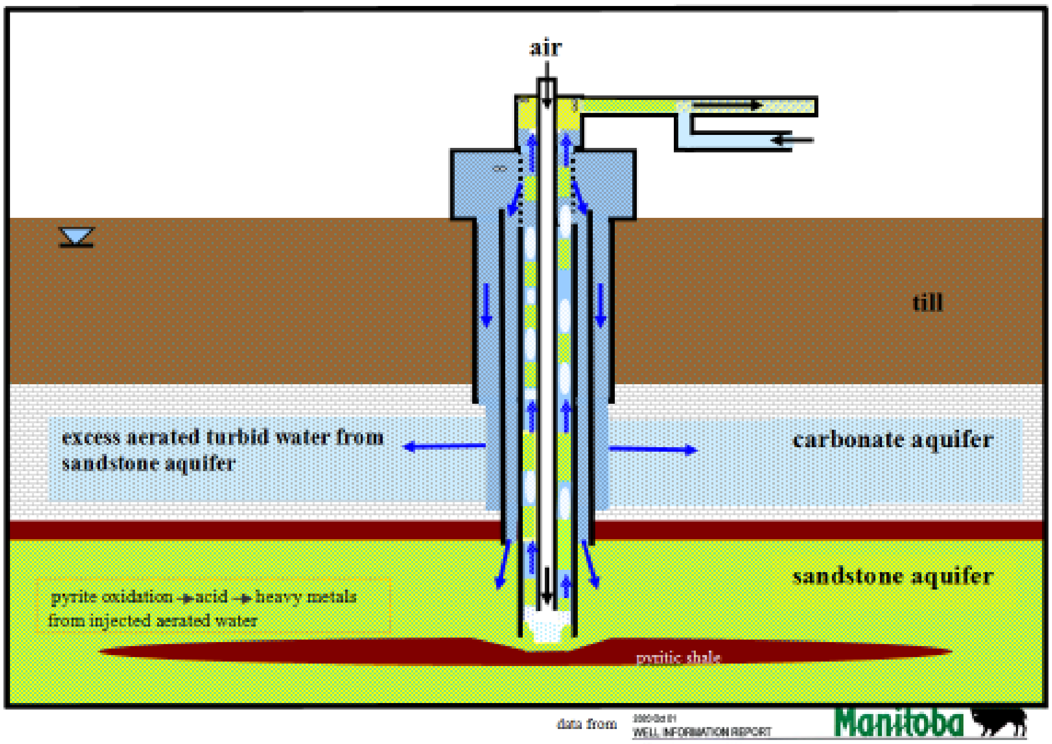
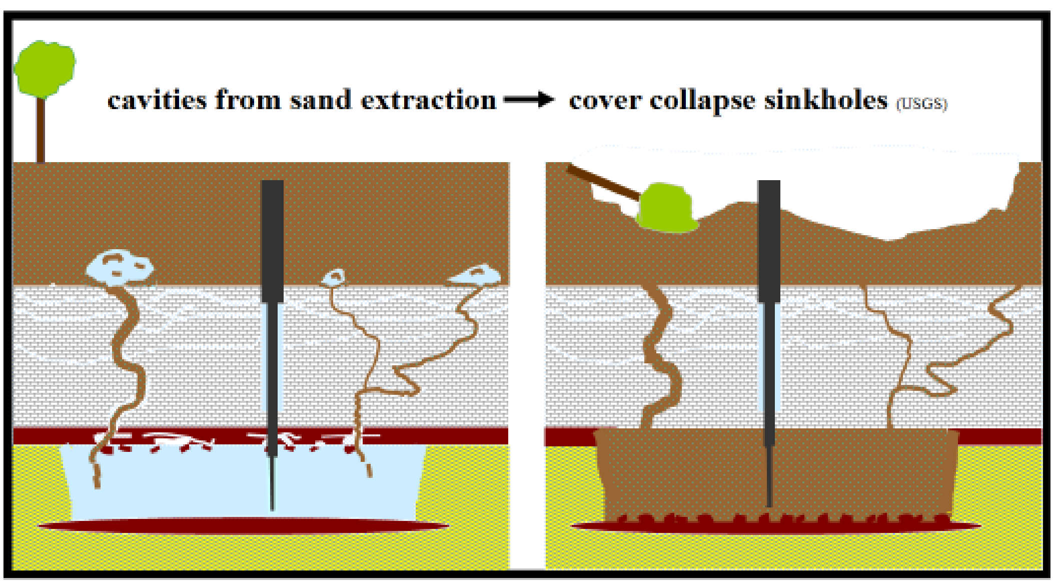
Evidence for Aquifer and Slurry Line Contamination and Land Subsidence From Vivian Silica Sand Extraction Wells





by D.M. LeNeveu, M.Sc. (biophysics), B.Ed., B.Sc. (hons. physics)

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Prepared for What the Frack Manitoba

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by
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February 16, 2021
On Behalf of What the Frack Manitoba

1. Overview

HD Minerals/CanWhite Sands Inc. (CWS) plans to extract silica sand from the Winnipeg Formation aquifer that together with the overlying carbonate aquifer supplies water to a large portion of south east Manitoba. The sand is to be extracted using air lift wells that would withdraw a mixture of air, sand and water from the sandstone aquifer of the Winnipeg Formation. Excess aerated water is to be returned to the formation. The sand is to be delivered to the CWS Vivian Sand Processing Plant by means of closed loop slurry lines. The sand is to be stockpiled and processed at the plant at Vivian, Manitoba, township SE32-10-8E. Silt and fine sand are to be removed in a clarifier tank at the processing pant and the water returned to the remote extraction locations to pick up more sand. A large number of extraction wells will be drilled to deliver 1.36 million tonnes of silica sand per year to the processing plant. After up to five days of extraction each well is to be sealed. The lifetime of the project is expected to be 24 years. CWS has over 80,000 hectares of mineral claims for sand extraction as shown in Figure 1. Not included in Figure 1 is the potential CWS extraction of silica sand from existing or future quarry leases over a larger area.

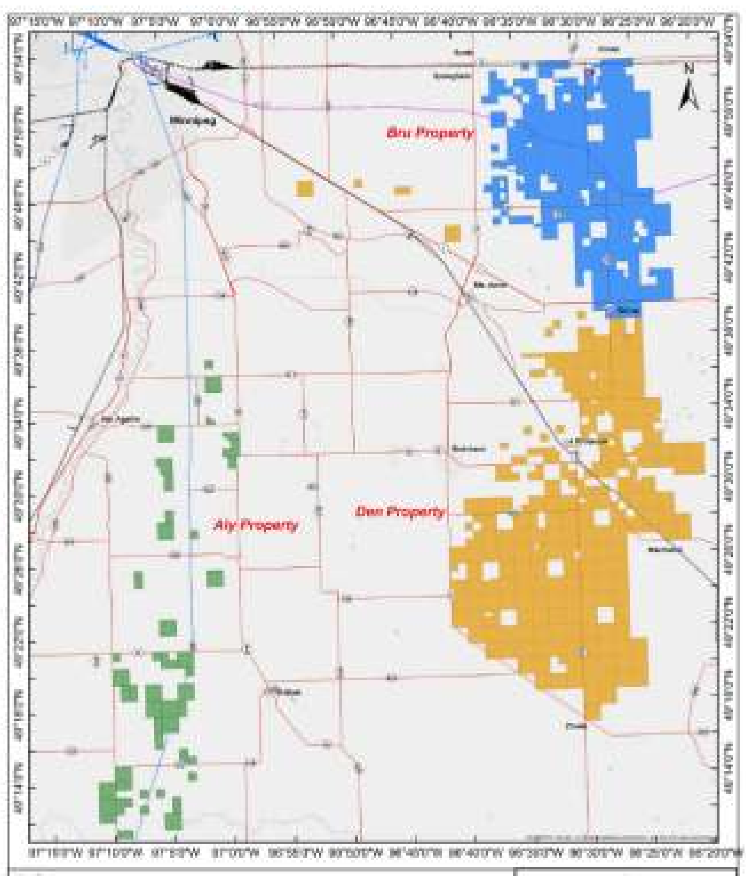

Figure 1. CWS mineral claims

2. Executive Summary

Mr. Somji, President and CEO of CanWhite Sands, in a letter to the Impact Assessment Agency of Canada (IAAC) of September 11, 2020 described the configuration of the CWS triple tube silica sand extraction well.[1] Air is to be introduced through an inner tube that is shorter than the surrounding second extraction tube so that air should stay in the extraction tube. Sand and associated water is to be withdrawn through the second extraction tube assisted by air lift from the air injection tube. Excess water is to be returned to the formation through the outer tube. Sand is to be pumped into a slurry line for delivery to the CWS silica sand processing facility near Vivian, Manitoba.

The construction, sealing and core logs of 42 CWS wells is given in Friesen Drillers well information reports obtained from Manitoba Groundwater.[2] Two of these wells with PID numbers of 199982, 197863 completed in the summer of 2018 at the Centre Line Road site township location SW19-10-8E where sand was extracted by CWS were indicated to be "*air lifting*" in the well records. Other wells at this site may have been also used for air lift sand extraction.

Excess water from air lift sand extraction is to be returned to the formation. Excess water must be injected into either the sandstone aquifer or the carbonate aquifer or both. The outer tube of air lift wells 199982 and 197863 terminate at the top of the carbonate aquifer with an open hole extending beneath. The outer tube of 8 other wells at the Centre Line Road site also terminate near the top of the carbonate aquifer with open hole extending beneath. It appears that these wells are constructed to inject excess water withdrawn with the sand into the carbonate aquifer. The mixing of water from separate aquifers would be a violation of the Manitoba Groundwater and Water Well Act. [13] A large amount of water injected into the carbonate aquifer would result in an unsustainable draw on the sandstone aquifer.

Excess water returned to the sandstone aquifer would be aerated from the air lift process. Air in the excess water would react with pyrite in the shale aquitard and shale layers and with marcasite (white pyrite) and pyritic oolite nodules in the sand generating acid. The presence of marcasite in the sand has been verified by certified laboratory results of samples of CWS extracted sand. Acid would mobilize toxic heavy metals in the shale and sand contaminating the sandstone aquifer.[3-12]

If all the excess water is pumped into the carbonate aquifer that water would be laden with fine sand and silt from the sandstone aquifer changing the water quality. If excess water were pumped into both aquifers the water in both aquifers would become contaminated with acid and heavy metals. If excess water were pumped into the sandstone aquifer only, the sandstone aquifer would become contaminated with acid and heavy metals. [3-12]

In the slurry line acid would form from oxidation of marcasite in the sand and from oxidation of pyrite in shale fragments and oolite nodules withdrawn with the sands. The acid would mobilize heavy metals into the slurry line water. Acid and heavy metals would also be withdrawn from the sandstone aquifer into the slurry lines if aerated excess water is returned to the sandstone aquifer. Acid and heavy metal bearing waste such as mud cakes from the clarifier tank in the processing plant and drill mud and cuttings from the numerous wells would require specialized disposal. Contamination in slurry line including highly toxic acrylamide monomer from the beak down of polyacrylamide in the clarifier tank, acid and heavy metals would accumulate in the recycled water of the closed loop system. The CWS EAP specifies the recycled water of the closed loop system is to be stored in an onsite tank over winter to avoid disposal. Eventually the recycled water would be too contaminated and too acidic to be used in the wash plant and would require disposal in an engineered tailings pond facility. The CWS EAP does not include any reference to disposal of waste or contaminated slurry line water that would be necessary over the 24 year lifetime of the project.

Figure 2 illustrates the scenario for aquifer and slurry water contamination and unsustainable draw on the sandstone aquifer for well PID 199982 at Centre Line Road.

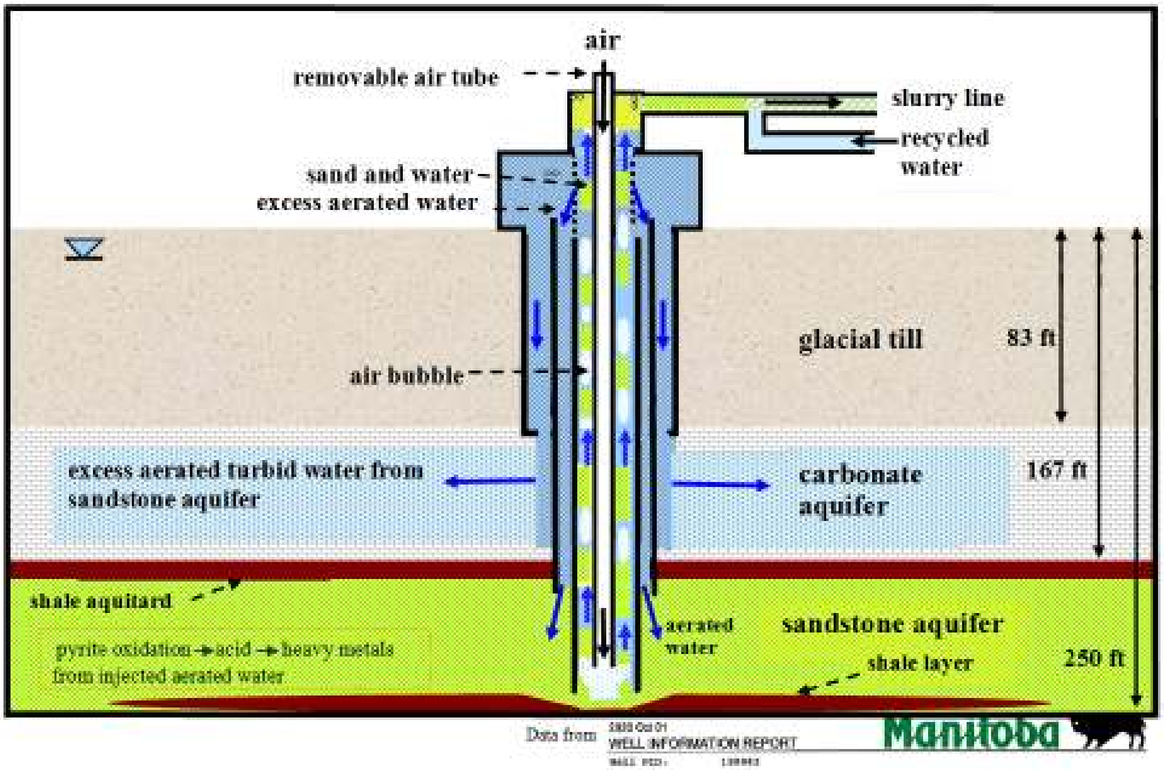

Figure 2. Aquifer and slurry water contamination scenario from interpretation of CWS well drilling record ID 199982 obtained from Manitoba Groundwater Section**.**

CWS well 203699 was completed on Aug. 9, 2019 in or near the LSL sand and gravel quarry at the junction of Oakwood Road and Highway 302, township location NW19-11-8E. The Manitoba Drainage Rights online water portal shows a temporary authorization for water use for HD Minerals/CWS at a second sand and gravel quarry near the junction of Highway 15 and Highway 302 less than one kilometre from the town of Vivian Manitoba (Figure 15). Local residents observed extracted silica sand piles in October 2021 at this location (Figure 16). There is no well record for the CWS silica sand extraction wells at the quarry near Vivian. Both these quarries are outside the CWS mineral claims and not part of the approvals process for the CWS Vivian Sand Facility Project and the upcoming CWS Vivian Sand Mine and Extraction Project under the Manitoba Environment Act. Unregulated contamination and mixing of aquifer waters could occur from CWS silica sand extraction wells over quarries throughout the extent of the Winnipeg formation.

Five wells completed in June 2019 at the site of the proposed Vivian sand processing plant are in the well records. Some of these wells have been used for silica sand extraction. Excess water extracted with sand at the Vivian site may have been returned to the formation or discharged on surface. The well records indicate excess water may have been returned to the carbonate aquifer in one well.

Since 2017 CWS has received 16 temporary authorizations from the Manitoba Drainage and Water Rights Licensing Branch to pump water to the surface at rates of between 350 to 1500 US gallons per minute. These temporary authorizations imply that water discharge occurred. A Google Earth image from June 7, 2019 shows piles of extracted sand surrounded by water at the Vivian location SE32-10-8E confirming surface discharge occurred (Figure 14). Discharged water from airlift sand extraction is liable to be contaminated with heavy metals and acid from oxidation of pyrite by air injected into the sandstone aquifer.

