Via email

Sept.8, 2021

The Honourable Jonathan Wilkinson
Minister of Environment and Climate Change
House of Commons
Ottawa, Ontario, K1A 0A6
jonathan.wilkinson@parl.gc.ca

Barbara Pullishy
Director, Prairie and Northern Region,
Impact Assessment Agency of Canada
1145-9700 Jasper Avenue
Edmonton, Alberta, T5J 4C3
barbara.pullishy@canada.ca

Dear Minster Wilkinson and Ms. Pullishy:

Re: Request to Designate the Vivian Sand Extraction Project Based on Missing and Misleading Information in the Vivian Sand Extraction EAP and the Hydrogeology and Geochemistry Assessment Report prepared by AECOM Canada Ltd.

On the behalf of What the Frack Manitoba I am requesting that the Vivian Sands Extraction Project be designated on the basis of missing and misleading new information in the CanWhite Sands Extraction Environment Act Proposal (EAP) and the Hydrogeology and Geochemistry Assessment Report (HGR) prepared by AECOM Canada Ltd. The missing and misleading new information pertains to significant effects from the project that would be within federal jurisdiction.

On November 16, 2020, Barbara Pullishy, Director, Prairie and Northern Region of the Impact Assessment Agency of Canada (IAAC) wrote a letter to F. Somji, President and CEO of CanWhite Sands Corporation (CWS) informing him that even though the Vivian Sand Processing and Extraction Project had not been designated that:

"*The Agency appreciates the information that you provided in response to our request of August 28, 2020. Recognizing that CanWhite Sands is still undertaking studies and planning related to the Extraction Project, many responses were insufficient for the Agency to determine the potential for effects within federal jurisdiction, as relate to that Project.*

The Agency requires that CanWhite Sands provide any information related to the Vivian Sand Extraction Project and its potential effects, including the results of any ongoing studies, to the Agency as it becomes available. The Agency will advise the federal Minister of Environment and Climate Change should new information arise to suggest the Project may lead to significant effects within federal jurisdiction. The Agency will further review new information with a view to determining if it warrants the Minister to re-consider designating the Project.

The Agency also requests that CanWhite Sands provides its Environment Act Licence application for the Vivian Sand Extraction Project to the Agency, upon submission to Manitoba Conservation and Climate."

This letter was obtained through an access to information request number A-2020-00050 submitted March 11, 2021. A similar letter was written to Don Sullivan of What the Frack Manitoba by David McGovern, President of the IAAC on Dec.16, 2020.

The EAP and HGR have been completed for the Vivian Sand Extraction Project now undergoing licensing review. The reports can be found in the Manitoba Public Registry 6119.00 - Silica Sand Extraction Project - CanWhite Sands Corp.

We prepared a list of questions supported by references for the CWS Virtual Open House of Aug. 24, 2021. The submitted questions document a series of inadequacies and misleading or incorrect information in the EAP and HGR. The questions were submitted Friday Aug. 20, 2021 before the virtual open house. CWS did not specifically address any of the submitted questions in the virtual open house. Attached with this letter is the questions document submitted to the CWS Virtual Open House. In the chat box during the open house I submitted five written questions that were "*dismissed by the host*." The chat box was configured such that participants could not see written questions of others.

Some oral statements were made by the CWS participants in the virtual open house that seemed to be a partial rebuttal to some of the questions submitted in advance, however no specific advance questions were read out and completely addressed. There is no indication that any proper thorough response will ever be forthcoming. The questions may be posted on public registry along with other public comments. The posting is likely to occur after the Oct. 7, 2021 deadline for public submissions and after responses from the provincial Technical Advisory Committee (TAC) are received. The TAC would not be able to review and respond to the public comments. For the Vivian Sand Processing Project and other projects, the TAC has responded in a siloed fashion, addressing issues only pertaining to their particular narrow jurisdiction. With these procedures the public comments will receive no independent qualified technical expert review and response other than from AECOM personnel who are hired to represent the interest of CWS.

It is essential that the IAAC give a proper independent technical review and response to the issues raised by the public and What the Frack Manitoba and their own experts. We request the IAAC open a new public registry for the Vivian Sand Extraction Project, accept public input and make a formal decision as to designation with written reasons.

We understand that the IAAC can make a narrow decision based only on issues under federal jurisdiction. However the IAAC Act under section 9(1) provides leeway for designation on broader grounds based on public interest, health and safety and protection of the environment that could overlap provincial jurisdiction.[1] We are urging the IAAC to take a broad view of protection of the valuable aquifers in southeast Manitoba and the health and safety of all the residents who rely on this water source. We think that under the present provincial process legitimate issues are being ignored and suppressed. We emphasize that designation of the Vivian Sand Extraction Project would necessarily require designation of the Vivian Sand Processing facility Project and Railway Yard Project as required by the Impact Assessment Act relating to cumulative and incidental interacting effects of these projects.[1] We remind the IAAC that a response has not yet been received to an official request from What the Frack Manitoba sent on May 19, 2021 to designate the CWS Vivian Sand Railway Yard Project. We request that the IAAC send this letter and the attached question document to relevant federal departments for technical review and input. One combined project encompassing the Vivian Sand Extraction, Processing and Railway Yard Projects should be considered for designation. The list of questions and references prepared on behalf of What the Frack Manitoba for the CWS Virtual Open House of Aug. 24, 2021 are attached.

The main issues raised by the questions for the CWS Virtual Open House that would lead to project effects within federal jurisdiction are itemized below.

1. Re-injection into the aquifers of excess water from sand extraction

The UV sterilization system specified in the EAP will not be effective in eliminating harmful microbes due to manganese and iron and fine particulate in the water that will scatter UV light. Re-injection to the sandstone of excess aerated water extracted with the sand will carry harmful microbes and oxygen into the aquifer. The oxygen in the re-injected water will react with sulphide in pyrite in the shale aquitard and deeper layers of shale within the sandstone, with marcasite (a form of pyrite) in the sand, with pyritic oolite layers in the sandstone and with pyritic concretions in the sandstone to form acid. The acid formed by oxidation of sulphide will mobilize heavy metals such as arsenic that the HGR report documented in the shale. The geochemistry results of the HGR that reported low or no sulphide in the shale and sand were corrupted because the sand samples and core logs were subject to air and moisture for a long period. These issues are all described with references in the attached questions document.

Particularly egregious was the collection of sand samples from stockpiles from well Bru 95-3. Well Bru 95-3 was completed on June 28, 2019 according to drilling records obtained from MB Groundwater. The sand stockpiled outside was exposed to air and moisture until the time of sampling in November of 2021. Any marcasite in the sand as was reported for Winnipeg formation sand from Wanipigow would have long been leached out.[2]

It is essential that sand and core sampling be redone with many more samples over the entire Bru area. The sand must be protected from air during extraction. Air lift extraction of the sand cannot be used. Sonic drilling methods such as were used at Wanipigow may be required.[2] Sand and core samples must immediately be sealed in air tight containers and sent for analysis. The sampling and sealing of the samples must be done by an independent agency or company that has expertise in this area.

At the CWS Virtual Open House I had the opportunity to ask one question at the end of the meeting. I asked about the sand sampled from Bru 95-3 that would have been corrupted due to weathering in the outdoor sand stockpile from which the sand sample was taken. The response was that the sand in the Vivian area was from the Carman sands that are different from the sand at Wanipigow and would have no marcasite. The name given to the sands is irrelevant. To determine the amount of sulphide in the sand a valid sample must be taken that has been protected from oxidation. Figure 4 of the attached question document provides evidence that the Carman sands are south of the Vivian extraction area.

