to the Technical Expert Reports – Geotechnical, filed November 29, 2022 issue 6.

e) While the request is a matter of legal argument, refer to Responses to the Technical Expert Reports – Geotechnical, filed November 29, 2022 issue 6, Responses to the Technical Expert Reports – Hydrogeology, filed November 29, 2022 issue 7, and the response to CEC-IR-009.

f) See the response to DLN-IR-002(f), (p) and (q) and public comments for the Extraction Project, response #5 and #17.

g) Sio declines to respond as this request is based on the author's assumptions and Sio disagrees with the assumptions made.

h) Sio declines to respond as this request is based on the author's assumptions and Sio disagrees with the assumptions made.

i) DLN-IR-001(b), (d) and (f). Also see DLN-IR-004 (l) and DLN-IR-007 (oo).