Surface discharges that occurred during exploration could also occur during production from leakage and spillage from CWS slurry lines and from the wash plant. As new wells are drilled about every five days, the slurry lines must be continually emptied and moved increasing the risk of spillage and leakage. Extremely toxic acrylamide monomer from the breakdown of polyacrylamide used in the processing plant clarifier tank could enter the water table from spillage.[14]

The well information records report sand collapsed into open holes drilled in the sandstone in two of the CWS air lift wells. Sand collapse indicates that sand will creep into extraction cavities decreasing the area of support for the overlying shale aquitard. The unsupported area of shale aquitard will likely eventually collapse into the cavities. Overburden pressure and the process of shale slaking would facilitate this collapse.[48,49] Land subsidence and sinkholes would be expected to occur as a result as shown in Figure 17 and Figure 18 and as illustrated on the cover page. The subsidence and sinkholes would increase each year as the area of CWS wells advance.

The required mine closure plan for this Project that should have been filed before commencement of advanced exploration in accordance with the Manitoba Mines and Minerals Act must include measures to minimize contamination of the aquifers and land subsidence. Provision of financial assurance to the Crown for rehabilitation must be provided.[15] The Mines and Minerals Act regarding the mine closure plan has not been enforced by the Manitoba Mines Branch despite a July 22, 2020 letter from Don Sullivan spokesperson for What the Frack Manitoba to the Manitoba Minister of Agriculture and Resource Development asking for compliance with Act. The failure to enforce the requirement for a mine closure plan was also included in the submission by D.M. LeNeveu to the CWS processing facility environmental review process under the Manitoba Environment Act.[12]

Several residents of Springfield Manitoba on Feb. 1, 2021, filed a report with the Director of the Manitoba Water Science and Management of suspected violations of the Manitoba Groundwater and Water Well Act.[13] The report includes complaints of deterioration of their well water quality since the start of CWS advanced exploration activities in the area. The suspected violations of the Manitoba Groundwater and Water Well Act include,

- contaminating and adversely affecting the quality of groundwater in the area of a well or test hole,
- allowing the interconnection or mixing of groundwater between the Winnipeg Formation and the overlying aquifer,
- failure to adequately emplace annular sealing at the time of well construction,
- failure to affix a well identification tag,
- failure to properly secure well covers,
- failure to issue separate well construction and sealing reports within the required time period, and
- failure to protect the sandstone aquifer of the Winnipeg formation from unsustainable draw.

We recommend this project be immediately halted until the mine closure plan and the investigation into suspected violations of the Manitoba Groundwater and Water Act are completed and made publicly available for the review process under the Manitoba Environment Act. The mine closure plan must address all processing and extraction risks, including the risks described in this report. We recommend a full public panel review process hearing for both the silica sand processing facility and the mining extraction be undertaken under a quasi-judicial independent body such as the Manitoba Clean Environment Commission. The mine closure report and the findings from the investigation of suspected violations of The Manitoba Groundwater and Well Water Act must be provided for the panel review process.

3. Approval Process

Under the Manitoba Environment Act, CWS Environment Act Proposal (EAP) for the CWS Vivian Sand Processing Facility was filed in the public registry 6057.00 on July 2, 2020.[26,29] The information filed in the EAP was restricted solely to the processing facility. In the EAP no detailed engineering drawings with dimensions of buildings and details of wash plant or dry plant operations were given. Extraction activities that would have an implication on the operation and design of the processing facility were omitted. The EAP states,

"*A separate Environment Act licence application will be submitted later this summer for the silica sand extraction activities that will supply the Processing Facility with sand ('Extraction'). Extraction will involve temporary water well drill holes that are located on small sites for relatively brief periods of time. Water and sand exist naturally together in the formation and, assisted only by injection of air, they will flow to the surface as slurry. The slurry will be transported to the Processing Facility using a moveable slurry line, which will be re-located from site to site as the water well drilling rigs relocate. The slurry line will be included in the project description for extraction. CanWhite's permanent buildings, facilities and infrastructure are part of this sand Processing Facility Project and are included in this application*."

The sandstone formation from which the sand is to be extracted is known to have sources of pyrite. In a wet environment, pyrite will react with air to form acid.[3,4,5] The acid can mobilize heavy metals causing contamination. This is a well known problem in mining called acid drainage.[5] The brief disclosure in the CWS EAP of air injection to the aquifer is gravely concerning. I described in my submission to the Manitoba public review of the CWS processing facility, how the injection of air would react with the pyrite in the formation causing heavy metal contamination of the aquifer.[12] I reported that shale fragments and pyritic oolite was observed by local residents in sand piles near Vivian extracted by CWS during advanced exploration activities as shown Figure 3.

Figure 3. Shale fragments interspersed in CWS extracted sand near Vivian Manitoba

Samples of sand taken by residents were sent for analysis in an accredited laboratory. The analysis showed the presence of sulphide in the sand. From other reports the sulphide is known to be from marcasite (white pyrite) coating the sand grains.[7,11] The sources of pyrite extracted with the sand will be exposed to air and transported in the slurry lines to the CWS processing facility. The formation of acid and heavy metals would affect the operation of the facility and may require the necessity of engineered tailings ponds for the disposal of acid mine waste from the facility such as mud cakes from the clarifier tank and drill mud and cuttings from the numerous CWS wells. An engineered tailings facility was not included in the CWS EAP for the Vivian Sand Processing Plant.

The evidence I submitted to the Manitoba public review process for CWS processing facility was also submitted to the Impact Assessment Agency of Canada (IAAC) as part of a request for designation of the CWS Vivian Sand Project for a federal environmental review under the Impact Assessment Act. To counter the information presented in my submission and other submissions to the Manitoba public review and to the IAAC, Mr. Somji, CEO of CanWhite wrote a letter to the IAAC on Sept. 11, 2020.[1] His letter was posted in the public registry 6057.00 for the CWS Vivian Sand Facility.

The IAAC did not designate the Vivian Sand Facility Project for federal impact assessment mainly due insufficient information provided in the Vivian Sand Processing Facility Review Process.[1] Federal designation may be reassessed based on the completeness of information provided by the proponent for the upcoming CWS mine extraction approval under the Manitoba Environment Act. The CWS mine extraction process will not under go an independent technical review under the Clean Environment Commission of Manitoba. This report is being submitted in advance of the Manitoba approvals process for the CWS Mine Extraction Project in an endeavour to ensure that the important technical information documented here is fully addressed.

4. Excerpt from Mr. Somj's Letter of September 11, 2020 to the IAAC

Mr. Somji's letter to the IAAC of September 11, 2020 states;[1]

"*Water well drillers around the world, and more specifically in Manitoba, utilize air to clean out sand from newly drilled and producing water wells. This method has been used for over 50 years and is proven to not harm the formation or water quality. Building upon this process CWS has developed a patented sand lift system where sand is brought to surface with air and associate aquifer water is left in the aquifer. A net zero solution, CWS has proven the ability to not remove aquifer water while harvesting the sand, therefore there is no anticipated water draw from the aquifer or need for water disposal or discharge at surface.*
On private lands under access agreement, a standard 25 cm well is drilled to formation and cemented in place to preserve the existing aquitard. A second 15 cm extraction tube is placed inside the wellbore to the formation. Inside the 15 cm extraction tube an air introduction tube is placed. The air introduction tube is shorter than the extraction tube so the air stays within the extraction tube. As air is introduced into the extraction tube it immediately rises to surface. This movement creates momentum to the surface bringing up the associated fluid and solids. The movement creates a suction effect at the bottom of the extraction tube due to a natural lower pressure inside the extraction tube versus the natural pressure of the geologic formation. This pressure differential allows the formation to "push" the sand into the extraction tube. The end result is very similar to drinking a slush drink with a straw. As the sand is removed the associated water returns to the formation through the annular space between the 25 cm and 15cm tubing. At no time is the formation subject to overpressure and as the sand is delivered wet no dust is generated.

The Harvest process takes an estimated 5 days per well after which the wells are abandoned under the standards defined by the Manitoba's Mines and Minerals Act, Drilling Regulation, 1992, and the surface is immediately remediated. As the harvest sites are temporary and portable, the site returns to its natural state within weeks of CWS harvest completion. No traditional mining activities take place and therefore there are no open pits and no underground operations."

No data, references or evidence were submitted to support the information in Mr. Somji's letter to the IAAC. Mr. Somji's letter was submitted at a time when no response from the public or the Technical Advisory Committee could be made via the Manitoba environmental review process under the Manitoba Environment Act. A rebuttal to Mr. Somji's letter I submitted to the IAAC could not be filed on the Manitoba Public Registry for the project because the public comments period had already closed.[6]

5. Air Lift Pumps

Air lift pumps have long been used for dredging, sludge pumping, deep sea metallic nodule mining and other uses.[16] In dredging and deep sea-mining operations the air-lift pump tube must be moved to achieve sediment removal. A schematic of a typical air lift pump illustrating the air lift bubbles is shown in Figure 4a. The air injection tube is external to the extraction tube in Figure 4b. The size of the bubbles increases as they rise due to the drop in fluid pressure. In Mr Somji's description the air injection tube is within the extraction tube as shown in Figure 4b. In Figure 4b, as in Mr. Somji's description, air injection occurs above the end of the extraction tube so that air remains within the extraction tube.

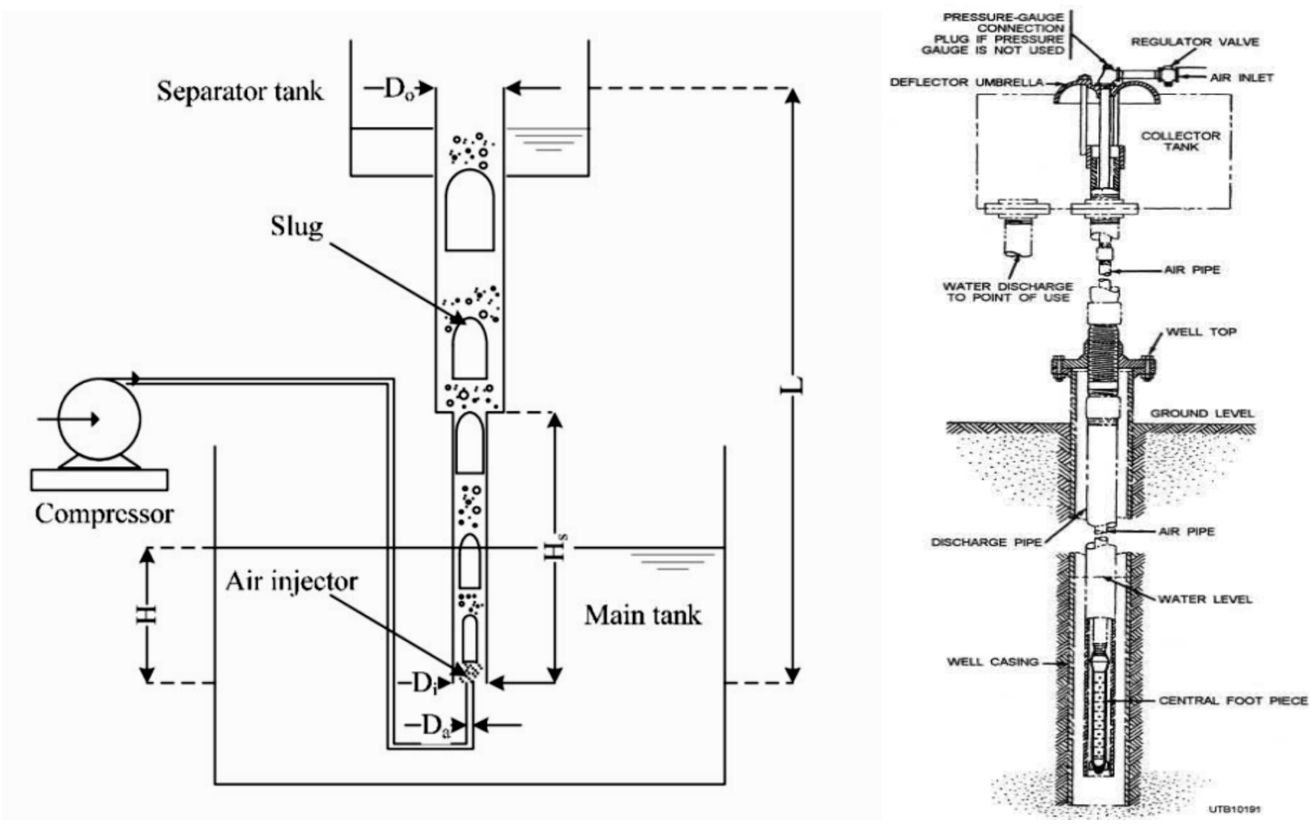

Figure 4. a. Schematic of a typical air lift pump from Hanafizadeh and Ghorbani, 2011[16] **b**. air lift pump showing central air tube and foot piece for air dispersion[17].

Excess water extracted with the sand according to Mr. Somji's Sept. 11, 2020 letter to the IAAC is to be returned to the formation through an outer well tube. Returning the excess water to the sandstone aquifer would be problematical. Much of the returned excess water would likely be sucked in with the sand in the adjacent extraction tube. To avoid this problem the design of many CWS wells have the outer tube terminating just below the start of the carbonate aquifer. A drilled open hole penetrates into the carbonate aquifer terminating above the shale aquitard. With this configuration returned water would enter the carbonate aquifer above the impermeable shale layer thus avoiding the problem of being sucked into the sand extraction tube in the sandstone aquifer. The much higher transmissivity of the carbonate aquifer makes it more suitable for excess water return than the sandstone aquifer.[44] Excess water returned to the carbonate aquifer, would carry fine sand and silt in some cases heavy metals and acid from pyrite oxidation in the sandstone aquifer. Sandstone aquifer water would be intermingled with the carbonate aquifer water which is not allowed according to the Manitoba Groundwater and Water Well Act Regulations.

6. Well Record for Triple Tube Air Lift Extraction Well ID 199982

In the well records for CWS wells there are four drilling reports for a triple tube air lift extraction well, located at the Centre Line Road Site.[2] The drilling report for well 199982 is reproduced in Figure 5.

2020 Oct 01
WELL INFORMATION REPORT

Manitoba

Well PID: 199982
Location: SW19-10-8E
UTMX:679941.8 UTMY:5524035.4 XY Accuracy:1 EXACT [<5M] [GPS]
UTMZ:277 Z Accuracy:4 FAIR - Shuttle at Centroid
Owner: CANWHITE SANDS LTD. / HD MINERALS

Driller: Friesen Drillers Ltd.
Well Name: BRU 82-5 / BH 6-18
Date Completed: 2018 Sep 28
Well Use: TEST WELL
WATER USE: Other
Well Status: SEALED Aquifer: SANDSTONE

REMARKS:
WITN:002472; #2650, 645 - 7TH AVENUE SW, CALGARY AB, T2P 4G8.
PRODUCTION AND OTHER: MINERAL EXPLORATION / SAMPLING. AIR LIFTING.
PUMPING TEST AT HIGHER DISCHARGE RATES TO BE COMPLETED. MOC:DROT.

WELL LOG (Imperial units)

From	To(ft.)	Log
0.0	18	BROWN TILL
18.0	83	GREY TILL
83.0	167	BROWN LIMESTONE
167.0	177	RED, GREEN SHALE
177.0	244	WHITE SANDSTONE
244.0	250	RED SHALE

WELL CONSTRUCTION

From	To(ft)	Const.Method	Inside Dia.(in)	Outside Dia.(in)	Slot Size(in)	Type	Material
0.0	85.0	CASING	23.5	24.0		WELDED	STEEL
85.0	158.0	OPEN HOLE	23.0				
0.0	180.0	LINER	19.5	20.0		WELDED	STEEL
0.0	190.0	LINER	15.5	16.0		WELDED	STEEL
190.0	250.0	LINER	15.5	16.0		WELDED	STEEL

0.0	85.0	SURFACE SEAL 20.0	23.5	HOLEPLUG	BENTONITE
0.0	170.0	SURFACE SEAL 16.0	19.5	HOLEPLUG	BENTONITE

Top of Casing: 0.0 ft above ground

WELL SEALED
Sealed Date: 2020-Jun-18

0.0	170.0	SURFACE SEAL 16.0	19.5	HOLEPLUG	BENTONITE

Top of Casing: 0.0 ft above ground

WELL SEALED
Sealed Date: 2020-Jun-18
Sealed By: FRIESEN DRILLERS LTD.
Sealed Type: CONTRACTOR - DRILLER
Sealer Remarks: CASING CUT OFF AT 2 FT BGS.
Outside Sealed

Figure 5. Friesen drilling record for triple tube air lifting well ID 199982 from Manitoba Groundwater

The configuration of triple tube air lift extraction well of Figure 2 and Figure 5 does not conform to the description in Mr. Somji's letter to the IAAC of Sept. 11, 2020. The outside diameter of the extraction well tube is given as 24 inches, much larger than the outside diameter of 25 cm. (9.8 inches) given in Mr. Somji's letter. The inner 16 inch diameter steel tube of well 199982 extends into a red shale layer. Red shale fragments from the hole drilled six feet into the red shale layer are likely to be extracted with the sand. Shale fragments have been observed in the CWS extracted sand piles by local residents as shown in Figure 3.