Selenium was reported in the geochemistry results of the HGR in the carbonate, shale and sandstone despite the exposure of the samples to air that would oxidize and mobilize the selenium. Shake flask tests and other geochemistry results in the HGR have documented potentially toxic levels of selenium in the carbonate aquifer, shale aquitard and the sandstone aquifer. The concentration of selenium (Se) and arsenic (As) for Bru 1221-1 in the shale was particularly high at 1.64 mg/L Se and 0.0306 mg/L As. The selenium concentration of 0.002 mg/L in the sandstone aquifer for Bru 121-1 was attributed in the HGR report to shale fragments in the sandstone. The reported selenium and arsenic would be expected to be underestimated due to oxidation of the samples that occurred.

ALS lab results for solid core samples for Bru 121-1 give high values for heavy metals with arsenic at 30.4 ppm, barium, 30 ppm, boron,70 ppm, and selenium 13.1 ppm. The solid core sample results for Bru 95-8 also had elevated heavy metal content with 24.2 ppm arsenic, 30 ppm barium, and 58 ppm chromium. The XRD results from Table 1 Appendix A Part 6 in the HGR showed pyrite at 1.3 weight percent in the shale aquitard for well Bru 95-8 near Vivian and 0.6 weight percent for well Bru 121-1 even though much of the pyrite would have oxidized from exposure of the samples to air.

Reference 9 gives methods to prevent oxidation of pyrite in core samples in the attached questions document. A further reference by Basu et al. (2000) describes methods to prevent oxidation of shale samples including air tight containers and refrigeration at 4 degrees.[3] A reference, König et al (2000) documents the oxidation pyrite in core samples that are exposed to air during storage reporting, "*Massive Fe(II) to Fe(III) oxidation, which involved between 24% and 45% of the initial Fe(II), occurred within only 6 months of refrigerated storage.*"[4] These references establish that oxidation of pyrite in samples can occur rapidly and that the geochemical results conducted in the HGR would underestimate sulphide concentrations.

Ryan Mills, senior hydrogeologist who helped prepare the HGR admitted at the CWS Virtual Open House the core log samples were exposed to air but stated that the samples were prepared according to standard industry practice. He stated that pyrite oxidation was sufficiently slow, that very little would have oxidized before analysis. To keep core logs exposed to air in core boxes is standard practice for preserving a record of the extent of an ore body but is not acceptable for geochemical analysis. Two of the three core log samples Bru 121-1 and Bru 146 were held in storage in Steinbach for over a year where they would have been exposed to air. Bru 121-1 well was completed in Feb. 19, 2019 when the core logs would have been retrieved. The core log from the site near Vivian, Bru 95-8, extracted on Nov.11, 2020 and analyzed Jan.5, 2021, was not in an air tight container nor maintained at 4C. The samples were sent in low density polyethylene (LDPE) bags that allow air ingress. (reference 11 of the attached questions document)

The shale aquitard is reported in the HGR to be likely compromised by extraction activities. The shale aquitard is liable to crumble into the sandstone.

The well log from Bru 95-7 reports shale layers interbedded with sandstone below the pure sand layer at depth below surface between 72.24 to 74.68 meters. This shale could be extracted with the sand. Figure 1 shows a picture taken in the spring of 2020 of extracted sand piles south of Vivian show shale fragments interspersed in the sand. These pictures provide incontrovertible evidence of shale fragments within extracted sand.

Figure 1. Photo of shale fragments extracted with the sand near Vivian Manitoba, spring 2020. The photo was taken by a local concerned citizen (name withheld for privacy reasons)

Shale extracted with the sand would oxidize sulphide in the extraction processing tanks to form acid and mobilize heavy metals. Selenium in the shale would oxidize to a soluble form and be released as well. Most of the contaminated water from the processing tanks would be re-injected into the sandstone aquifer. Some of the contaminated water would be directed into the slurry lines. Oxidation of the selenium and pyrite in the small shale fragments carried in the sand would further contaminate the slurry line water. The oxidation of the pyrite and selenium in shale fragments would occur from aerated re-injected water in the sandstone aquifer. The sand grains in the sandstone aquifer may contain marcasite since the geochemical tests for the sand was corrupted due to exposure of the sand samples to air. The oxidation of marcasite would form more acid and mobilize heavy metals and selenium.

A paper by Schrieber and Riciputi (2005) identifies concretions formed in the Winnipeg sandstone as containing pyrite and marcasite.[5] The HGR describes screening out of concretions from the sandstone after extraction of the sand. Oolite nodules described as pyritic by Watson have been observed in extracted sand piles at Vivian.[6] The concretions and oolite nodules have not been analyzed for the presence of sulphide, selenium and other heavy metals. These concretions and ooilite nodules in the sandstone aquifer would be another source of contamination when exposed to aerated re-injected water.

The HGR reports mixing of the carbonate and sandstone water will occur due to degradation of the shale aquitard caused by the extraction activities. Mixing of aquifer water is prohibited by the regulations of the Manitoba Groundwater and Well Water Act.[10] The aerated re-injected water would enter the carbonate aquifer where selenium has been detected at levels that produced toxic concentrations in shale flask tests documented in the HGR. The aerated re-injected water would oxidize and mobilize selenium in the carbonate aquifer. Contaminated water from the sandstone could enter the carbonate aquifer from the mixing.

Groundwater moves relatively quickly in the carbonate aquifer eventually discharging into the Red River, a major fish bearing water body. The contaminants including selenium introduced and formed in the aquifer by the re-injected aerated water will eventually discharge into the Red River. Selenium is toxic to aquatic organisms above two parts per billion.[8] All the water wells along the flow path would be contaminated.

Rebuttal remarks in the CWS Virtual Open House by CWS personnel that the sandstone and carbonate aquifers already have oxygen are not credible. A paper by Phipps et al. (2008) reported, over a large area of the Winnipeg formation in eastern Manitoba including the Vivian area, that no dissolved oxygen (D.O.) was detected in the carbonate and sandstone aquifers for most samples.[11] In particular Phipps's paper reported:

Carbonate aquifer:
"*Measured pH ranges from 7.0 to 8.1, with a median value of 7.5. Redox and D.O. were measured in 17 sites. The D.O. ranges from 0.03 (oxygen is absent) to 1.14 mgL-1. Only one sample has greater than 1 mgL-1,* ***whereas the remaining samples are almost completely depleted of oxygen,*** *containing less than 0.20 mgL-1. Eh ranges from -223 to 244 mV*."

Sandstone aquifer:
"*pH varies from 7.2 to 8.2 (median = 7.6). Only one sample, located near the erosional margin, had D.O. concentration > 1 mgL-1 and three other samples had low concentrations >0.1 mgL-1,* ***however, the remainder had concentrations of 0.06 and lower (effectively 0 mgL-1 D.O.))****.(n=18) The Eh ranges from -30 to +181 mV.* "

Dissolved oxygen levels are reported in table 4.7 of the HGR for several Bru 95 wells in the carbonate, shale and sandstone ranging from 0.2 to 7 mg/L. These results are generally high compared to the results from Phipps et al.(2008). The results from Phipps et al. (2008) were over a much broader region and should be considered to be more representative of the generally very low dissolved oxygen concentrations that would be found throughout the Bru area.

The HGR states; "*the Winnipeg Shale is extensively weathered to clay and shows a strong blue color in the bottom half of its thickness at some locations suggesting limited access to oxygen*." The blue shale colour confirms lack of oxygen can occur in the shale aquitard layer.