A removable tube was likely used to inject air into the inner 16 inch diameter steel tube as shown in Figure 2. Otherwise the 16 inch diameter steel tube would have injected air directly into the sandstone far below the second 20 inch diameter steel tube that terminates three feet below the shale aquitard. Such a configuration would have violated the assertion in Mr. Somji's Sept. 11 letter that the air introduction tube is shorter than the adjacent extraction tube.

The 24 inch diameter outer tube terminates at 85 feet below ground surface two feet below the start of the limestone. A 23 inch diameter open hole extends 73 feet into the limestone below the outer tube. This configuration indicates that the well was designed for excess water taken from the sandstone aquifer to be injected the carbonate aquifer.

The second twenty inch diameter tube terminates three feet into the white sand layer. Excess aerated water could be injected into the sandstone from this tube. Excess water according to the design for well 199982 could be injected into both aquifers. Air in the excess water injected into the sandstone would oxidize the pyrite in the shale aquitard immediately above and the marcasite in the sand. Excess water injected near the top of the sandstone could act to push sand toward the extraction tube terminating in the red shale layer below. This aerated water would eventually contact and oxidize the red shale layer. A photograph of well 199982 taken in the spring of 2020 before it was cut off and sealed is show in Figure 6.

Figure 6. CWS triple tube air extraction well 199982/002472 at Centre line Road site and an unidentified well Centre Line Road showing visible surface sealing between the outer casing and the adjacent inner casing**.**

Note that sealing of well 199982/002472 did not occur until June 18, 2020, almost two years after completion in September 28, 2018. Sealing outside the external casing and inside the tubes did not appear to occur until June 18, 2020 according to the records. The fact that the three tubes remained open and unsealed until the sealing date of June 18, 2020 is verified by the photograph of Figure 6 taken May 31, 2020. The surface of the water table was visible inside the unsealed tubes. An unidentified well with no well tag and visible surface sealing between the outer and adjacent steel casing is also shown in Figure 6 at the Centre Line Road site. The photograph of the unidentified second well of Figure 6 verifies that if well 199982 had annular sealing between the steel casings, it would have been visible.

The casings for well 199982/002472 were cut off two feet below ground upon sealing on June 18, 2020. Combining the sealing report and the well construction report long after the completion of the well is a violation of the Manitoba Groundwater and Water Well Act.[13] This violation makes it impossible to determine when the annular sealing between the triple tube casings was emplaced by means of the well information report. The well photograph, witness accounts and a photograph of another well with annular sealing between the outer and adjacent steel tubes establishes that the annular spacing between steel casing in well 199982 were open and functional at the time of sand extraction.

Well 199982 had no affixed well tag. The well was identified as PID 199982 WINT 0002472 by the unique triple tube diameters in the well records that match the measurement shown in Figure 5. Both wells shown in Figure 6 as well as many others at the Centre Line Road site were left improperly covered. Mr. Somji in his letter to the IAAC of Sept. 11, 2020 claimed that vandalism occurred on CWS unattended drill sites. Figure 6 shows the cover for the inner tube was partially welded on. Specialized equipment such as a cutting torch would have been required to remove well covers over the outer well tubes. Attributing the lack of proper covering of the well to vandalism is not credible. Inadequate well covering and failure to affix well tags are violations of Well Standards Regulation 21/2015 of the Manitoba Groundwater and Water Well Act.[13]

The aquifer contamination scenario for the triple tube configuration corresponding to well ID 199982 in the Friesen drilling records for CWS wells is shown in Figure 2.

7. Well Record for Triple Tube Air Lift Extraction Well ID 197859

Well 197859 at Centre Line Road is similar in construction as 199982 with three nested steel tubes. The outer 12.5 inch diameter tube terminates three feet below the start of the limestone with 12.0 inch diameter open hole beneath until 6 feet below the termination of the limestone. The second 8.6 inch diameter tube terminates 15 feet below the shale aquitard in the white sand layer. The third 6.6 inch diameter tube extends to a depth of 238 feet terminating 4 feet above the bottom of the white sand layer. An open hole is drilled further through a hard white sand layer and a layer of green shale. The well information record for well 197859 is reproduced in Figure 7.

2020 Oct 01

WELL INFORMATION REPORT

Manitoba

Well PID:	197859
Location:	SW19-10-8E
UTMX:679884.9	UTMY:5524057.9 XY Accuracy:1 EXACT [<5M] [GPS]
UTMZ:277	Z Accuracy:4 FAIR - Shuttle at Centroid
Owner:	CANWHITE SANDS LTD. / HD MINERALS
Driller:	Friesen Drillers Ltd.
Well Name:	BRU9
Date Completed:	2018 Jun 05
Well Use:	OTHER
WATER USE:	Other
Well Status:	SEALED Aquifer: OTHER

REMARKS:
WITN:000712; #2650 - 645 7TH AVENUE S.W., CALGARY AB, T2P 5G8.
PUMP TEST DONE AFTER DRILLING TO 160 FT. MOC:DROT;

WELL LOG (Imperial units)

From	To(ft.)	Log
0.0	25	BROWN TILL
25.0	84	GREY TILL
84.0	166	BROWN LIMESTONE
166.0	171	RED SHALE
171.0	242	WHITE SANDSTONE
242.0	247	WHITE HARD SANDSTONE LAYERS
247.0	250	GREEN SHALE

WELL CONSTRUCTION

From	To(ft)	Const.Method	Inside Dia.(in)	Outside Dia.(in)	Slot Size(in)	Type	Material
0.0	87.0	CASING	12.0	12.5		WELDED	STEEL
87.0	160.0	OPEN HOLE	12.0				
0.0	187.0	CASING	8.0	8.6		WELDED	STEEL
0.0	217.0	LINER	6.0	6.6		WELDED	STEEL

217.0	238.0	LINER	6.0	6.6	WELDED	STEEL
238.0	250.0	OPEN HOLE		4.0		
165.0	170.0	ANNULAR FILL	6.6	8.0		CEMENT

Top of Casing: 2.0 ft above ground

PUMPING TEST
Date : 2018 Jun 05 Pumping 360.0 Imp. gallons/minute
Water level before test : 15.9 ft below ground
Water level at end of test : 27.2 ft below ground
Test duration: 1:00:00
Test Zone: from 87.0 ft to 250.0 ft

WELL SEALED
Sealed Date: 2020-Jun-17
Sealed By: FRIESEN DRILLERS LTD.
Sealed Type: CONTRACTOR - DRILLER
Sealer Remarks: CASING CUT OFF AT 2 FT BGS

From	To(ft)	Outside Dia.(in)	Sealed Material
0.0	40.0		BENTONITE
40.0	65.0		PEA GRAVEL
60.0	70.0		BENTONITE
70.0	85.0		PEA GRAVEL
85.0	90.0		BENTONITE
90.0	105.0		PEA GRAVEL
105.0	150.0		BENTONITE
150.0	175.0		PEA GRAVEL
175.0	190.0		BENTONITE
190.0	230.0		PEA GRAVEL
230.0	250.0		BENTONITE

Figure 7. CWS Triple tube air lift sand extraction well 197859 at Centre Line Road

Well 197859 is not designated as air lifting in the remarks section as was well 199982. The construction of well 197859 is similar to 199982 indicating both were air lift wells used for the sand extraction with a removable air injection tube. An annular cement seal was emplacement at a depth of 165 to 170 feet at the level of the shale aquitard. The cement seal across the aquitard would prevent interchange of aquifer water across the aquitard as is required by the regulations of the Manitoba Groundwater and Water Well Act and would prevent discharge of excess water into the sandstone aquifer. No sealing is shown external to the 8.6 diameter steel liner across the aquitard. According to the well information report the outer tube and the open hole below into the carbonate aquifer remained unsealed at the time of construction. Well 197859 appears to be designed to discharge excess water into the carbonate aquifer thus mixing aquifer waters. The pump rate of 360 imperial gallons per minute indicates that a large draw would occur on the sandstone aquifer.

The 197859 well information report shows sealing did not occur until June 17, 2020 more than two years after completion. The annular placement of alternating layers of bentonite and pea gravel sealing material is not given. Reporting surface sealing and well construction information together in the same report two years after the completion date is a violation of Wells Standards 215/2015 of the Manitoba Ground Water and well Water Act.

Well 203682 at Centre Line Road completed on Dec. 15, 2018 has three steel tubes. The outer 20 inch diameter tube terminates at 85 feet deep at the start of the limestone layer. Inside the outer tube is 16 inch diameter tube terminating at 115 feet in the limestone which terminates at 161 feet. Below the outer 20 inch diameter tube a 19 inch diameter open hole extends the remaining length of the well terminating in a 18 foot thick shale layer at 263 feet deep. Two regions of cement annular fill are indicated one terminating at 115 feet deep and the other at 170 feet at the end of the shale aquitard. A comment states an 11 foot cement plug was placed at 164 feet just below the start of the shale aquitard. The sealing does not specify which annuli the cement seals were emplaced. A 10 foot diameter inner steel casing penetrates from the surface to 204 feet followed by a well screen from 204 feet to 245 feet. The sandstone layer extends from 171 feet to 245 feet. The well was sealed on Aug. 23, 2020. The seal emplacement location is not specified. If this well were used for air lift sand extraction it appears to be constructed to allow water return in the carbonate aquifer. The lack of information on the placement of the cement seals makes it impossible to determine the configuration for excess water return.

The report for well 197863 at Centre Line Road SW19-10-8E indicated as air lifting, shows a double tube well with the four inch diameter inner steel tube terminating 12 feet into an unusual 86 foot thick multi shale aquitard layer. This well shows only a thin two foot layer of sandstone before a seven foot layer of mixed sand and shale layers followed by a 58 foot thick layer of white shale and a ten foot layer of black sandstone terminating in granite 326 feet below the surface. Similar to well197862 around the inner liner presumably for air injection into the sandstone aquifer by a removable air tube is a five inch diameter open hole to a depth of 326 feet. An 8.6 inch diameter steel outer casing extends 86 feet terminating two feet into an 81 foot thick limestone layer. A cement surface seal extends to 80 feet followed by annular fill to 160 feet. Two shale traps are given at the level of the shale aquitard. The placement of the surface seal and annular fill is not given. Similar to well 197862, the construction of well 197863 indicates that excess water from sand extraction would be discharged into the carbonate aquifer through the open hole penetrating the limestone layer below the outer well tube. The sand layer in well 197863 is only 7 feet thick mixed with shale layers. Any sand extracted by this well would have a large amount of shale fragments intermixed.

Well 197863 with no significant white sand layer demonstrates the wide variation in white sand thickness and shale layer location within the sandstone aquifer. The pervasive presence of shale below the aquitard contradicts Mr. Somji's assertion in his Sept.11th letter to the IAAC that pyrite is never present in the white sand layer. Well 197863 is labelled as active. The information record 197863 indicates that CWS wells might not always be properly sealed allowing the potential for surface contamination including fecal matter to penetrate into the carbonate aquifer.

The outer well tube of six other wells at Centre line Road, 200818, 204173, 233688, 203678, 203682 and 203691 terminates near the start of the limestone layer with open hole beneath. These wells all are designed to potentially return excess water to the carbonate aquifer. All have an inner tube extending into the white sand layer below the shale aquitard except well 203678 that has an open hole extending into the white sandstone layer.

In summary all nine wells in the record for Centre Line Road are designed to allow excess water extracted with silica sand to be pumped into the carbonate aquifer depending on the nature of the annular sealing. Air is likely to be introduced by a central tube that is removed after air injection and is therefore not shown in the well construction. The documentation of the location and timing emplacement of annular sealing is not adequate to determine the potential for excess water return to the formation. Excess water from sand extraction wells with sealed annular spaces would be discharged to the surface. One well 199982 may be constructed to allow excess water to be pumped into the sandstone aquifer. Pumping into the carbonate aquifer water withdrawn with the sand from the sandstone aquifer violates Well Standards Regulation 21/2015 the Manitoba Groundwater and Water Well Act.

8. Other wells designated as air lift in the well records

Table 1 gives the information on other wells designated in the well records as "*air lifting*"

Table1. Wells outside Centre Line Road (CLR) designated as air lift

Well PID number	Township	Description
197860	SW14-10-7E	steel outer casing into limestone, open hole below to bottom of 13 foot thick shale aquitard – active not sealed completed May 15, 2018, 3 km SW of CLR
197858	NE15-10-7E	steel outer casing into limestone, open hole below to bottom of 15 foot thick shale aquitard – active not sealed completed June 7,2018, 3 km S CLR
197923	SW7-10-8E	steel outer casing to limestone with open hole beneath to granite at 338 feet hole caved in from 185 feet to 338 feet in 59 feet of white sandstone followed by shale - well is located 3 km SW CLR
197862	SW18-10-8E	Steel outer casing to limestone with open hole beneath to 300 feet into shale, inner 2.0 inch steel liner steel liner from surface to 220 feet terminating 42 feet into a 59 foot white sand layer – well is located 2 km S CLR

Wells 198760, 197858 and 197923 were constructed with no means to discharge excess water from sand extraction in to the formation. Excess water extracted during sand air lifting would have been discharged to surface or returned to the formation through a separate injection well. Well 197862 was constructed so that excess water from sand air lifting could have been discharged via the annular space between the outer casing and the liner into the carbonate aquifer. Wells 197860 and 197858 are still labelled as active and not completely sealed more than two years after completion. These two wells further illustrate CWS wells might not always be properly sealed allowing the potential for surface contamination including fecal matter to penetrate into the carbonate aquifer. The open hole in well 197923 caved in illustrating the sand pillars separating the cavities from sand extraction will likely gradually slump into the cavities increasing the unsupported area above increasing the risk of subsidence

9. Water draw on the sandstone aquifer

Excess water extracted with sand from the sandstone aquifer and returned to the carbonate aquifer could create an unsustainable draw on the sandstone aquifer once the CWS continuous mining of sand begins.

The water to sand volume flow rate has been reported to be between 1.4 and 2.5 for a conventional air lift pump for sand extraction. There is no intended water discharge in the closed loop water recycling system for the proposed CWS sand processing facility except for the 15% water in the sand stockpiles reported in the CWS EAP. The 0.15 water to sand ratio in the sand stockpiles is small compared to the expected water to sand ratio extracted by the air-lift well thus almost all water extracted with the sand would be returned to the formation. The specified sand production rate for the CWS Processing Facility is 1.36 million tonnes per year according to the CWS EAP. Based on a dry sand density of 1.65 tonnes per cubic meter and a water to sand extraction ratio of 1.4 to 2.5 (from Srodowiska et al., 2018),[18] about 1.5 million cubic meters of contaminated water per year could be pumped into the carbonate aquifer from the sandstone aquifer.

An email of Jan.19, 2020 from the Manitoba Drainage and Water Rights Licensing Branch stated,

"*I can confirm that HD Minerals Ltd./CanWhite Sands has submitted 16 requests for Temporary Authorizations in order to complete a borehole and hydrogeological testing program as part of their mineral claims in various areas throughout the province since 2017. The Temporary Authorizations (not Water Rights Licenses) provided permission to drill exploration wells and conduct short-term pump testing. Authorizations were issued for time frames of several weeks to several months. Pumping rates ranged from*

350 USgpm to 1500 USgpm. Only two (2) of these authorizations remain active and the remaining fourteen (14) are completed and have expired."

Copies of letters from The Manitoba Drainage and Water Rights Licensing Branch to personnel from HD Minerals/CWS authorizing the withdrawal and diversion of water from CWS testing boreholes in Springfield, La Broquerie and for a quarry near Vivian outside the CWS claim area have been obtained. A summary of the information in the letters is given in Table 2.