Inconsistent sealing results were reported for the core logs in the HGR. For instance Bru 95-7 core log reports,

"*surface seal completed to a depth of 7.62. m (25ft) BGS using 0.51 m (20") diameter tri-cone bit and bentonite–cement grout*"

Bru- 95-8 core log reports,

"*bentonite-cement grout was injected down the tremmie pipe and was used to backfill the hole from 0 to 55.09 m BGS*"

The grout for Bru-95-8 grout would have penetrated past the shale aquitard which terminates at 52 m BGS whereas the surface seal for Bru 95-7 would not have penetrated to the shale aquitard. It is possible that some dissolved oxygen was introduced into the Bru 95 wells during drilling and testing procedures.

Sand has been extracted in the Vivian area such from well Bru 95-3 using air lift methods that may have introduced oxygen into the aquifers accounting for the higher results of dissolved oxygen reported in the HGR for Bru wells near Vivian.

2. Slurry Line Leakage

A spill from the CWS slurry lines that would carry selenium, arsenic, other toxic heavy metals, and harmful microbes could drain into fish bearing water bodies such as the Brokenhead River and Cook's Creek. The slurry line would be expected to carry the extremely toxic acrylamide monomer from the clarifier tank.[7] The contaminants will be ever increasing in the slurry lines as water is recycled and fresh extracted sand and flocculent is added to the slurry line and recycled water loop.[7]

The federal guideline limit for selenium in water for aquatic organisms is very small, two micrograms per litre.[8] Mitigation measures for potential selenium and other contaminant leakage into the environment have not been adequately addressed. A precedent has been set with the Grassy Mountain Coal Project[9] where the project was denied by a joint IAAC and provincial review in part because of potential selenium release to the environment.

The potential for spill from the slurry lines affecting fish is acknowledged in the Extraction EAP which states;

"*Accidental releases, depending on the type and quantity of substances released, have the potential to affect air, surface water, groundwater and soils, with* ***consequential effects*** *on vegetation****, aquatic resources*** *and possibly human health and safety*"

In the CWS Virtual Open House mitigation of spill risk was mentioned by CWS personnel who stated that pressure transducers will be installed in the lines that would automatically shut down the slurry lines in the event of a leak. No such automated system is documented in the EAP. No plans or engineering drawings have been provided for such a system. Even if an automated shut down system were installed, pressure transducers would not detect small continuous leaks that may over time release more contaminated water to the environment than a single large slurry line break. The slurry lines are subject to erosion by the sand particles and many other sources of potential leakage as documented in the attached questions (reference 20 in questions).

The EAP never assessed the potential for ongoing small leaks from the slurry lines when they would be emptied into vacuum trucks and moved every five to seven days. Considering there would be about 455 wells drilled per year at full production each requiring slurry line movement, the potential for spillage during emptying and movement is significant.

3. Sinkholes and Subsidence

Cover collapsed sinkholes would occur in the approximately 65 well clusters drilled per year as documented in the question 1 of the document submitted for the CWS Virtual Open House. CWS personnel claimed that literature reports specifying a stable thickness of the limestone larger than 37.8 meters does not apply in the Bru area where the limestone is very strong. The Stantec reports referred to in the HGR specifying a minimum thickness for the limestone of 15 meter thickness have not been produced. The Stantec limit is therefore unverified.

The core log for Bru 95-8 in the HGR report gives the limestone from 32.3 to 35.3 meter depth below surface to be weathered and incompetent. Thus there are 3 meters of incompetent limestone documented. This is followed by 1.6 meters of competent limestone to a depth of 36.9 meters. Next are 1.5 meters of limestone with small vugs which are small cavities. Limestone with vugs would not be competent. Next is a clay rich layer of 1.5 meters to a depth of 39.9 meters, followed by a 1.5 meters limestone with horizontal fractures to a depth of 41.4 meters. The clay layer and the limestone layer with horizontal fractures would not be competent. A final limestone layer 4.6 meters thick to 46 meters depth is reported with no comment as to integrity. In the column of limestone for Bru 95-8 there are at most only 6.2 meters of competent limestone out of the13.7 meters. Other Bru core logs in the HGR report competent limestone but this could be due to less detailed core logging for these holes most of which were not completed to the same depth as Bru 95-8. The Bru 95-8 core log is hard evidence supplied by CWS itself that the limestone in the Bru area is not altogether competent or strong.

Note as well that the full depth of the limestone for well Bru 95-8 at 13.7 meters is les than the Stantec limit of 15 meters. Figure 1 of the questions document shows that none of 37 drill reports give limestone thickness in the Bru are over 37.8 meters. In the eastern area where extraction will begin, most limestone thicknesses are less than the unverified Stantec limit of 15 meters.

The so called "sand pillars" between clusters will likely slump and move into the large cavities created by the sand extraction. The forty-two CWS drill reports obtained from Manitoba Groundwater documented many instances of sand collapsing into drill holes demonstrating the sand pillars are not stable. The well log for Bru 95-8 in the HGR report states that the sandstone is fine grained, well sorted, poorly cemented and of low strength and that the borehole would not stay open without drill mud. The core logs for Bru 95-6, 95-7, and 96-1, all state the sand is poorly cemented with low strength. These drill reports and core logs demonstrate the sand pillars would be prone to slumping. The airlift method of extraction would not be viable for strongly cemented sand pillars. Wherever sand extraction occurs with the airlift method, sand must be unconsolidated and therefore prone to slumping into the extraction cavities.

According to a recording and a transcript made by local volunteers for the CWS Virtual Open House, Brent Bullen, Chief Operating Officer of CWS stated in response to a question about the cavities;

"*We are seeing indication that the sand will actually move and rest back in. It's a unique sand it has many properties so would actually stand up.*"

This statement indicates that CWS acknowledges the sand pillars will slump into the cavities in the sandstone. However the statement by B. Bullen is nonsensical. How can sand rest back in and stand up at the same time?

Sand slumping will enlarge the cavities under the well clusters creating an ever more unstable situation. Figure 2 illustrates the geometry of the well clusters and a unit cell within the clusters. The unit cell in figure 2 is 114 meters wide by 98.7 meters high with a central cavity of 54 meters in diameter. The extraction ratio in the sand layer for the unit cell shown is 0.203 (~20%). The unit cell and the 20% extraction ratio in the sand layer repeats as the clusters expand. The extraction ratio quoted in the EAP for the processing plant of 5% would include the layers of limestone and glacial till above the sand layer thus giving a much smaller extraction ratio.

At the CWS Virtual Open House Brent Bullen stated;

"*We look at global sustainability we actually will take on average 1% of the resource in the global space that's in the Winnipeg formation.*"

The global ratio in the entire global space of the Winnipeg formation is not relevant to subsidence for the room and pillar configuration in the excavated area of the well clusters. To determine subsidence the extraction ratio within the sand layer is required only in the area of the extraction well clusters. The thicknesses of the limestone and till layers are relevant to determine the stability of the limestone and the total unsupported weight of overburden above the cavities but not to determine the extraction ratio relevant to sand slumping. In fact the thicker the layers above the extracted layer, the more unsupported weight that would contribute to subsidence and formation of sinkholes even though, if included in the extraction ratio, thicker layers of limestone and till would decrease the extraction ratio.

As the sand slumps into the cavities the unsupported cavity area will increase as the extraction proceeds. Eventual collapse of the limestone and till and subsequent subsidence is inevitable over the entire area of the well clusters.

The sand layer from the well log for Bru 95-7 documented in the HGR to be 20 meters is representative of the initial area where extraction is planned. The maximum sand extraction depth according to the HGR is 25 meters. Thus the average depth of the general subsidence would be 4 to 5 meters based on an extraction ratio of 0.2 (20%) in the sand layer. A huge ever growing depression from subsidence would result that would fill with surface water. The depth of the depression is likely to vary from a few meters to up to 20 meters depending on the degree of slumping and sinkhole formation. Individual sinkholes could form for a well cluster to a depth of 20 meters (the total depth of the sand layer). The general subsidence area covered by all well clusters could be punctuated with these deeper sinkholes.

The carbonate and sandstone aquifers would be exposed to contamination from agricultural chemicals animal fecal matter, septic tank seepage and surface run off into the subsided depression and sinkholes. This contamination would migrate in the carbonate aquifer exposed by subsidence. The contamination would eventually discharge to the Red River contaminating all the wells along the flow path. There may be hydrogeological connections between the aquifers and Cook's Creek and the Brokenhead River causing discharge of contaminants into these fish bearing waters. The large and ever growing area of subsidence and sinkholes would disrupt the local surface run off patterns and may create permanent swamps that could drain into the Brokenhead River and Cook's Creek carrying contaminants into fish bearing water bodies.

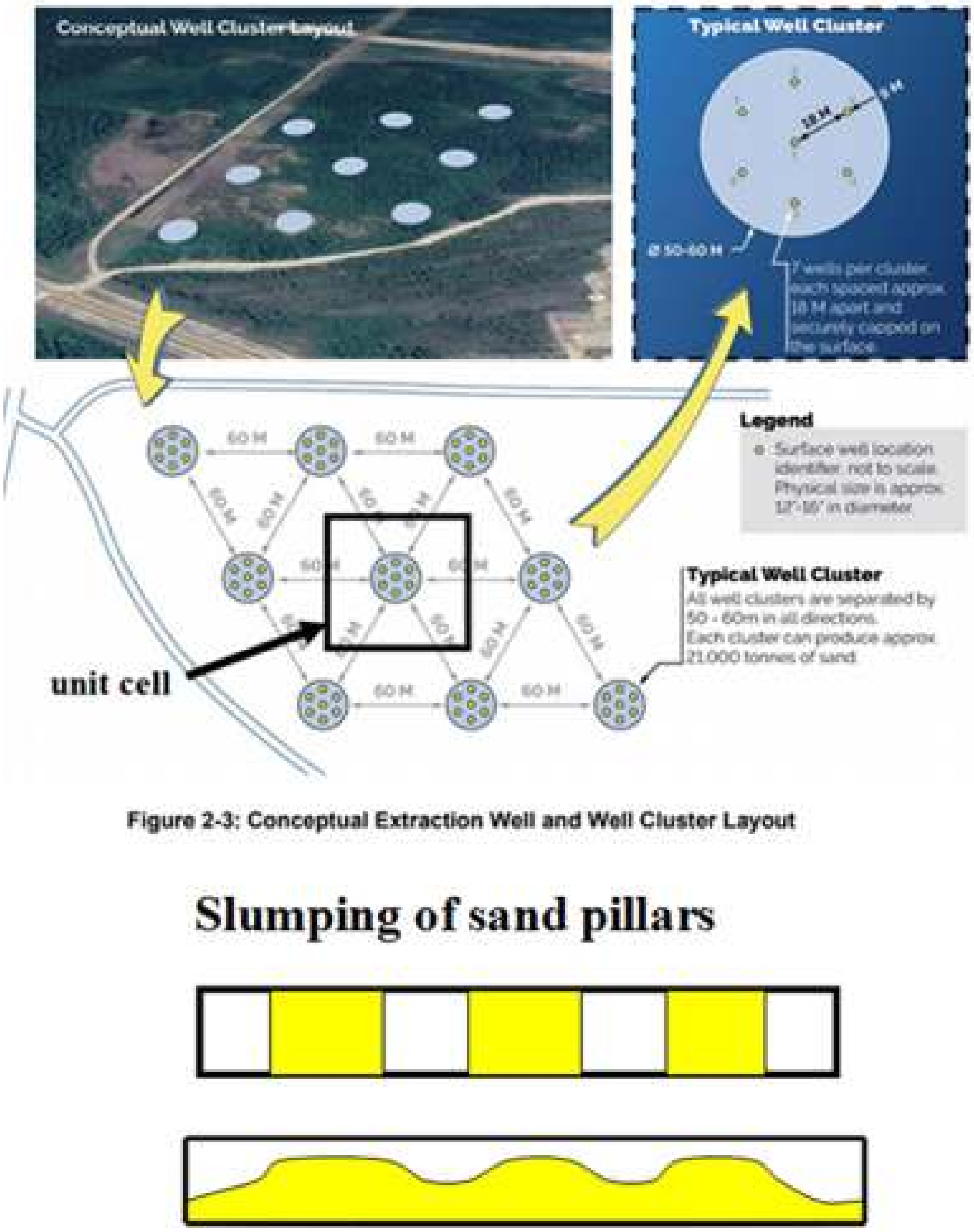

Figure 2. Slumping of sand pillars leading to subsidence between well clusters. Figure 2-3 from the CWS EAP was modified for this figure.

4. Waste Disposal

According to the HDR oversized particles, mainly sand concretions, will be screened out at the extraction site and sent for disposal at a licensed facility. The facility is not named nor is the volume of screened waste material quantified. The paper by Schrieber and Riciputi (2005) identifies concretions formed in the Winnipeg sandstone as containing pyrite and marcasite.[5] Figure 3, a photograph of extracted sand south of Vivian taken by a nearby concerned citizen in the spring of 2020, shows that the concretions can be large and significant in volume. Pyritic oolite nodules[6] have also been observed in the extracted sand piles at Vivian. These oolite nodules could be screened out and add to the pyritic waste at the extraction site. Such concretions and oolite nodules were not analyzed for sulphide and heavy metal content nor subject to acid base accounting. These concretions and oolite nodules would likely be acid generating and would require specialized disposal and storage on site. It is essential that the concretions and oolite be independently sampled to prevent air exposure and analyzed.

Figure 3. Concretions potentially containing sulphide in pyrite and marcasite in sand piles extracted near Vivian Manitoba in the spring of 2020.

In addition, drill cuttings will require disposal. The HGR identifies the shale drill cuttings as potentially acid generating (PAG). Some of the larger shale fragments could be screened out and require specialized disposal for PAG waste. The volume of such screened out shale fragments has not been considered.

5. Unrealistic Groundwater Model Simulations

The groundwater model simulations using the finite-element code FEFLOW v.7.3 were unrealistic. Only 0 and 50 percent re-injection of water was modelled. CWS has explicitly stated that no discharge of water to the environment will occur from the extraction operations. Thus virtually all the water extracted with the sand will be re-injected. The EAP states that only 10 US gallons per minute (gmp) per well cluster will be directed into the slurry line recycle water loop. The remainder of water in the sand will be re-injected. The maximum rate of water plus sand extracted per well cluster is given in the HGR as 540 gpm. The amount of water extracted with the sand will vary according to the HGR from about 30% initially to 80% by the end of the 5 to 7 days of extraction. The water sent to the recycled loop would be used to replenish the water lost to wet the sand stockpiles at the processing plant.

The model did not examine the actual intended operating conditions of near 100% re-injection of water. Modelling of the fate and quantity of re-injected aerated water is essential. It is recognized in the HGR that the shale aquitard would likely be compromised leading to mixing of aquifer waters. The amount of water that would enter the carbonate aquifer during re-injection at operational rates should have been modelled. Contaminated water can move much more quickly though the fractures in limestone than through the sand matrix of the sandstone aquifer. The contamination could include harmful microbes, acid, and heavy metals including arsenic and selenium. It is essential to determine movement of the re-injected water through the carbonate to determine the contamination potential of the aquifer.