Table2. Summary of the information in the temporary authorization letters from Manitoba Drainage and Water Rights Licensing Branch.

Start Date	Expiry Date	Locations	Total allowed withdrawal (cubic meters/ (persons for100days))	Maximum Withdrawal rate (Litres per minute/USGPM)	Number of boreholes
June 13, 2017	Dec. 31, 2017	NE 19&24-10-8E, SW 27,18&7-10-8E	1365/41	378.5/100	5
June 13, 2017	Dec. 31, 2017	Extended to SE 18, SW 19 and NW 17-10-8 E and SW 14 and NE 15-10-7E	1365/41	378.5/100	Not given
Aug.4, 2017	Dec.13, 2017	NE 19&24 10-8E SW27,18 and 7-10-8E,SE18,SW19 and NW 17-10-8E and SW and NE 15-10-7E	Same as above	Same as above	Not given
May 3, 2018	May 3, 2019	Same as above	Same as above	Same as above	Not given
June 21, 2018	May 3, 2019	SE29-10-8E W1/2 29-10-8E	Same as above	Same as above	Not given
Oct.9, 2018	Apr. 30, 2019	La Broquerie (locations not given)	54,000/1641	3785.41/1000	9
March 26, 2019	Sept.30, 2019	S1/2 32-10-8E	24,000/729	3785.41/1000	4
April 11, 2019	Sept.30, 2019	Same as above	Same as above	5678.12/1500	Not given
May 21,2019	June 30, 2019	SW19-10-8E	182/5	3028.3/800	Not given
Aug. 16, 2019	Sept.30, 2019	SW19-10-8E	23,000/699	2650/700	5
Feb.20,2020	Aug.31, 2020	SW5-11-8E Q	25,000/760	2271.25/600	7
June 18,2020	Oct. 31, 2020	SE 32-10-8E	25,000/760	2271.25/600	3
Oct.5,2020	Apr. 30, 2021	SW5-11-8E Q	3,800/116	1514.16/400	2

The Temporary Authorizations require that CWS correct any water supply problems or provide temporary water supply to anyone whose well(s) are negatively impacted as a result of pumping. Q indicates quarry near Vivian outside the CWS mineral claim area.

The well information record for triple tube well 197859 at Centre Line Road SW19-10-8E gives a pump rate on June 5, 2018 of 360 IGPM (432 USGPM). This pump rate is consistent with the rates given in the email from the Manitoba Drainage and Water Rights Licensing Branch and verifies the large rates at which water and sand will be withdrawn.

An average of three CWS wells operating concurrently for 220 days a year would withdraw a total of from 0.4 to 1.8 million cubic meters of excess water per year at the rates given in the email from Manitoba Drainage and Water Licensing Branch and confirmed by the data in Table 2. The email verifies the large amount of contaminated water that could be withdrawn from the sandstone aquifer and injected into the carbonate aquifer. About 200,000 cubic meters of water per year would also be drawn from the sandstone aquifer for the 15% water in the sand stockpiles at the processing plant. A loss of more than one million cubic meters of water per year would be far beyond the sustainable limit of the sandstone aquifer.[19,20] Such a large draw would irreparably damage the sandstone aquifer in violation of Manitoba Groundwater and Water Well Act.

Even if the excess water were returned to the sandstone aquifer during extraction, the aerated water would react with pyrite in the aquitard and the sandstone. Oxidation of the pyrite would create acid and mobilize heavy metals extensively contaminating the sandstone aquifer.[3,4,5]

The email from Manitoba Drainage and Water Licensing Branch verifies that water has likely been discharged to the surface during advanced exploration activities. This discharged water may have been contaminated with acid and heavy metals from the reaction of injected air with sources of pyrite in the sandstone aquifer or by reaction with marcasite and shale fragments in the shale from sand extracted with the discharged water. [3-12] The required mine closure plan for the entire CWS Vivian sand project should have specified actions to minimize the risk from this potential contamination.

10. Evidence for Marcasite in Sand Extracted by CWS

The sand taken from the Winnipeg formation near Seymourville was found to contain marcasite a form of pyrite. The marcasite found at Seymourville is consistent with the paper by Schieber and Riciputi (2005) on the diagenesis of marcasite throughout the Winnipeg formation. The same process for marcasite diagenesis during the Ordovician era would be expected to occur in the sandstone throughout the CWS claim area. The marcasite in the sand is shown in microscope pictures from the 2014 NI 43-101 technical report of Claim Post Inc. reproduced in Figure 8.[7]

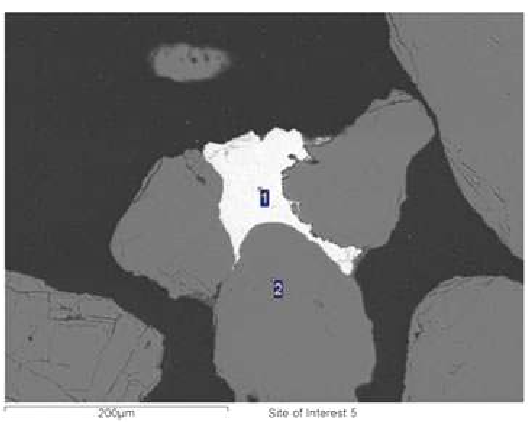

Figure 17: Backscattered Electron Image of Master Composite 6 Minutes Non-Mag -50/+70 Mesh
Quartz grains (grey) are cemented together by pyrite/marcasite (white).

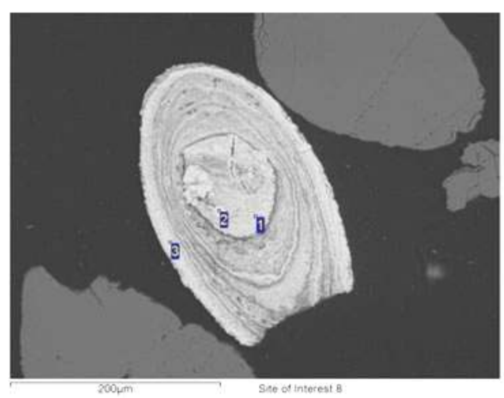

Figure 18: Backscattered Electron Image of Master Composite 6 Minutes Non-Mag -50/+70 Mesh
Rounded pyrite/marcasite grain exhibits concentric layering.

Figure 8. Electron microscope pictures of marcasite (a form of pyrite) between sand grains from the Winnipeg Formation near Seymourville.

The marcasite in Figure 8 is shown in white. Pictures in Figure 8 were reproduced from the 2014 NI43-101 technical report of Claim Post Resources.

The results of the acid base accounting test for the sand at Seymourville is shown in Figure 9 below.

Claim Post Resources Inc. – Seymourville – Project 14466-001 – Interim

Table 9: Standard Acid Base Accounting Test Results

Parameter	Unit	Master Composite A
LIMS		12782-APR14
Paste pH		6.16
Fizz Rate	---	1
Sample weight	g	2.03
HCl added	mL	20.00
HCl	Normality	0.10
NaOH	Normality	0.10
Vol NaOH to pH=7.0	mL	13.41
Final pH		2.08
NP	t $CaCO_3$/1000 t	5.3
AP	t $CaCO_3$/1000 t	7.34
Net NP	t $CaCO_3$/1000 t	-2.01
NP/AP	ratio	0.73
S	%	0.235
Sulphide1	%	0.10
SO_4	%	0.3
C	%	0.044
CO_3	%	0.035
CO_3 NP	t $CaCO_3$/1000 t	0.58
CO_3 Net NP	t $CaCO_3$/1000 t	-6.76
CO_3 NP	ratio	-0.079

Figure 9. Acid base accounting results from Winnipeg formation sand at Seymourville from the 2014 NI43-101 technical report for Claim Post Resources.[7]

The acid base accounting test showed a sulphide content of 0.235% from the iron sulphide (pyrite, marcasite) in the sand. The sand also contained a small amount of $CaCO_3$ which would act to neutralize acid formed from oxidation of the pyrite. The acid potential is expressed in terms of $CaCO_3$.[28] A net neutralization potential of -2.01 is equivalent to a net acid potential of 2.01 tonnes of sulphuric acid per 1000 tonnes of sand.

These results were submitted to the public review of the Wanipigow Sand Project.[29] The proponent declared that there was no pyrite in the sand. The Approvals Branch did not act on the certified laboratory report information in the NI 43-101 technical report. It appears that the unsupported declaration of the proponent was accepted over certified lab results from a NI 43-101 technical report.[12] The engineering company that prepared the Wanipigow EAP also prepared the CWS EAP.[29] The presence of marcasite and pyrite in the sandstone formation was not included in either EAP.

Sand samples were collected by local residents at Vivian in the spring of 2020. The CWS extracted sand piles at Vivian had been exposed and weathered for over one year. The collected sand samples were sent for analysis by ASL laboratories. The results showed the presence of 0.02% sulphide and no $CaCO_3$. This is consistent with all the $CaCO_3$ consumed by neutralization of the acid produced over a year of weathering. There was still sulphide present conclusively establishing that the sand at Vivian contains pyrite. The ALS report has rounded this to one significant of 0.6 tonnes. The certified lab results also show the presence of heavy metals in the sand. The acid base accounting results and trace metal analysis of the Vivian sand is given in Figure 10.

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To: OUR LINE IN THE SAND
PO BOX 689, STATION MAIN
STEINBACH MB R5G 1M5

CERTIFICATE OF ANALYSIS

WEI-21	OA-VOL08	OA-VOL08	OA-VOL08	OA-VOL08	OA-ELE07	OA-VOL08	S-IR08	S-GRA06	S-GRA06a	S-CAL06	C-GAS05
Recvd Wt.	MPA	FIZZ RAT	NNP	NP	pH	Ratio (N	S	S	S	S	C
kg	tCaCO3/1Kt	Unity	tCaCO3/1Kt	tCaCO3/1Kt	Unity	Unity	%	%	%	%	%
0.02	0.3	1	1	1	0.1	0.01	0.01	0.01	0.01	0.01	0.05
0.88 0.92	0.6	1	-1	0	8.0	0.00	0.02	<0.01	0.01	0.02	<0.05

ME-MS61	ME-MS61	ME-MS61	ME-MS61	ME-MS61	ME-MS61	ME-MS61	ME-MS61	ME-MS61	ME-MS61	ME-MS61	ME-MS61	ME-MS61	ME-MS61	ME-MS61
In	K	La	Li	Mg	Mn	Mo	Na	Nb	Ni	P	Pb	Rb	Re	S
ppm	%	ppm	ppm	%	ppm	ppm	%	ppm	ppm	ppm	ppm	ppm	ppm	%
0.005	0.01	0.5	0.2	0.01	5	0.05	0.01	0.1	0.2	10	0.5	0.1	0.002	0.01
<0.005	0.07	2.6	6.7	0.02	47	0.13	0.01	0.7	2.0	40	1.6	2.1	<0.002	0.01

ME-MS61	ME-MS61	ME-MS61	ME-MS61	ME-MS61	ME-MS61	ME-MS61	ME-MS61	ME-MS61	ME-MS61	ME-MS61	ME-MS61	ME-MS61	ME-MS61	ME-MS61
Sb	Sc	Se	Sn	Sr	Ta	Te	Th	Ti	Tl	U	V	W	Y	Zn
ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	%	ppm	ppm	ppm	ppm	ppm	ppm
0.05	0.1	1	0.2	0.2	0.05	0.05	0.01	0.005	0.02	0.1	1	0.1	0.1	2
0.07	0.3	1	<0.2	5.1	<0.05	<0.05	0.82	0.037	0.02	0.5	2	0.1	2.0	3

Figure 10. Trace Metal and Acid Base accounting results by ALS Laboratories for Vivian sand.

11. Potential for Acid Formation from Pyrite and Marcasite in CWS Sand Extraction

In the Steinbach area the bicarbonate concentration in the sandstone aquifer is about 350 mg/L.[25] Bicarbonate could neutralize acid produced from oxidation of pyrite. The ability of bicarbonate to neutralize acid produced from pyrite oxidation is complex. At pH 8.3, carbonate is converted to bicarbonate. At pH 4.5, it is certain that all carbonate and bicarbonate are converted to carbonic acid. Below this pH, the water is unable to neutralize the sulphuric acid.[32] To determine the potential for acid neutralization from the bicarbonate in the water a titration test is required.[33] Given that air is continually injected into the aquifer for up to 5 days during sand extraction the large amount of air would be expected to exceed the buffering capacity of the groundwater with respect to the acid produced from the oxidation of pyrite. The large amount of pyrite in the shale of the aquitard in the shale lenses in the sandstone, in pyritic oolite layers and in marcasite coating the sand grains would not be limiting in the formation of acid.

In the abandoned quarry on Black Island Manitoba silica sand was mined from the Winnipeg Formation since the 1920's. Oxidation of the pyrite in the shale layer overlying the white sand can be clearly seen on the excavation faces of the abandoned quarry to this day as shown in Figure 11. Litmus paper shows the seepage from the excavation faces is acidic with a pH of about 6 as shown in Figure 12. These field results demonstrate the bicarbonate naturally occurring in the sandstone is insufficient to neutralize the acid formed from pyrite oxidation. Phipps et al. (2008) reported the bicarbonate concentration over a wide area including near Black Island ranges from 226 to 532 mg/L with a median concentration of 346 mg/L similar to the concentration in the area around Steinbach.[35]

Figure 11. Acid drainage from excavation faces of the Winnipeg Formation sand overlain by shale at Black Island. The picture was taken by Don Sullivan Aug. 3, 2020

Figure 12. a. and b Hematite coloured water from acid drainage from Winnipeg Formation sand and overlying shale in the abandoned quarry pit at Black Island and litmus paper test showing acidic water from pyrite dissolution at Black Island after almost 100 years of leaching. The pictures were taken by Don Sullivan Aug. 3, 2020. The pH test was witnessed by Don Sullivan.

Mr. Somji in his Sept. 11 letter to the IAAC writes

"*Pyrite and Aquifer Contamination*

• CWS will not, and never has, harvested sand from the Black Island Member where pyrite could exist. Figure 5 is not a complete detail of the Winnipeg Formation. The upper member is called the Carmen member and is comprised of white silica sandstone. This is the member CWS harvests sand from. The lower members containing Pyrite are the Black Island members, these are layers CWS do not harvest sand from;
• CWS does not excavate or take sand from the Black Island members so Figure 6 and claims of Acid drainage are incorrect and not relevant;
• Any comparison to Black Island is not relevant as it is an entirely different minerology;
Figure 10 CWS have extensive minerology tests conducted on the Vivian Sands which have been shared with relevant authorities. The results in Figure 10 are not representative of the sand minerology, nor can the sampling authenticity be verified;
• pH of the CWS sand was taken at 7.4 to 7.6 and comparing it to the Black Island sand is not scientifically correct;
• Figure 11a,b have nothing to do with CWS;
• Using the NI 43 101 report from another company, in another area, in another deposit has no relevancy to CWS;

Mr. Somji's references to figures 6 (Black Island excavation faces) and figure 10 (ALS lab report) are Figure 11, and Figure 10 in this report. Mr. Somji confirms that lower in the sandstone aquifer, pyrite is found. The core logs from the well information reports obtained from Manitoba Groundwater show that the sand layer varies in thickness from 14 feet to 92 feet over the entire CWS claim area. In two wells, well 204771 at SW14-10-7E about three miles southwest of the Centre Line Road site and well 198763 at Centre Line Road the shale aquitard is 70 and 86 feet thick indicating a shale layer merged with the aquitard. The aquitard is normally between 5 and 15 feet thick as shown in Figure A1. Mr. Somji's letter does not address the variability in white sand thickness and the universal presence of shale layers at various unpredictable depths within the sandstone aquifer and the universal presence of the shale aquitard. All of the shale contains pyrite that would react with injected air to form acid.[4,5,10]

Mr. Somji's claim that ALS lab results are not representative of the sand mineralogy is not supported by evidence. The sand analyzed at ALS labs was taken from sand extracted by CWS at the Vivian site. Mr. Somji's letter of Sept. 11 does not give results of CWS analysis of the sand. I requested in my submission to the public review of the CWS Vivian sand facility project that CWS complete an independent geochemical analysis including acid base accounting test and trace metals analysis on representative core logs of sand over the entire CWS claim area.[12] This request for a complete independent geochemical analysis was ignored.