The fate and amount of the aerated re-injected water in the sandstone should also have been determined.

The amount of heavy metals released to the aquifers is likely to be oxygen limited. It is essential to know how much oxygen would be introduced to the aquifers and the movement of the oxygen through the aquifers. Not only dissolved oxygen could be re-injected but gaseous oxygen in air bubbles entrained in the water during the airlift process. Gaseous air could also enter the aquifers directly from the air injection tube in the extraction wells. CWS has stated in the Sept. 11 letter of F. Somji to the IAAC that the air injection tube is shorter that the sand recovery tube so that the air will not directly enter the aquifer. However, especially during initial priming of the system and during operation, some leakage of gaseous air to the aquifer could occur. It is essential to quantify the volume, rate and fate of all sources of oxygen introduced into the aquifer by the extraction process. This has not been done in the groundwater modelling.

6. The Winnipeg Aqueduct

As shown in figure 4 in the questions document attached, the Winnipeg aqueduct traverses the entire CWS project area. The slurry lines and return recycled water loops will eventually have to cross the aqueduct likely multiple times. The aqueduct is known to have cracks that allow infiltration of surface water (reference 25 in the attached question document). Slurry line spills near the aqueduct could contaminate Winnipeg's drinking water supply with harmful microbes, arsenic, selenium, other heavy metals and the highly toxic acrylamide monomer. A major break of the slurry line would leak at a rate of up to 24 cubic meters per minute as documented in the CWS processing plant EAP. The aqueduct could be submerged with a volume of about an Olympic sized swimming pool in two hours. A gradual undetected leak could infiltrate the aqueduct undetected for a long time.

CWS is applying for a licence up to 2025. The excavations are not planned to reach the aqueduct by 2025. Project alterations after 2025 such as crossing of the Winnipeg aqueduct could be approved by an alteration request under the Environment Act with no consultation with the City of Winnipeg or the federal government. The Winnipeg aqueduct transverses a provincial boundary and Shoal Lake is part of Lake of the Woods, an international water body. Therefore the aqueduct should fall under federal jurisdiction. The IAAC should consider the crossing and potential contamination of the Winnipeg aqueduct in the decision about designation.

7. Section 35 Consultations

The large land disturbance from clearing slurry lines and well cluster drill pads will cause long term damage to the traditional lands of First Nations and Métis in the area. The land subsidence and sinkholes would have a devastating impact on traditional lands and wildlife and likely the fish bearing water bodies of Cook's Creek, the Brokenhead River, and the Red River. The entire extraction project is on treaty one lands. Crown land where the indigenous people has harvesting rights will be adversely affected by the extraction project. There has been no Section 35 consultation undertaken by the provincial crown and as specified in the sections 155 (b) and (i) and other provisions of the Impact Assessment Act and by the Constitution of Canada. The extraction EAP states

"*The Project is not expected to adversely impact the exercise of Indigenous or Treaty rights*"

No consultation is planned. The IAAC should ensure that province carry out the consultations. The IAAC should consider this egregious lack of indigenous consultation in the decision to designate. Without IAAC intervention no indigenous consultation will occur.

8. Greenhouse Gas Emissions

The greenhouse gas (GHG) emissions summarized in Table 6-3 of the Extraction EAP were not combined with the GHG from the processing facility and the projected GHG from all users of a new gas line to be constructed to serve the CWS processing plant. The GHG emissions from the pant and extraction project might not extend beyond the 2050 target for zero net emissions according to the project 24 year stated lifetime. However the project start date could be delayed or production could continue beyond 2050 through submission of project alterations as described in the executive summary of the extraction EAP. The natural new natural gas line planned for the CWS processing plant would continue operation beyond 2050. There are no plans to meet 2050 GHG reduction targets that would be required by the new Canadian Net-Zero Emissions Accountability Act (Bill C-12). Bill C-12 is federal legislation that comes under IAAC jurisdiction. The IAAC must consider in its decision to designate, the cumulative GHG project emissions including from all users along the proposed new natural gas line for the CWS project. The mitigation measure of geothermal electrical heating for the CWS processing plant sand dryer may be required to conform to the new federal legislation.

9. Conclusion and Recommendations

We recommend the IAAC send this letter and the attached questions document to relevant federal departments for technical review and input. The IAAC should open a public registry on the Vivian Sands Extraction Project. Based on the evidence submitted here, review by federal technical experts and public concerns expressed on a new public registry the IAAC we request the IAAC designate the Vivian Sands Processing Project, the Vivian Sands Extraction Project and the CWS Railway Yard project integrated as one Vivian Sands Project. We think that the evidence given here and provided elsewhere will require such designation.

References

1. Impact Assessment Act of Canada SC. 2019, c.28, s.1 https://laws.justice.gc.ca/eng/acts/I-2.75/index.html

2. Technical report and preliminary economic assessment on the Seymourville Silica Sand Project, Manitoba, Canada for Claim Post Resources Inc., NI-43-101 & 43-101F1, Eugene Puritch, P.Eng., Richard Sutcliffe, P.Geo., Ph.D.,Yungang Wu, P.Geo., David Burga, P.Geo., Jarita Barry, P.Geo., Kenneth Kuchling P.Eng., David Orava, P.Eng., David Anthony, P.Eng., Michael Esposito, P.E., P&E Mining Consultants Inc., Report No. 292, November 1, 2014 sedar.com

3. Best Practices for Shale Core Handling: Transportation, Sampling and Storage for Conduction of Analyses. February 2020, Journal of Marine Science and Engineering 8(2):136,S. Basu, Adrian P Jones, Pedram, Mahzari, https://www.researchgate.net/publication/339426332_Best_Practices_for_Shale_Core_Handling_Transportation_Sampling_and_Storage_for_Conduction_of_Analyses

4. Iron oxidation in sediment cores (Site 1062) during six months of storage in the Ocean Drilling Program archive, September 2000, Proceedings of the Ocean Drilling Program: Scientific Results 172:1-11, I. König et al. https://www.researchgate.net/publication/262791290_Iron_oxidation_in_sediment_cores_Site_1062_during_six_months_of_storage_in_the_Ocean_Drilling_Program_archive

5. Pyrite and Marcasite Coated Grains in the Ordovician Winnipeg Formation, Canada: An Intertwined Record of Surface Conditions, Stratigraphic Condensation, Geochemical Journal of Sedimentary Research 75(5):907-920. Jurgen Schieber, Lee Riciputi November 2005 https://pdfs.semanticscholar.org/c726/0c14eefc435745019d169ed8f741ed4da6df.pdf

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

7. Critique of CanWhite Sands Minor Notice of Alteration, Jan. 22, 2021 by D.M. LeNeveu, B.Sc. (hons. phys.), M.Sc. (biophysics) B.Ed. On Behalf of What the Frack Manitoba Feb. 23, 2021, submitted to the Public Registry 6057.00 CanWhite Sands - Vivian Sand Processing Facility https://www.gov.mb.ca/sd/eal/registries/6057canwhite/canwhite_sands_minor_noticeofalteration.pdf

8. Canadian Environmental Protection Act, 1999 - Federal environmental quality guidelines – selenium Environment and Climate Change Canada, June 2021 https://www.canada.ca/en/environment-climate-change/services/evaluating-existing-substances/federal-environmental-quality-guidelines-selenium.html

9. Canada Grassy Mountain Coal Project, Canadian Impact Assessment Agency Registry, 2021 https://iaac-aeic.gc.ca/050/evaluations/proj/80101