Mr. Somji's claim that the mineralogy at Seymourville and Black Island is not representative for the CWS mining claims is not supported by evidence. The sandstone formation at Black Island was formed in the same Ordovician area and by the same processes as around Vivian.[11] The papers by Phipps et al. and Schieber and Riciputi and the report by Watson all support that similar mineralogical properties of the Winnipeg Formation extend over the entire formation covering a large area from Saskatchewan to Eastern Manitoba and from Black Island in the north to Minnesota in the south[8,11,35]

12. Evidence for Injection into the Carbonate Aquifer of Excess Water from the Sandstone Aquifer

A resident near Centre Line Road wrote in the public comments for the Manitoba licensing approval of CWS Vivian sand processing facility; [30]

"*The company states that the extraction process will be a closed loop system but little details are provided. They have suggested a slurry technique but have not provided any details as to how this method was going to work. They have injected air into the aquifer previously. As I reside approximately two kilometers from the Centre Line Road, when they were extracting the sand, my water had a brown discolouration from the outdoor tap, first time in thirteen years of living in RM of Springfield. I have not seen clear documentation as* *to the affects on our drinking water when introducing substances into the aquifer. Common sense suggests that when you have a sealed system like and aquifer, introducing substances that are not normally present or present to that concentration will affect the natural system to some extent*."

In limestone most of the water flow is through the fractures.[22] A study of limestone quarry outcrops in England by Medici et al. (2019) determines water flow velocities ranging from 500 m/day to 9000 m/day in faulted zones. The driving force for water flow was rainfall infiltration.[27] The hydraulic gradient in the study by Medici et al varied from 0.005 to 0.0024 while the hydraulic gradient in the Springfield area in the carbonate aquifer is about 8.5×10^{-4}.[25] A CWS injection well would provide a much larger driving force that would compensate for the somewhat smaller gradient in the Springfield area compared to the Medici study.

A determination of the hydraulic gradient expected from the injection of water into the carbonate aquifer was obtained from an implementation of the Theis solution.[31] The gradient for a transmissivity of the carbonate aquifer of 100,000 US gallons/day/ft,[22] a storativity of 10^{-4} was roughly constant at 3.5×10^{-3} at 100 meters and 3.4×10^{-4} at 1 kilometre. The pumping rate used for the Theis solution was 500 US gallons per minute for five days consistent with the pumping time given in Mr. Somji's Sept. 11 letter to the IAAC. The gradient was determined numerically by dividing the head difference obtained from the Theis solution at two slightly different radii by the difference between the two radii. The radial increments were decreased until convergence was obtained. The results from the Theis solution verify that the pumping rate would increase the gradient especially closer to the injection well.

Fine silt and sand in the excess water injected to the carbonate aquifer could be expected to appear in a well two kilometres distant in a matter of a day or two given the fracture flow velocities of 500 to 9000 meters per day given in the report by Medici et al., (2019).[27] The aquifer studied by Medici et al. is similar in nature to the carbonate aquifer in Springfield. Both have karst near the surface and dolomite in the formation. [22,25,27,35]

Ionic contaminants such as heavy metals that might otherwise absorb on aquifer surfaces and be retarded can absorb on colloids enhancing transport.[9,34] Rapid and substantial transport of colloid particles through karst conduits is reported by Goppert and Goldscheifer (2008).[34] The evidence of turbidity in the residential well near Centre Line Road at time of sand extraction is evidence for large water velocities in limestone fractures and verifies contamination from excess water injection to the carbonate aquifer can be expected to reach wells several kilometres from CWS extraction wells. Widespread well contamination is likely to occur from CWS extraction operations.

13. Late Well Sealing and Reporting

The CWS wells sealed long after completion are listed in Table 3.

Table 3. CWS Wells sealed long after completion

Well PID	Location	Completion Date	Sealing Date
203682	SW19-10-8E	2018 Dec 15	2020-Jun-23
201401	SE32-10-8E	2019 Jun 28	2020-Aug-26
201400	SE32-10-8E	2019 Jun 16	2020-Aug-26
201399	SE32-10-8E	2019 Jun 07	2020-Aug-26
197862	SW18-10-8E	2018 May 19	2020-Jun-18
203688	SW19-10-8E	2019 Aug 16	2020-Aug-21
199982	SW19-10-8E	2018 Sep 28	2020-Jun-18
197859	SW19-10-8E	2018 Jun 05	2020-Jun-17
203678	SW19-10-8E	2019 Aug 26	2020-Aug-20
203691	SW19-10-8E	2018 Nov 14	2020-Jun-23

The Manitoba Groundwater and Water Well Act states

"*Well construction and well sealing reports*
50(1)
Subject to the regulations, a person who
(a) constructs a well or test hole; or
(b) seals, or partially seals, a well or test hole;
must prepare a report in the prescribed form and containing the prescribed information, and provide a copy of it within the prescribed time to the director and to the owner of the land on which the well or test hole is located.
Combined report
50(4)
If a test hole is sealed immediately after it is drilled, the required information relating to the sealing may be included in the well construction report."

In the wells listed in Table 3 the well sealing report and the well construction report were combined even though the sealing was carried out long after the construction. This is a violation of section 50(4) of the Manitoba Groundwater and Water Well Act.

14. CWS Wells near Vivian Manitoba SE 32-10-8E

Five CWS wells with PID/ well tag numbers 201401/002447, 201400/002445, 201399/002446, 201159/02521 and 201398/02444 were completed June and July 2019 south of the town of Vivian at the location of the proposed Vivian Sand Processing Facility. The five wells are shown in Figure 13.

Figure 13. Five wells at SE32-10-8E south of Vivian MB completed June to July 2019. The well tag numbers (WINT) numbers from left to right are 002447, 02445, 02446, 02521 and 02444

Some of these wells would have been used to extract sand at the Vivian site shown in Figure 14.

Well 201399 was completed June 7, 2019 with an 16.0 inch outer steel casing to 122 feet terminating four feet into the limestone. A 15 inch diameter open hole extends below the outer casing to 238 feet penetrating a 10 foot thick green shale layer. A 12.8 inch steel diameter inner casing extends from the surface to 178 feet terminating in a 65 foot thick white sandstone layer from 153 to 218 feet below surface. A steel well screen extends from 178 feet to 218 feet terminating at the beginning of the green shale layer. The penetration of green shale layer would have generated shale fragments that would likely have been withdrawn with sand. A surface seal of cement extends down to 151 feet terminating in the red shale aquitard. The surface cement seal terminates at 151 feet half way into the red shale aquitard suggesting that this seal filled the annular space between the inner and outer casing and the open hole in the limestone preventing aquifer flow across the aquitard. The annular location of the cement seal or time of emplacement was not specified in the well information report therefore its sealing function cannot be established. The cement seal could have prevented discharge of excess water into the formation through the open hole into the limestone and sandstone. Well 201399 was sealed on Aug. 26, 2020. The combination of the sealing and construction report one year after completion in violation of The Manitoba Groundwater and Well Water Act makes it impossible to determine if excess aerated water was returned to the carbonate and sandstone formation through the open hole that extends to the bottom of the well.

Well 201401 was completed June 28, 2019 with an 12.8 inch outer steel casing to 122 feet with a 6.6 inch steel casing inside extending to 178 feet. The inner steel casing terminates in a 60 foot thick white sandstone layer from 158 to 218 feet below surface. An open hole of extends to 230 feet terminating in a green shale layer. The annular space between the outer and inner casing and between the open hole and the inner casing in the pink limestone layer was sealed with cement preventing discharge of excess water to the formation from this well. Two shale traps were emplaced across the open hole at the level of the shale aquitard. If this well had been used for air lifting sand excess water would have been discharged on the surface or pumped into a separate disposal well. Well 20401 was sealed Aug. 26, 2020

Well 201400 was completed on June 16, 2019 with the same configuration as well 201401. The annular space between the outer and inner casing was sealed with cement preventing discharge of excess water into the formation. Well 201400 was sealed Aug. 26, 2020. The well use was given as "*recharge/return*". Excess aerated water from sand extraction injected using this well would have entered the sandstone aquifer potentially contaminating the aquifer from pyrite oxidation and mobilization of heavy metals.

The persistence of the ten foot thick green shale layer at 226 feet depth that is penetrated by wells 201399, 201400 and 201401 illustrates the Mr. Somji's assertion in his Sept .11 letter to the IAAC that "*CWS will not, and never has, harvested sand from the Black Island Member where pyrite could exist"* is not correct. Shale fragments and the marcasite in the sand would begin to generate acid upon exposure to air during air lifting. Such acid with mobilized heavy metals would be in water returned to the formation potentially contaminating the aquifers.

Well 201159 was completed on July 2, 2019 with a 5.5 inch PVC outer casing extending 120 feet down terminating in a sand, boulder layer just before the limestone layer starting at 128 feet below surface. An open hole of 4.8 inches extends below the outer PVC casing from 120 to 148 feet terminating at the start of the 14 foot thick red shale aquitard. An inner 2.4 inch PVC inner liner extends from the surface to 162 feet down terminating in a white sandstone layer. A stainless steel well screen 2.4 inches in diameter extends another 10 feet into the white sandstone layer. The well status is, "*active*". Bentonite seals the exterior 7.9 inch diameter borehole to 120 feet terminating in the layer of sand and boulders. No sealing is indicated across the shale aquitard. Excess water extracted with white silica sand using a removable air lift inner tube could be returned to the carbonate aquifer in well 201159 through the annular space between the PVC inner and outer tube and the open hole extending throughout the limestone aquifer. The well use is given as "*recharge/return*" verifying excess water could have entered the carbonate aquifer. This well status is "active" as of Oct. 1 2020.

Well 201398 was completed June 26, 2019 with a 8.6 inch steel casing extending 12 feet into the surface layers of peat moss black fill and sand. A 5.5 inch diameter inner PVC casing extends 121 feet down terminating two feet into a red limestone layer. A 4.8 inch open hole extends to the bottom of the red limestone layer. A bentonite seal is emplaced between the steel outer casing and the inner PVC liner. This well is still active as of Oct 1, 2020. Well 201398 could be used to supply water to workers or as a separate injection well for excess water withdrawn with silica sand.

Of the five wells, active well 201159 could be have been used as a sand extraction well with excess water returned to the carbonate aquifer. Wells 201399, 201400 and 201401 could have been used for sand extraction with surface discharge or discharge to the formation with a separate injection well or used for injection of excess water to the sandstone aquifer or both. Active well 201398 completed into the carbonate aquifer could be used for injection of excess water into the carbonate aquifer or for drinking water or both.

A Google earth image shown in Figure 14, taken June 7, 2019 the date of completion of well 201399 at Vivian, shows that water was discharged around the sand piles. The other four wells were not completed at this time. Google Earth image shows excess water was discharged around the sand piles consistent with well 201399 not being designed to discharge excess water into the formation.

Figure 14. Discharged water around sand piles extracted by CWS air lift wells near Vivian Manitoba

The discharge water could have contained heavy metals and acid from the oxidation of marcasite and shale fragments in the extracted sand and from oxidation of marcasite and pyrite in the sandstone formation from return of aerated excess water. Laboratory reports for samples of the extracted sand collected by local residents show the sand was coated with marcasite consistent with the NI 43-101 report for sand at Wanipigow and a literature report describing the diagenesis of marcasite in the Winnipeg Formation.[6,27] Leaching of heavy metals and acid could have occurred from rainfall on the sand piles. The lower content of sulphide measured in weathered sand at Vivian compared to the sulphide content of fresh sand from Wanipigow provides evidence that marcasite oxidation occurred. (See Figure 9 and Figure 10)
The contamination from the sand piles and CWS well water discharge may have seeped into the water table and eventually migrated to the Brokenhead River or the carbonate aquifer.

In October of 2020, local residents observed drilling activity and extraction of white sand at a quarry near the junction of highway 15 and 302 north of Vivian outside the CWS mine claim area. The online water rights portal maintained by the Manitoba Drainage and Water Rights Licensing Branch records temporary authorizations for water use given to HD Minerals as shown in Figure 15.

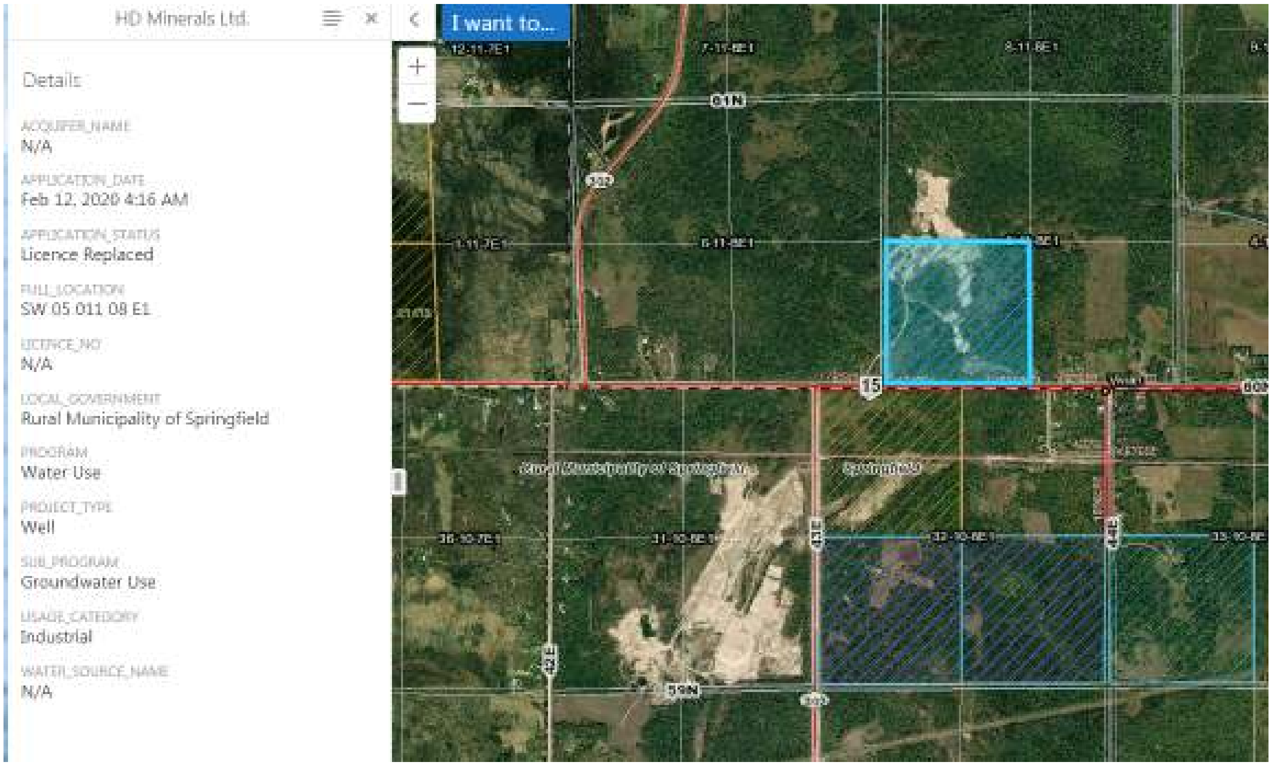

Figure 15. Temporary authorizations for water use at a quarry in township SW05-11-8E north east of Vivian and water authorisation permits for SE32-10-8E south of Vivian. Sand extraction occurred at both sites.

Excess water from sand extraction at the quarry of Figure 15 would have been discharged on the surface or injected into the formation or both. Discharge of contaminated water onto the surface of a quarry would quickly migrate down through the permeable sand and gravel of the quarry toward the carbonate aquifer. It is inconceivable that up to 28,800 cubic meters of water withdrawn from the quarry as shown in Table 2 would have been discharged. Residents did not notice a large amount of surface discharge. Much of the water extracted with the sand water would have been likely pumped into the carbonate aquifer as evidenced by the triple tube air lift well construction at Centre Line Road. There are no available well records for this site.

We suspect that such a large perturbation to the aquifer would have contributed to the continuing well water problems experienced by residents of Vivian. A silica sand pile extracted at the quarry site in October of 2020 near Vivian is shown in Figure 16.