10. The Groundwater and Water Well Act (c.c.s.m. c. g110) Well Standards Regulation 215/2015, Registered December 21, 2015 Interconnection of geologic formations 3(1) https://web2.gov.mb.ca/laws/regs/current/_pdf-regs.php?reg=215/2015

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

Sincerely on behalf of What the Frack Manitoba,
Dennis LeNeveu

Questions for CanWhite Virtual Open House for the Vivian Sand Extraction Project and Hydrogeological Report
by D.M. LeNeveu B.Sc. (hons. physics) M.Sc. (biophysics) B.Ed.
Aug. 20, 2021

1. Subsidence

The Can White Sands Corporation (CWS) Extraction EAP written by AECOM recognizes that subsidence of the extraction holes with design diameter of 54 meters may be a problem. The EAP states;

"*Results of a geotechnical assessment based on preliminary exploratory drilling associated with this Project from 2017 to 2021 indicated that the overlying carbonate (limestone) geological layer needs to be at least 15 m thick to minimize the possibility of surface subsidence during sand extraction activities (Stantec, 2019; 2020; 2021).*"

The Stantec reports are not available to substantiate this claim. The CWS hydrogeological study states;

"*Removal of the sand will form a void in the shape of a cone extending from the bottom of the Carman Sand Member to the base of the Winnipeg Shale. The pattern of extraction cones is planned to extend laterally by successively extracting from new boreholes across the extraction area in a "room and pillar" style in accordance with the geotechnical model*."

The geotechnical model is not given.

A peer reviewed paper by Waltham and P. Fookes specifies that minimum stability thickness for limestone above a cavity must be 70% of the cavity opening dimension excluding overburden cover.[1] For the CWS standard design opening for a seven well extraction cluster the limestone thickness must be at least 37.8 m. The limestone of the carbonate aquifer in the Bru extraction area has a thick overburden cover of glacial till whose unsupported weight will increase the minimum stability thickness for the limestone.

Figure 1 shows the limestone thickness of the carbonate aquifer in the Bru extraction area and the Stantec and Waltham and Fookes thickness limits. The data was taken from CWS well records supplied by Manitoba Groundwater and from the CWS borehole records in the hydrogeological report. The well records demonstrate that over the entire Bru extraction area all limestone thicknesses are less than the minimum criteria stated by Waltham and Fookes for stability. All limestone thicknesses in the eastern Bru area where extraction activities will begin are less than the Stantec limit of 15 meters. The limestone thickness in general increases westward.[13]

A report released by What the Frack Manitoba in February 2021, peer reviewed by A. Ingraffea of Cornell University a world renowned expert on geo-mechanics, determines the shale aquitard will be unstable and slake into the cavity from the sand extraction.[2]

The CWS hydrogeological report in section 4.3.2 states

"*It is possible that project operations will result in increased hydraulic communication between the Red River Carbonate and the Winnipeg Sandstone within the Project Area due to fractures and borehole annuli that may extend across the Winnipeg Shale aquitard. Degradation of the Winnipeg Shale could lead to a* *more interconnected aquifer system comprising the Red River Carbonate aquifer and the underlying Winnipeg Sandstone aquifer*."

This statement confirms the shale aquitard could be compromised.

The glacial till overburden will gradually migrate into the cavity through the compromised limestone layer causing a cover collapse condition. In cover collapse subsidence the cavity created in the till overburden by gradual migration through the limestone layer will suddenly collapse at some undetermined time in the future leaving a large sinkhole as illustrated in Figures 2 and 3. All of the well clusters created by CWS operations are susceptible to cover collapse. A moonscape of water filled sinkholes will be eventually created. Water contaminated iron bacteria, fecal coliform from septic fields and animal feces, other microbes, and chemicals from surface runoff will have direct access to the carbonate aquifer and the sandstone through the compromised shale aquitard. This subsidence scenario is untenable.

Question:
Will CWS move their operations westward into the ALY area where the limestone is thicker and the sandstone aquifer is saline to avoid subsidence?

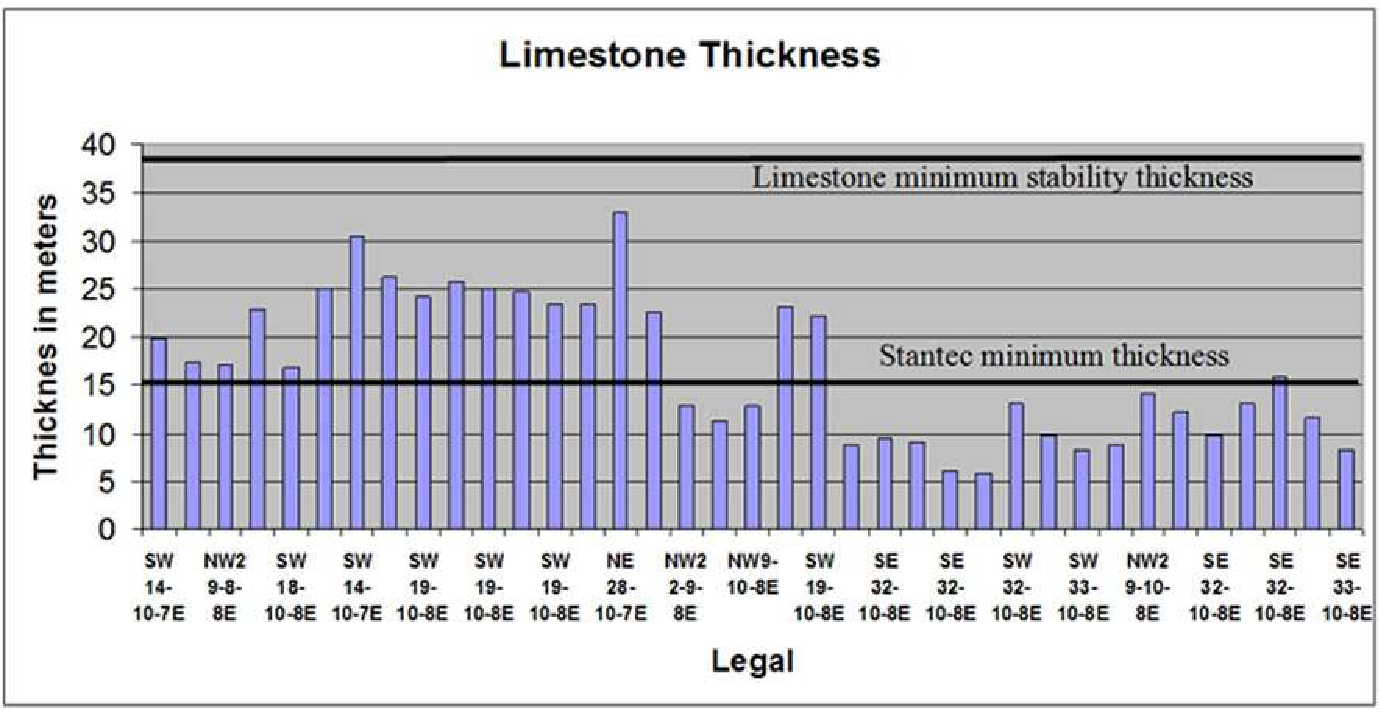

Figure 1. Limestone thickness in the carbonate aquifer of the CWS BRU extraction area.