Figure 16. Silica sand extracted by CWS at a quarry near the junction of Highway 15 and 302 within one kilometre of Vivian, Manitoba

In November 2020 CWS drilled five wells 205003, 205011, 205013, 205015, 205016 at SE32-10-8E and SW33-10-8E for hydrogeological testing at the proposed site for the Vivian Sand Processing Facility. Wells 205003, 205011 and 205013 were completed into the sandstone. 205015 and 205016 were completed into the carbonate. All with double tubes have sealing between the inner and outer tubes. All were likely used for water withdrawal for hydrogeological testing with no sand extracted by air lift. Well PID 205003 is recorded in the well information records as having withdrawn 27,000 imperial gallons of water over a 72 hour period at a rate of 375 IGPM. This large volume of water was either discharged onto the land or injected into the formation through separate injection well or both. The water would not have been aerated and not have caused pyrite oxidation in the sandstone aquifer. However heavy metals including iron liberated during earlier air lift extraction activities could have been withdraw and re-injected into the carbonate aquifer. Well PID 201398 was completed with 17 feet of open hole into carbonate aquifer on June 26, 2019. Well 201398 is still active and could have been used to inject water from the pumping test of November 23, 2020. Well 205015 completed on Nov.10, 2020 with 21 feet of open hole into the carbonate aquifer could also have been used to inject water from the pump test into the carbonate aquifer. Injection of water withdrawn from the sandstone aquifer to the carbonate aquifer would be a violation of the Well Standards Regulation 215/2015 of the Manitoba Groundwater and Water Well Act. Evidence indicates that such a violation has occurred at the Centre Line Road site. Given this history such a violation may well have occurred during the hydrogeological pumping test on November 2020. Discharge of a large quantity of groundwater that may contain heavy metals including iron mobilized in earlier air lift sand extraction would also be detrimental.

15. Well 203699 NW19-11-8E in a Quarry North of the CWS Mineral Claim

According to the well information report, CWS well 203699 was completed on Aug. 9, 2019 near the junction of Highway 302 and Oakwood Road NW19-11-8E. The well is adjacent to or within LSL quarry. The quarry is north and outside of the CWS mine claim area. The central tube is given in the well construction record as a borehole 7.6 inches in diameter extending the full 182 foot depth of the well. We interpret this to be the central tube for air injection. The second 10.6 inch diameter steel tube around the central "borehole" terminates at 182 feet in the white sand layer. The outer tube of 12.6 inches in diameter terminates at the start of the limestone layer consistent with return of excess water into the carbonate aquifer.

A resident who lives on highway 302 about four miles north of well 203699 has noticed iron staining and deterioration of water quality since the construction of well 203699 in Aug of 2019. A resident living about 5 kilometres west of this site noticed change in water quality in the summer of 2019. The CWS well near Oakwood Road and Highway 302 along with the CWS sand extraction wells near highway 15 and 302 at Vivian, Manitoba illustrates that CWS wells can occur in quarries over a wide area outside the mineral claims.

There are no well records in the Manitoba Groundwater Section for the CWS sand extraction wells at the quarry near Vivian. In these operations excess water likely contaminated with acid, heavy metals, fine sand and silt will be discharged either on to the surface or into the carbonate aquifer. Contamination from surface discharge on a quarry property is likely to penetrate through the permeable sand and gravel of the quarry to the carbonate aquifer. Injection of water taken from the sandstone aquifer to the carbonate aquifer violates the Well Standards Regulation 215/2015 of the Manitoba Groundwater and Water Well Act[13] and could contaminate the carbonate aquifer. There appears to be no temporary authorization for water use from Manitoba Drainage and Water Rights Licensing Branch for the quarry at Oakland Road and no well records in the Manitoba Groundwater Section for CWS wells at the quarry near Vivian. Based on this experience CWS activity in quarries could occur over a wide area with no notification or permission other than existing quarry rights. A large drawdown on the sandstone aquifer, degradation of water quality by mixing of aquifer waters, and extensive contamination of both aquifers could occur by such uncontrolled, unauthorized and surreptitious CWS activity in quarries.

16. Acrylamide

The CWS EAP for the Vivian sand processing plant reports a polyacrylamide flocculent is used in the clarifier tank to remove suspended solids such as clay, silt and sediment from the closed loop. The use of the flocculent allows water to be recycled and removes the need for settling ponds. A peer reviewed paper by Xiong et al. 2018 reports that the presence of iron ions and acid will degrade the polyacrylamide into the carcinogenic, neurotoxic, teratogenic acrylamide monomer.[14] Iron ions and acid would be present in the slurry water from the reaction of air with pyrite in the sandstone aquifer and with marcasite, shale fragments and oolite nodules in the sand carried by the slurry lines. Small amounts of the toxic highly soluble acrylamide monomer will also be present as a residual from manufacturing even without degradation.[42]

In the EAP and Mr. Somji's letter to the IAAC the flocculent is described as a biodegradable food grade flocculent that is commonly used in water treatment operations. Water treatment operations do not normally recycle water and do not normally contain dissolved iron ions and acid. Every time a parcel of water passes through the clarifier tank, more acrylamide would be added ever increasing the concentration. The peer reviewed paper by Xiong et al. reports the acrylamide monomer will persist for more than two months in drinking water. Two months is much longer than the transit time for a parcel of water in the closed loop system. Therefore biodegradation will not appreciably affect build up of the acrylamide monomer. Leakage from slurry lines and the processing plant could contaminate groundwater and the water table.[44] The Minnesota Department of Health guidance allowed level of acrylamide in drinking water is 0.2 parts per billion.[43] Subsurface movement of the monomer could eventually contaminate the carbonate aquifer and the Brokenhead River.

17. Slurry Lines

Slurry lines will extend over a large area outside the plant site. According to Mr. Somji's letter to the IAAC, high-density poly pipe (HDPE) will be used.[1] There are many failure modes for the slurry pipe including joint failure, accidental impact, deterioration from UV and pressure surges from water hammer.[45] Water hammer is of particular concern considering the frequent stoppage and starting of slurry pumps in the process of moving slurry lines. Gradual slow leaks from joints and elsewhere may not be easily detected. Leakage from silica sand wash plants has been frequently reported in Wisconsin including a case of extensive flooding of the St. Croix River in Wisconsin from wash plant leakage.[44] Leakage of heavy metals and other contaminants such as acrylamide would drain toward the Brokenhead River. Some of the contaminants could enter the carbonate aquifer through permeable soils documented in appendix A of the CWS EAP. The onsite leakage into the aquifer could contaminate the domestic well serving plant employees.

Trichloroethylene leaked from surface spillage into the carbonate aquifer near Rockwood Manitoba in the early 1990's contaminating the drinking water over an area of about 6 km by 4 km.[46] The biological half-life of trichloroethylene is normally considered to be of the order of two days under aerobic conditions.[47] The trichloroethylene has persisted in the carbonate aquifer in the Rockwood sensitive area since the early1990's, almost thirty years to date. Similarly acrylamide would be expected to persist in the aquifer due to the absence of organics and oxygen that are necessary for microbial degradation. The high water flow rate in the highly fractured carbonate aquifer could spread the contamination to nearby wells of local residents as has occurred in Rockwood. [46]

A paper by Burn et al. 1998 reports an annual breakage frequency of HDPE water pipe in Australia of about one per 12.5 km.[36] A report by Utah Sate University gives a similar break rate from 2012 to 2018 for Canada and the US as for HDPE water main pipes as for Australia.[37] The water loss due to leakage and breakage from all types of water pipes was 10% in the University of Utah study. The break rate for HDPE pipes in the Utah study was not significantly different that other pipe types although data was sparse. A leak rate of up to

10% could occur with HDPE pipe. In another example HDPE water pipes in Resolute Bay experienced numerous leaks resulting in 40% water loss.[38] According the Mr. Somji's letter to the IAAC wells are pumped for up to five days.[1] Frequent movement of CWS pipes to newly drilled wells renders burial impractical. Consequently the exposed CWS return water and slurry pipes have the added failure risks from animals, ATV, snowmobile traffic and gravel pit and farm machinery and other accidental breakage.[39] In the winter water filled HDPE pipes can withstand freezing but become more brittle.[65] Unattended frozen pipes will be susceptible to damage from snowmobiles. Mechanical joints would be particularly susceptible to freeze damage. According to the CWS EAP the onsite water tank at the processing plant was designed to hold wash plant water over winter to prevent discharge. The tank would not be able to accommodate the large volume of water retained in the slurry line pipes. The pipes would have to be left exposed and brittle with frozen water inside over winter.

HDPE pipe can be permanently joined by a thermal fusion process that is relatively leak free. Due to frequent movement the CWS slurry lines will likely have to be decoupled using mechanical joints that are more prone to leakage.[40] Slurry lines would be too heavy to move when full. They could be drained for movement using mobile slurry vacuum trucks. Spillage of some residual water will likely occur during movement. Given these leakage risks 10% loss is likely an underestimate for the CWS water loop. For the CWS EAP specified flow rate of 24,416 litres per minute into the clarifier tank a 10% leakage would result in a surface discharge of in excess 700,000 cubic meters of slurry loop water per year. This would add to the unsustainable drawdown on the sandstone aquifer. Aquifer and well contamination from heavy metals and acrylamide in the slurry loop water is likely to occur over a wide area. Some surface drainage of the leakage toward the Brokenhead River would occur. Given the likelihood of significant water loop leakage slurry line leak detectors with remote alarms for an emergency response crew should be required.

An independent baseline survey of trace metal, acrylamide content and water quality in representative wells in both the carbonate and sandstone aquifers over the entire mineral lease area and additional quarry extraction areas should be funded by CWS. Results of yearly sampling of representative wells in both aquifers over the area of active slurry lines should be made available online. CWS should pay for replacement water supply of all contaminated wells.

The Winnipeg aqueduct which crosses the CWS mineral lease area is known to leak.[41] When slurry lines approach within drainage distance of or cross the Winnipeg aqueduct, the aqueduct water should be regularly sampled for acrylamide, heavy metals and change of water quality.

In forested areas slurry lines cannot be moved simply by dragging without unacceptable clear cutting. The land disturbance from the slurry lines and drill sites will be very large. The mine closure plan should have addressed rehabilitation and compensation for long term damage from this land disturbance.

The EAP states,

"*Periodically there may be excess water not required for recycling back into the Wet Plant, which will be stored in an on-site surface tank*"

Mr. Somji's Sept. 11 letter to the IAAC states.

"*At the facility the sand is deposited wet into a Work In Process (WIP) pile on an engineered surface which contains the equivalent of French Drains allowing full containment of any water discharge. The water, rain and snow melt are captured and recycled for WIP pile wetting and continuous water loop*"

French drains may not capture all of the runoff from the sand stockpiles. The sand stockpiles will contain contaminants that build up in the recycle loop including heavy metals mobilized from air injection in the sandstone aquifer and toxic acrylamide from the clarifier tank. The on site surface tank may not be large enough to accommodate captured runoff from heavy rains or snow melt or excess water not required for recycling. The dimensions of the storage tank were not given in the EAP. No calculations of the volume of excess water and captured runoff were provided. Water held in the storage tank would have to be gradually released back into the water loop. To accommodate this extra volume in the water loop more aerated water would be returned to the aquifer. Extra aerated water returned to the sandstone aquifer would cause more pyrite oxidation, acid and heavy metal mobilization. Excess water injected into the carbonate would violate the Manitoba Groundwater and Water Well Act prohibiting mixing of aquifer water and introduce more contaminates into the aquifer.

The extra information regarding the French drain system and the return of excess water to the formation was not given in the CWS EAP. This significant added information in Mr. Somji's Sept. 11 letter was not subject to public or TAC review.

18. Land Subsidence

The collapsing of the open holes in the sandstone in wells 197860 and 197923 illustrates the sand is unconsolidated and likely to collapse or creep into cavities left by sand extraction. The area of sand supporting the shale aquitard will lessen as the sand creeps into the cavity. According to Goodman (1989), "*shales vary widely in strength and deformability. Cemented shales can be hard and strong whereas compaction shales are just compacted clay soils and have the attributes of hard soils rather than rocks*." [48] The rock quality of shale can deteriorate as fresh surfaces are exposed as would occur when sand is removed by air lift extraction. Shales are subject to slaking.[48] Slaking can be exacerbated by entrapped air as would occur during CWS air injection under the shale aquitard.[49] The relatively thin shale aquitard is known to be weak along the bedding plane. [21] The weakness of shale along the bedding plane is illustrated in Figure 3

Lapenskie (2016) describes the shale overlying the sandstone of the Winnipeg formation as "*composed of a pyritic, bedded to laminated shale. The weathered shale is light to medium grey, and fresh surfaces are dark grey. In places, the shale is composed of up to 50% pyrite nodules, which are rounded, equant to elongate, concentrically layered, and 0.5–1.0 mm in diameter.* [10]" Figure 3 shows the shale is clearly unconsolidated and fragile. Rutulis (1981) illustrates the aquitard between the carbonate and sand stone aquifers as an impermeable mixture of shale, till and clay.[24]

Laboratory tests are required to determine properties of the shale aquitard in the Vivian area. The evidence from Lapenskie (2016), Rutulis (1981) and Goodman demonstrate that the shale aquitard in the CWS mine claim area is of the compacted soil type with attributes of hard soil rather than rock.[48] Such softer layered shales are more susceptible to slaking.[49]

The overburden pressure and fluid pressure from water injection above and slaking will likely cause the shale aquitard to collapse into the cavities in the sandstone aquifer as the area of supporting sand decreases.[49] In the Vivian area the fluid pressure in the carbonate aquifer is larger than in the sandstone aquifer so that aquifer water would naturally flow from the carbonate into the sandstone exacerbating the potential for collapse of the aquitard into cavities in the sandstone.[50] This water flow would result in prohibited mixing of aquifer waters.

Appendix 1 gives a simplified analysis of the failure criteria for a shale layer overlying a cavity with overburden pressure from above.

Subsidence is known to gradually develop by erosion of sand and gravel overburden through vertical fractures in a limestone layer with a cavity underneath. This is termed cover subsidence sinkholes. Sinkholes are known to occur suddenly when an impermeable overburden such as glacial till erodes through vertical fractures in limestone layer in to a cavity below. This is termed cover collapse sinkholes. These two mechanisms for subsidence are illustrated in Figure 17 and Figure 18. Figure 17 and Figure 18 do not show a shale aquitard above the cavity. The shale aquitard will have likely collapsed into the cavity from the overburden pressure and slaking.[49] Figure 17 and Figure 18 are therefore applicable to the CWS operations. Glacial till containing clay or a mixture of sand and gravel would overlie the limestone as documented in the 42 core logs for CWS wells. The CWS core logs show glacial till is most common therefore cover collapse sinkholes would be expected to predominately occur.