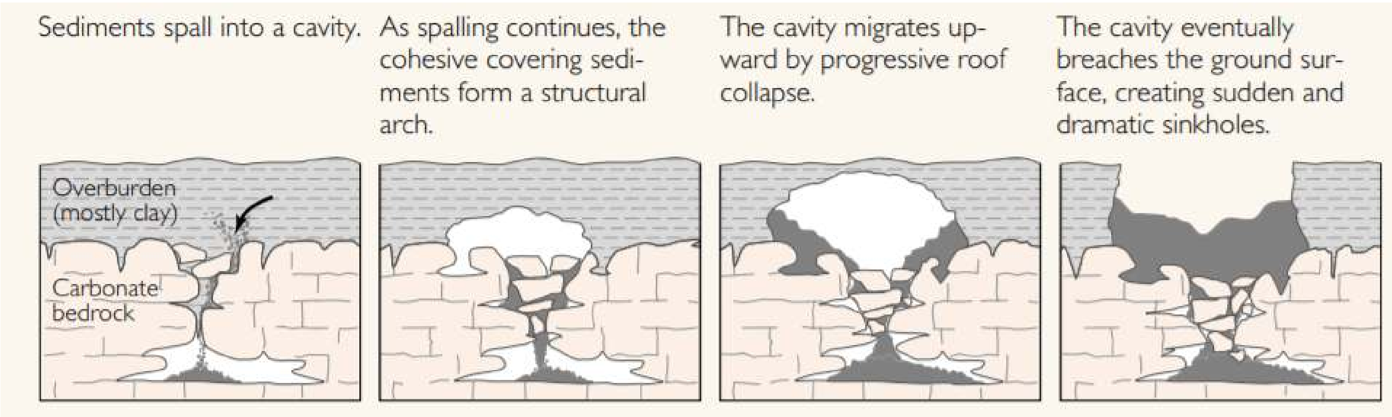

Figure 2. Cover collapse sinkholes from USGS.[3]

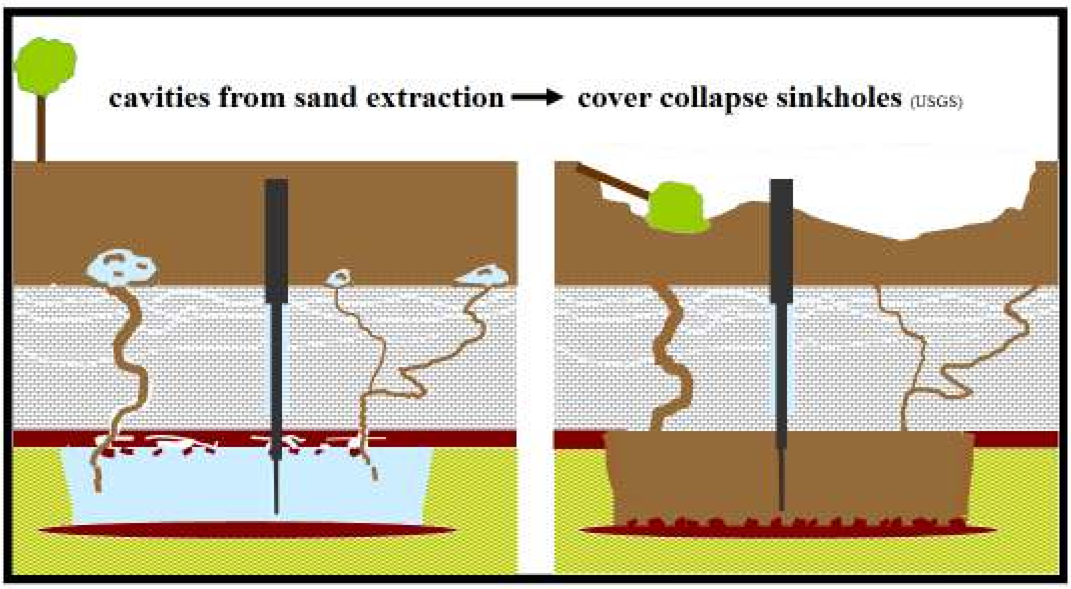

Figure 3. Sinkhole development from CWS sand extraction[2]

2. UV Light Sterilization

The CWS extraction EAP admits that bacteria and microbes may be introduced into the extracted water that will be re-injected to the sandstone aquifer. The EAP states;

"*The groundwater flows past a series of UV lamps that expose the water to UV light and renders all bacteria and other microorganisms inactive. UV light acts very rapidly by rending any bacteria, viruses or protozoa that may be present inert when they are exposed to the UV light making these organisms, if present, incapable of growing or infecting the water*."

The EAP admits in addition to potential microbes the re-injected water will contain oxygen. The EAP attempts to minimize the effect of this large change in the water chemistry of the aquifer system that is essentially initially anaerobic (no oxygen) by such statements as;

"*For some constituents, the impact was simulated to be positive due to reduction of concentrations of iron and manganese when oxygen (air) is introduced into the aquifer or is allowed to mix with water containing lower concentrations of those elements*."

The Government of Australia Department of Health states;[4]

"*UV light will only travel in a straight line so any shadow or obstruction will reduce its efficiency. Water that is not filtered can contain iron, manganese and other particles that can either absorb or scatter UV light reducing the effectiveness of the disinfection system. Microorganisms that are able to pass through protected by shadows created by dirt, debris or other microorganisms may be able to survive treatment*."

The Water Research Centre of Dallas Texas gives the following conditions for UV sterilization to be effective[4]

1. Five to ten micron pre-filtration of suspended solids
2. iron concentration less than 0.3 mg/L
3. manganese concentration less than 0.05 mg/L
4. colour – none.

Pre-filtration of the re-injection water with 5 to 10 micron filters would generate a huge filter maintenance and disposal problem for the large amounts of captured filter material. Pre-filtration of the re-injected water with 5 to 10 micron filters is not viable.

The concentration of manganese the water in the sandstone aquifer given in table 4.3 of the hydrogeological study is between 24 and 45 ppm (mg/L). The iron concentration is between 0.22 and 0.65 mg/L. The hydrogeological study states,

"*Although the naturally elevated concentrations of dissolved iron and manganese were simulated to decrease in response to aeration or mixing, they may remain elevated above drinking water quality criteria during and following operations*"

Thus the concentrations of iron and particularly manganese will not be reduced to acceptable levels for disinfection in the extraction dewatering process where the water becomes aerated.

This evidence demonstrates that the UV radiation will be ineffective and that potentially harmful microbes will be introduced to the aquifer. The re-injected aerated water will provide an environment where the introduced harmful microbes can proliferate contaminating the drinking water.

Question:
How will CanWhite disinfect the water re-injected to the sandstone aquifer given that UV radiation cannot be effective?

3. Core log and Winnipeg Formation sand samples are compromised

All core log samples for the Red River Carbonate aquifer and the Winnipeg Shale aquitard, (Bru 95-8, Bru 121-1 and Bru 146) and sand samples from the Winnipeg aquifer were not protected against oxidation by air. The sand samples from borehole Bru 95-3 were taken from outdoor stockpiles that had been exposed to air, rain and weathering since the well completion date of June 28, 2019 as determined by CWS well reports obtained from MB Groundwater**.** Sand from Bru 95-3 was extracted by air lift wells that would have exposed the sand to air in the well pipe before reaching the surface.

Samples of sand from the Winnipeg Sandstone from Bru 121 and 146 according to the CWS hydrogeological report had been previously collected and submitted by others to ALS Environmental Laboratories (ALS).

How the samples were collected, at what time and by whom is not given. Pictures of the sand samples in the hydrogeological report are open to the air and the Bru 146 samples show some brown discoloration consistent with oxidation of marcasite coating the sand. (Appendix A part 5). These samples would have likely also been collected by air lift methods and stockpile outside. All sand samples would have been exposed to air during extraction and stockpiling outside.