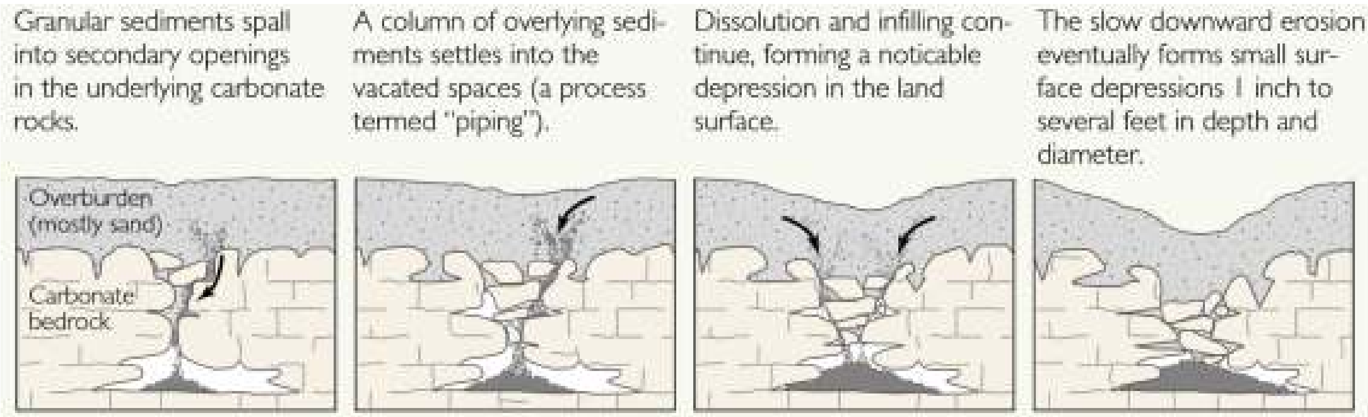

Figure 17. Cover subsidence sinkhole into a cavity in limestone. The image is from US Geological Survey (USGS).[23]

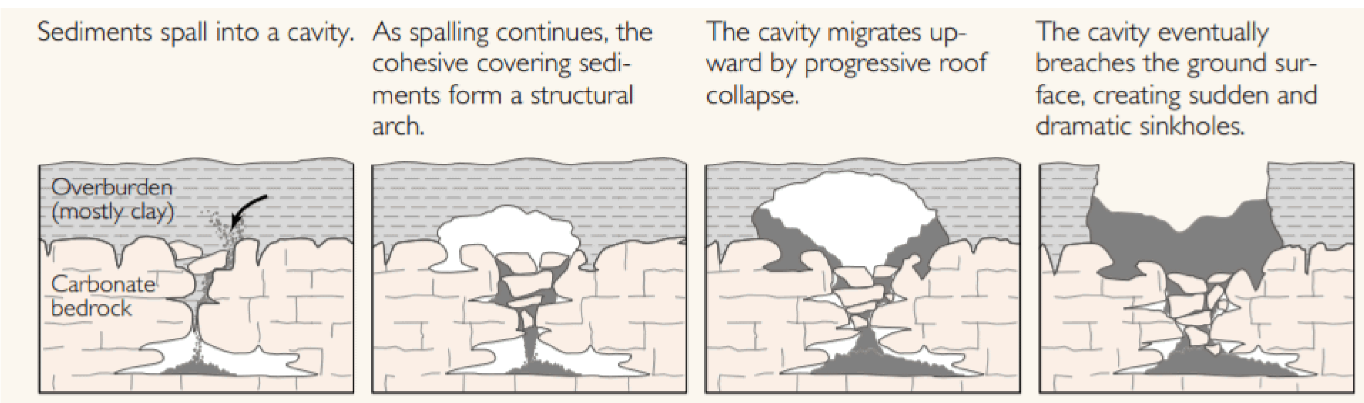

Figure 18. Cover collapse sinkhole into a cavity in limestone. The image is from USGS.[23]

The formation of sinkholes can be accelerated by acidic groundwater such as from pyrite oxidation and from increased aquifer flow from water injection.[23] The limestone is about 80 feet thick at the Centre Line Road site but only about 30 feet thick at the Vivian site at township SW32-10-8E. Sinkholes are more likely to develop in the areas with a thinner limestone layer where the distance for downward piping of the till through vertical cracks is smaller. Sinkholes are found in the Springfield area.[24,25] From this evidence land subsidence into the cavities caused from sand extraction by CWS is almost certain to eventually occur. Given the large number of CWS wells to be drilled per year the resulting subsidence will be a serious problem over a large area. The mine closure report required under the Manitoba Mines and Minerals Act would have quantified the risk of land subsidence. The closure plan and financial assurance would have addressed rehabilitation measures for subsidence.

19. Conclusion

Prior to commencement of advanced exploration activities that according to the drilling records substantially began in 2018, CWS did not file a mine closure plan and financial assurance with the Director of the

Manitoba Mines Branch as required by the Manitoba Mines and Minerals Act. The legally required mine closure plan was not submitted as part of the CWS Environment Act Proposal of July 2, 2020, for the CWS processing facility. The public and the TAC did not have the opportunity to review the mine closure plan that should have contained essential information on protection of the environment, rehabilitation and minimizing hazards to public safety as required by the Manitoba Mines and Minerals Act.

A letter to the Manitoba Minister of Agriculture and Resource Development written on July 22, 2020 by Don Sullivan, spokesperson for What the Frack Manitoba, highlighting the failure to enforce the mine closure provisions in the Manitoba Mines and Minerals Act has not received a reply to date. A disclosure of the failure to file the mine closure plan in the public comments submission by Mr. LeNeveu for the Manitoba environmental review process of the CWS processing facility was ignored.

This report describes the risks of contamination to the sandstone and carbonate aquifers and the risk of land subsidence from CWS operations. Actions to be taken to minimize the hazards to public safety from this potential drinking water contamination have not been submitted in a mine closure plan as required by the Manitoba Mines and Minerals Act. Rehabilitation measures required to address potential land subsidence and land disturbance from the actions of this project have not been submitted in the required mine closure plan as required by the Act.

The Manitoba Mines and Minerals Act requires the mine closure plan to cover both processing and extraction activities. The mine closure plan must be filed before the public review process under the Manitoba Environment Act gets underway for CWS proposed mine extraction activities. In the Canadian Premium Sand Project, Manitoba public registry file number 5991.00, the required mine closure plan was made a condition of the project licence.[30] Similarly the mine closure plan will more than likely be made a licence requirement once an environment licence is issued to CWS for its proposed silica sand mining development project. Public and TAC review of the mine closure plan will be completely avoided. Under the requirements for advanced exploration activities undertaken for the CWS project, the mine closure plan should have been submitted before commencement of the advanced exploration in 2018. Requiring the mine closure plan as a condition of the licence for the CWS extraction project is a violation of the Manitoba Mines and Minerals Act. To conform to the provision 74(2) of the Act all aspects of the CWS project must halt and not recommence until the Director of the Mines Branch approves the mine closure plan and accepts the security provided with the plan for the performance of rehabilitation.

Mine Closure Plans are not required for quarry activities. CWS activities in quarries expose the inadequacies of the Mines and Minerals Act to protect public and environmental health.[64] CWS silica sand extraction in quarries should cease.

The way the provincial regulatory review process is structured, the issues raised in this report cannot be submitted until the Manitoba public review process for the CWS mining and extraction activities begin. Public comments submitted for this environmental review process that are placed on the Manitoba Public Registry are not provided to the Technical Advisory Committee (TAC) before the TAC review is completed. With this procedural sequence, an expert technical review of the issues raised here and in other reports from the public will not occur.

The technical concerns detailed in this document will likely be ignored in CWS Environment Act Proposal and in the Manitoba public review process for the silica sand mining and extraction activities, just as issues I raised in the Manitoba review process for CWS processing facility were ignored. The ignored issues for the processing facility include pyrite oxidation and acid and heavy metal release from shale, oolite and marcasite withdrawn with the sand and the unsustainable draw on the aquifer from water contained in the sand stockpiles of the facility. Certified laboratory reports of samples taken by local residents of extracted sand were submitted by Mr. LeNeveu during the Manitoba public review process of CWS silica sand processing facility. The lab results showed the presence of sulphide from marcasite in the sand. The certified laboratory results were ignored during the Manitoba public review process of the CWS processing facility. The CWS EAP did not mention the presence of pyrite and marcasite even though AECOM who also authored the EAP for the Wanipigow Sand Extraction Project prescribed remedial measures to address acid drainage from pyrite for Wanipigow belatedly after failing to include such measure in the Wanipigow EAP.

The issues I raised in my submission to the Manitoba public review for the CWS processing facility were dismissed in Mr. Somji's September 11, 2020 letter to the IAAC, without verified evidence provided by Mr. Somji. The rebuttal to Mr. Somji's September 11, 2020 I wrote containing substantive evidence supported documentation submitted to the IAAC could not be submitted to the Manitoba Public Registry or be reviewed because the Manitoba public comment period had expired. Numerous other issues raised in the Manitoba public review process of the CWS processing facility such as concerns about the exposure to toxic acrylamide from degradation of the flocculent used in the clarifier tank were ignored or dismissed without evidence. Similarly written questions I submitted for online CWS public meeting of Dec.15, 2020, mandated by the Manitoba Environmental Approvals Branch were ignored. My questions were not answered nor posted on the Manitoba public registry 6057.00 for the CWS processing facility although a meeting summary prepared by the proponent was posted on the registry.

The CWS well records, obtained after the public comment period had expired for the Manitoba public review process, corroborate the extensive presence of pyritic shale in the sandstone aquifer. The well records indicate large volumes of excess potentially contaminated water from the sandstone aquifer will be injected into the carbonate aquifer. Mixing of aquifer water in this manner is not allowed according to the regulations of the Manitoba Groundwater and Well Water Act. One record for well 199982 at Centre Line Road indicates excess aerated water may have been injected into both the carbonate and sandstone aquifers which could have caused pyrite oxidation and mobilization of heavy metals in the sandstone aquifer. Even if CWS extraction process injects excess aerated water into the sandstone aquifer rather than the carbonate aquifer extensive contamination of the sandstone aquifer would certainly occur from pyrite oxidation. The well records document sand collapse into open drill holes in the sandstone aquifer. Sand collapse into extraction cavities would worsen the risk of land subsidence.

Disposal is not considered of potentially acid generating waste containing heavy metals from drill mud and cuttings from the numerous CWS wells, from mud cakes from the processing tank clarifier tank and from recycled water that has become too contaminated with acid, acrylamide and other dissolved contaminants to be further used. Spillage and leakage from the slurry lines and wash plant must be addressed.

Several residents in the Springfield area reported well complaints in a report of suspected violations of the Manitoba Groundwater and Water Well Act submitted to the Director of the Water Branch and to the Manager of the Manitoba Ground Water Section on Feb. 1, 2020. The suspected violations include,

- contaminating and adversely affecting the quality of groundwater in the area of a well or test hole,
- allowing the interconnection or mixing of groundwater between the Winnipeg Formation and any overlying aquifer,
- failure to adequately emplace annular sealing at the time of well construction,
- failure to affix a well identification tag,
- failure to properly secure well covers,
- failure to issue separate well construction and sealing reports within the required time period, and
- failure to protect the sandstone aquifer of the Winnipeg formation from unsustainable draw.

We received an email from Manitoba Groundwater on Feb. 9, 2021 stating.

"*We are in receipt of your email and will be reviewing the information you have provided*." We have no information on the extent and expected completion date of this review. We hope that the review will properly address the issues raised here although the review will not be a part of the public review process for the entire Vivian Sand Project.

There appears to be no means to prevent in the upcoming public review of CWS silica sand extraction process the ignoring of evidence for the contamination of the aquifers, unsustainable draw on the sandstone aquifer, land subsidence, slurry line spillage and acid generating waste disposal. This abuse of the public review process under the Manitoba Environment Act and the failure to enforce the mine closure and security provisions of the Manitoba Mines and Minerals Act should not be allowed to continue. The drinking water of much of southeast Manitoba is at stake. Water is life. Where would the large affected population go once their water is contaminated? Surely this silica sand mine development project cannot be allowed to proceed without an independent technical investigation through a formal quasi-judicial public panel review process such as the Manitoba Clean Environment Commission.

20. Recommendations

We recommend;

- The approvals process for this project under the Manitoba Environment Act be halted immediately;
- The required mine closure plan covering all aspects or rehabilitation and minimization of risk from this mine development project including all aspects of processing and extraction be submitted and made publicly available;
- The risks described in this report and in the public comments submissions by Mr. LeNeveu and others placed on Manitoba Public Registry related to the review of the CWS EAP for its silica sand processing facility be thoroughly addressed in the mine closure plan;
- The results of a review of suspected violations of the Manitoba Groundwater and Water Well Act and well complaints of residents of Springfield be made publicly available before the public review of the CWS mine extraction process;
- An independent publicly available baseline survey of trace metal, acrylamide content and water quality in representative wells in both the carbonate and sandstone aquifers over the entire mine claim area should be funded by CWS;
- An independent publicly available geochemical analysis on representative core samples taken over the entire CWS claim area should be funded by CPS;
- The analysis of the sand, shale and oolite should include an acid-base accounting test and heavy metal content;
- An independent publicly available rock mechanics study should be funded by CPS to evaluate the potential for land subsidence caused by CPS sand extraction;
- A full public panel review process hearing of the mine closure plan, the Manitoba Groundwater investigation of violations and complaints, the silica sand processing facility and the mine extraction be undertaken under a quasi-judicial independent body such as the Manitoba Clean Environment Commission.

Appendix 1. Analysis of the Failure of the Shale Aquitard Overlying a Cavity in the Sandstone

Extraction of sand from the sandstone aquifer in the Vivian area will leave cavities below the shale aquitard overlying the aquifer. From the ground surface down there is a layer of soil, till, sand and gravel and limestone rock above the shale aquitard. From core logs in the area taken from Friesen Driller well records for CanWhite wells obtained from Manitoba Groundwater the overburden thickness of soil/till/gravel is usually about 25 meters. The carbonate aquifer is about 20 m thick. The shale aquitard varies in thickness from about 2 to 5 meters as shown in Figure A1. There are two anomalously thick samples of the shale aquitards that can be attributed to a merging with shale lenses normally found further down in the aquifer. The average thickness of the aquitard in the Bru claim area is 2.83 m excluding the two anomalously thick samples. The dry density of the till and gravel overburden is about 2.0, the carbonate 2.5 and the shale 2.2 t/m^3 [48,51,52,53]

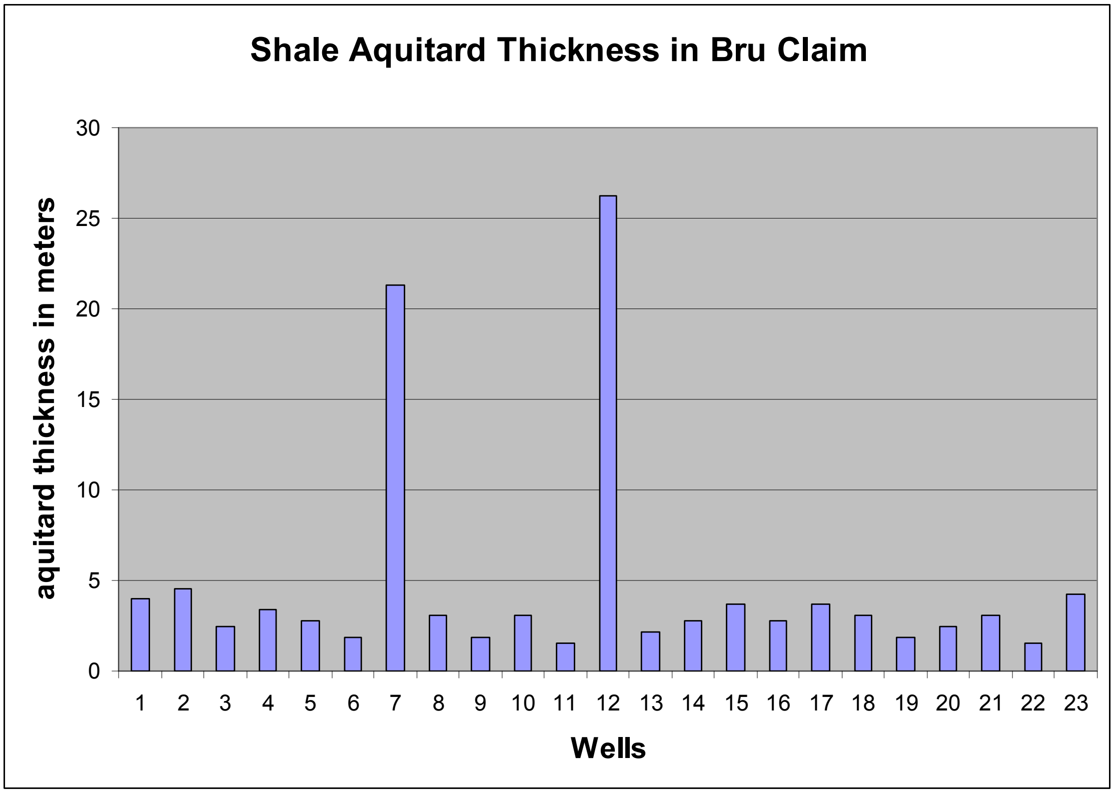

Figure A1. Shale aquitard thickness in Bru claim area south of Vivian, Manitoba from CWS well information records

The downward lithostatic above the aquitard will be given by the height and the average density. Where the formation is below the water table the buoyancy (pore) pressure of water must be taken into account. The dimension of the cavity below the aquitard created by extraction of sand is unknown. The downward lithostatic pressure will stress the unsupported shale aquitard overlying the sand cavity. The average depth of pure sand that can be extracted before shale is encountered below the aquitard from core logs is about 20 meters. For an extraction well tube that does not penetrate far into the sandstone, a cavity below the aquitard with a radius of about 20 meters from sand extraction can be expected. The CanWhite well records report that two of 42 holes drilled into the sandstone collapsed. The sand pillars between excavated voids are unconsolidated. The well record collapse provides evidence that in time the sand pillars between excavation cavities will slump into the cavities increasing the unsupported area of the overlying shale.

Figure A2 shows the relationships for the defection δ and the maximum stress on the disc due to a pressure from above σ.[54]

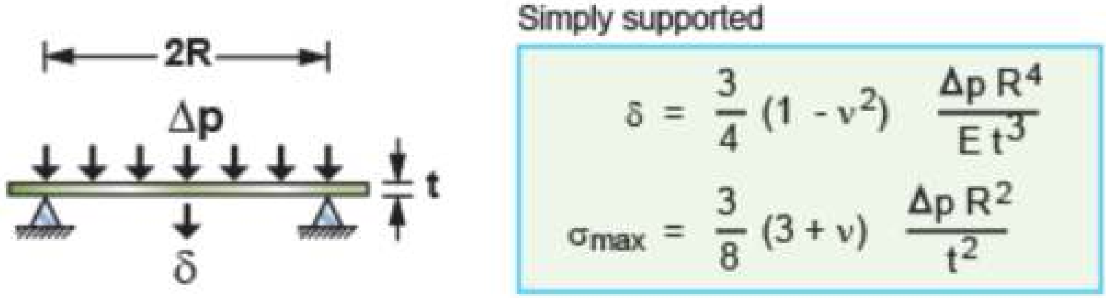

Figure A2. Maximum stress for a simply supported loaded shale aquitard layer

In Figure A2 υ is Poisson's ratio. R is the radius of the circular slab representing the unsupported aquitard suspended over the cavity in the sandstone. Δp is the pressure difference, t is the slab thickness, E is Young's modulus, δ is the deflection and σ_{max} is the maximum stress. As the circular shale slab deflects downward the under side will be under tension. The slab will break when the maximum strength exceeds the tensile strength along the bedding planes of the shale. Poisson's ratio is zero for a perfectly stiff material and has a maximum of 0.5 for a perfectly elastic material. [56] Shale will have a Poisson ratio of about 0.3. [59] The minimum radius of the unsupported circular slab of shale is 20 m. All that remains to determine the maximum stress is the pressure difference that will be given by,

$$\Delta p = (\rho_t - \rho_w)h_t g + (\rho_l - \rho_w)h_l g + \rho_w h_d g + \rho_u h_u g$$

g is the acceleration due to gravity, ρ_w is the density of water in the aquifer ρ_u is the density of the unsaturated layer and h_u is the height of the unsaturated layer, h_t is the height of the saturated till, h_l is the height of the limestone, ρ_t is the dry density of the till, ρ_l is the dry density of the limestone and h_d is the head difference between the carbonate and sandstone aquifers. h_d can be positive or negative. If the head of the carbonate is higher than the sandstone h_d is positive because the fluid pressure will downward on the shale layer. The first two terms in the equation for Δp account for the buoyancy effect by subtracting the effect of weight of water displaced.[60]

The buoyancy effect and the differential fluid pressure can be accounted for in determining the effective overburden stress σ_e by, [57],[58]

$$\sigma_e = \sigma_V - \alpha p \; .$$

Where σ_V is the overburden stress, α is Biot's effective stress coefficient and p is the pore pressure. The equation for Δp and σ_e give similar results.

The head difference between the carbonate and sandstone aquifers varies with location. West of Vivian the sandstone aquifer head is higher than the carbonate but around the Vivian area the heads reverse as shown in Figure A3.[50]

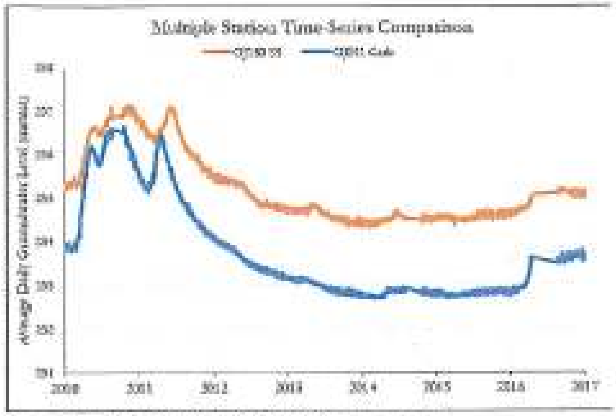

Figure 11 – G05OJ011/G05OJ180 comparison

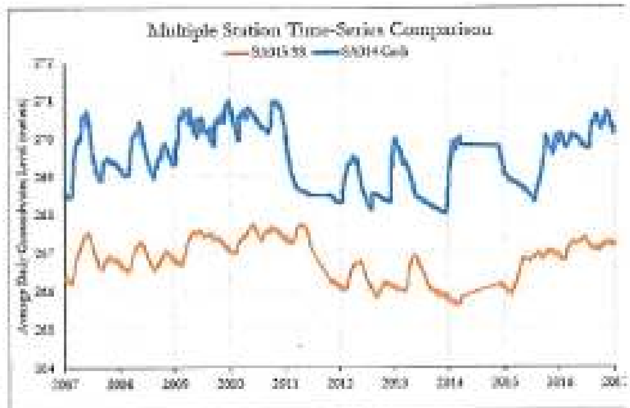

Figure 12 – G05SA015/G05SA014 comparison

Note that the OJ011/OJ180 station is located near Dugald, while the SA015/SA014 station is located near PTH 302. The sandstone level is shown in orange, while the carbonate aquifer level is shown in blue. (data source – MSD, 2015)

Figure A3. Head difference between carbonate and sandstone aquifer

Areas of flowing groundwater in the carbonate aquifer are shown in Figure A4.[50]

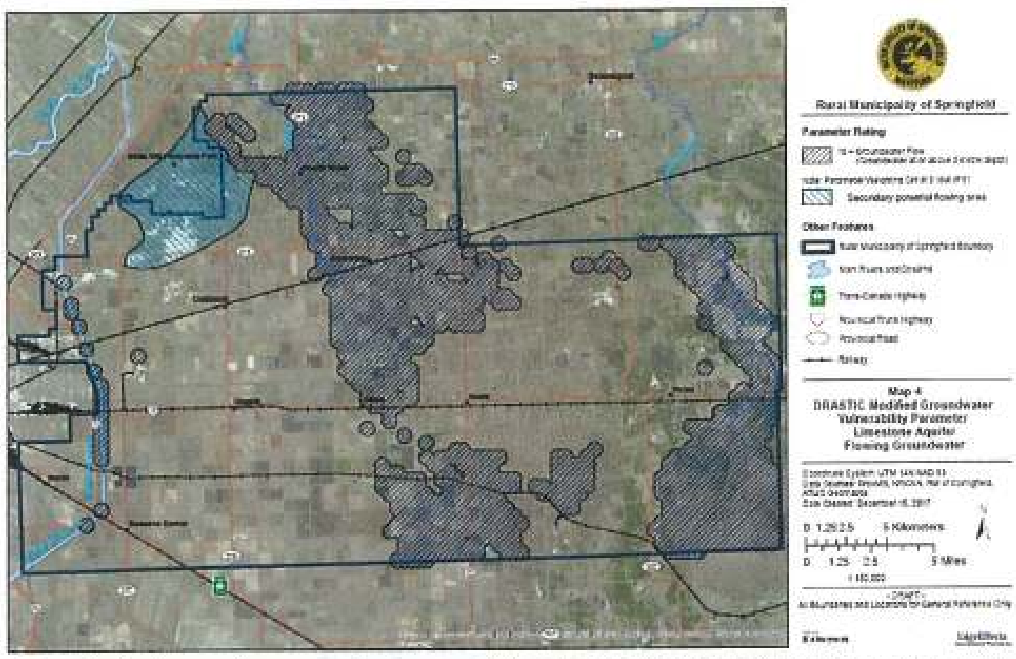

Figure 30 – Flowing groundwater areas in the carbonate aquifer throughout the RM of Springfield; modeled from hydrograph and Lidar topography data; Secondary potential flowing area is based off of topographical data, is approximate and will vary locally. (data source – MSD)

Figure A4. Areas of flowing groundwater in Springfield, Manitoba from Friesen Drillers[50]

The tensile strength of the shale in the Winnipeg formation is unknown. Literature values for the tensile strength of near surface shale throughout Western Canada vary from 30 to 280 pounds per square inch (200 to 1900 kPa).[55] When the overburden stress exceeds the tensile strength of the shale, the shale will collapse into the cavity in the sandstone.

Figure A5 shows the maximum stress on a shale circular slab as calculated from the second equation in Figure A2 as a function of the radius of the cavity in the sandstone created by potential CWS air lift extraction. Reference parameter values are given in Table A1.

Table A1. Parameter values for maximum stress on shale aquitard

Parameter name	Parameter value	units
Density of till/gravel/sand	2000	kg/m^3
Density of limestone	2500	kg/m^3
Density of unsaturated layer	1800	kg/m^3
Thickness of saturated till/sand/gravel	25	m
Thickness of limestone	20	m
Thickness of unsaturated zone	5	m
Thickness of shale aquitard	2.83	m
Aquifer water head difference	2.9	m
Density of water	1000	kg/m^3
Poisson ratio for shale	3.0	
Acceleration of gravity	9.8	m/s^2

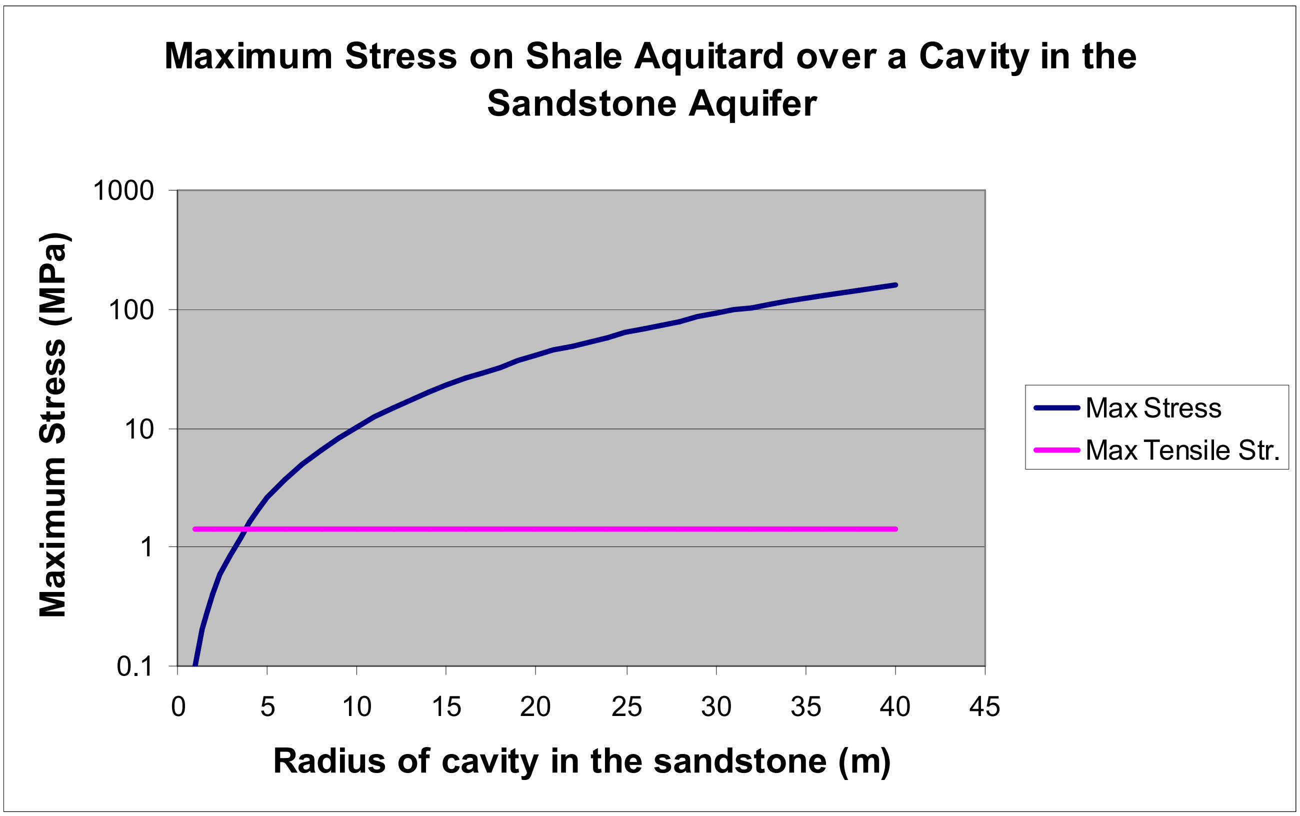

Figure A5. Maximum stress on the shale aquitard from the overburden pressure and maximum expected tensile strength of the shale aquitard.

Figure A5 illustrates the overburden stress on the shale aquitard would be expected to far exceed the tensile strength of the shale for a sandstone cavity radius of over 4 meters. The cavities will certainly exceed 4 meters in radius and will likely increase with time from sand slumping into the cavity. The process of slaking will also cause the shale aquitard to collapse into the cavity in the sandstone.[49]

The shale layer over the cavity might also fail due to maximum shear stress at the edge as show in Figure A6

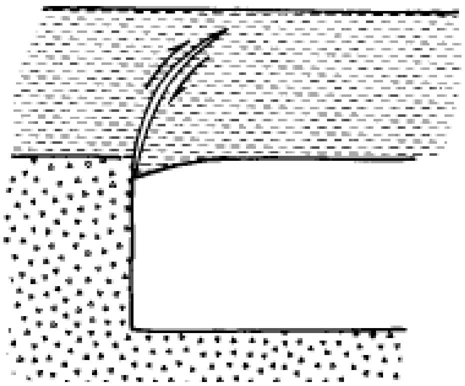

Figure A6. Shear stress at edge of a roof over a cavity from Goodman (1989)[48]

The equation for the maximum shear stress τ_m at the edge of a circular disc is $\tau_m = 3\Delta pR^2/(4t^2)$.[61]

The shear strength of shale is typically greater than the tensile strength.[59,62] The shear strength S for geological material is normally given by the Mohr-Coulomb failure law.[31]

$$S = c + \sigma \tan\phi .$$

Where σ is the normal stress across the failure plane, c is the cohesion of the material and ϕ is the angle of internal friction.

This equation can be modified for saturated conditions to give[31]

$$S = c' + (\sigma - p)\tan\phi' .$$

Where p is the fluid pressure c' and ϕ' must be determined under saturated conditions. ϕ' is reported to range from 24 to 38 degrees and c' ranges from 0.2 MPa to 5.6MPa for normal compaction in shale from various locations in Kentucky. A large range of values of shear strength of shales is given in Goodman (1989).[48] Given the wide range of literature values a laboratory measurement of shale samples near in the CWS claim area in needed to establish these values. In general the shear strength of shale is normally larger than the tensile strength thus the analysis from Figure A5 is limiting and applicable.[62,63]

The presence of the extraction well is not considered in this analysis. According to the well information reports of the triple tube air lift sand extraction wells, below the central tube for air injection is an area of open hole. After sand extraction the cavity will extend below the bottom of the well tubes in the sandstone. The well does not therefore contribute to the support of the shale layer suspended over the cavity. The weight of the well casings and annular fill would contribute to the load on and failure of the shale layer. A more complex analysis would include stress field associated with the well and well annular sealing.

The shale aquitard according to this analysis would collapse into the cavity in the sandstone created by CWS sand extraction. The till and sand overlying the limestone with time would migrate down through cracks in the limestone to gradually fill the cavity. Subsidence would gradually or suddenly occur in the future as indicated in Figure 18 in the main text. Since the predominant overburden is till rather than sand, cover collapse sinkholes would most likely occur suddenly at random future times. It appears that acid formed in the sandstone from oxidation of pyrite by injected air from CWS extraction wells would be injected into the carbonate aquifer. The acid would erode the limestone creating larger downward drainage paths for the surface till exacerbating the sudden formation of sinkholes. The sudden sinkhole formation would occur at random times for large number of CWS wells drilled per year. The collapsing sinkholes would increase each year as the CWS drilling advances. The boreholes in the exploration sand extraction were usually less than 100 meters apart as can be seen from Figure 13 in main. Large numbers of sinkholes appearing about every 100 meters every year would cause utter devastation of the surface landscape. This would be an intolerable consequence of the CWS sand extraction.

A comprehensive rock mechanics study by qualified technical experts is required to fully quantify the risk of land subsidence and sinkhole formation from CWS silica sand extraction activities. It is essential that laboratory measurements be made such as tensile and shear strength, the cohesion of the material, the angle of internal friction and slake tests of shale from the aquitard at representative locations. Drill cores of the carbonate aquifer should be analyzed for the potential of till piping downward through vertical cracks.

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