Air oxidation of pyrite releases sulphuric acid that mobilizes heavy metals that can escape from the samples.[6] Most of the sulphur remaining in the samples would be in the form of sulphate rather than the original sulphide in the pyrite (FeS2).[6] The sulphide determination from oxidized samples will be greatly underestimated. Selenium in the samples would be oxidized by the air to soluble selenates that could also migrate from the samples and be underestimated.[7] All the geochemical analyses in the hydrogeological report are invalid and cannot be used.

The photographs of the core in Appendix C1 of the hydrogeological are shown open to the air. Bru 95-8 according to the hydrogeoligical study was drilled Nov. 16 to 19, 2020. The core logs from Bru wells 121 and 141 near Ross MB and St. Anne were taken from historical core log storage in Steinbach. The core boxes shown in the photographs in the CWS hydrogeological study are not air tight. Well records obtained from MB groundwater show well Bru 121 was completed on Feb. 19, 2019. The core logs from Bru 121 well would have been exposed to oxidation since this time. The well records for BRU-146 were not obtained from MB groundwater however since the core logs were kept in the storage in Steinbach the samples would have been exposed to oxidation over a period similar to Bru 121.

A report by PetroWiki [9] calls for sealing of dry core samples in air tight cans or tubes and core samples in anaerobic jars or polycarbonate, steel, glass, or PVC containers with brine, oil, or other fluids.

Claim Post Resources used a sonic borehole technique to collect sand samples at Wanipigow. The 2014 NI43-101 technical report for Wanipigow documents that the extracted sand was immediately placed in air tight containers upon extraction and sent by closed custody for immediate analysis. The analysis of the protected Wanipigow sand showed 0.235 % sulphide and an NP/AP (neutralizing potential to acid potential) ratio of 0. 73 In acid base accounting an NP/AP ratio of less than one that indicates large acid drainage potential.

Electron microscope pictures in the NI 43-101 report at Wanipigow show marcasite a form of pyrite (iron sulphide) coating of the sand grains consistent with the laboratory analysis showing sulphide.[12] A report by Schieber and Riciputi (2005) describes the diagensis of marcasite in the sandstone over the entire Winnipeg formation. This report also shows electron microscope pictures of marcasite coated sand grains. The samples were taken in the western portion of the Winnipeg formation however the presence of marcasite at Wanipigow verifies that the marcasite formation occurred through the entire Winnipeg formation. The CWS hydrogeological report does not mention the documented occurrence of marcasite in the sand of the Winnipeg formation and the results from Wanipigow. The sand samples taken and analyzed for the CWS hydrogeological report were compromised so that marcasite would have been oxidized and washed away in the outdoor stockpiles.

The stated date of sampling of Bru 95-8 well core was Nov.11, 2020. The analysis date at ALS labs was Jan 5, 2021. The ALS lab reports showed all samples were received on LDPE bags. According to a paper published by Donald et al. (2016) reported in the PMC US National Library of Medicine, National Institute of Health,[11] the LPDE bags used for the CWS samples are not air tight. Air oxidation through the bags would have occurred from the sampling date to the analysis date. The core samples for BRU 121, 141 stored in Steinbach in non air tight boxes were exposed to air oxidation for at least one and one half years before the sampling date. All sand samples were exposed to weathering over a similar period. The ALS reports showed that many samples the analysis date was beyond the recommended time period between sampling and analysis. This information conclusively demonstrates all the geochemical samples analyzed were compromised.

Question:
Will CWS have representative sampling redone and resubmitted by independent experts to ensure the samples are properly handled and sealed in air tight containers immediately upon extraction? Will CWS ensure the sand samples are not exposed to air during extraction and immediately sealed in air tight containers?

4. Carman sands

The CWS hydrogeological report states;

"*CanWhite intends to develop and operate an in-situ sand extraction operation in southeastern Manitoba, and approximately 35 km east of Winnipeg. It will involve extraction of sand resources of the Carman Sand Member of the Winnipeg Formation for commercial and industrial use.*"

"*Black shale is present as part of the Black Island Member of the Ordovician-aged Winnipeg Formation. This unit was typically deposited on top of the Winnipeg Formation, but is not present within the Project Area.* a. *It is typically composed of up to 50% pyrite nodules, which are rounded, equant to elongate, concentrically layered and 0.5 mm to 1.0 mm in diameter (Lapenskie 2016)*"

"*Shale from the Project Area were below average crustal abundance criteria, and concentrations were typically one to two orders of magnitude lower than those in Black Island Shale. This clearly indicates that the Winnipeg Shale found within the Project Area has metals concentrations that are significantly lower than the Black Island Shale.*"

"The Winnipeg Formation has been subdivided into stratigraphically distinct units with subdivisions generally consisting of a lower sandstone unit (Black Island Member) and overlying units consisting of sandstone and shale layers (Icebox Member). A third unit (Carman Sand Member) is a clean very-fine-to-medium-grained sandstone zone that is up to 30 m thick in the upper portion of the Winnipeg Formation in Southeastern Manitoba. This feature extends from south of Brandon, Manitoba to the subcrop below the Sandilands Area (Ferguson et. al. 2007). CanWhite drilled over 40 boreholes between 2017 and 2020 to characterize local lithology and inform a Preliminary Economic Assessment (Stantec 2019). They found the Carman Sand Member was typically uncemented, well sorted, well rounded, and fine- to medium-grained, with a consistent thickness ranging from 20 m to 30 m."

The above quote states the Carman Sands are below the Sandilands area. Figure 4 shows the Carman Sands as determined from the Manitoba Energy and Mines Bedrock Geology Compilation Map Series [13] overlaid on the CWS 24 year Project area. Figure 4 clearly shows only very southern portion of the project area is within the Carman sands.

According to the report by Watson, Economic Geology,[14] that was recommended in the expert peer review by Friesen states,

"*A thickened portion of the upper part of the Winnipeg sandstone near Ste. Anne was tested for possible mining by hydraulic methods. This unit, known as the Carman sand body, varies in thickness and extent. It is* *generally about 27 m thick and extends westward from Ste. Anne for about 240 km to Ninette. It ranges in width from 24 to 100 km (McCabe, 197B). The sand in this body is similar to that in the lower Winnipeg at Black Island. It is a separate body, however, and is separated from the rest of the sand section elsewhere by shale rich rocks. The body is probably a former offshore bar and the increased thickness of the Winnipeg section is due to the compaction of the sandstone being less than for the shale-rich sections elsewhere. In 1966, the deposit was drilled in the area east of Steinbach (Fig. 13) by Norlica Minerals Limited (Underwood McLellan and Associates Limited, 1967). The drill holes intersected silica sand intermixed with shale, with high quality sand beneath the upper sand-shale layer. The sand ranged from loose to well cemented. Various methods were tried to loosen the sand, including water jets, suction and a mechanical cutter, in order to pump it from drill holes These methods were unsuccessful largely due to the presence of hard sandstone and shale layers within the section. The hard layers could not be broken and thereby prevented slumping and breakup of the sand layers between them*."

Thus even the lower portion of the Carman Sands in the southern portion of the claim area is interbedded with shale that is likely rich in pyrite.

Questions:
Does CWS acknowledge the northern part of the BRU project area is wholly within the Black Island member part of the Winnipeg formation known to contain pyritic shale, marcasite coating the sand, pyritic concretions such as oolite layers and not within the Carman sands area?[10,12,14,15] Does CWS acknowledge that the Black Island member from which sand will be extracted in the northern portion of the Bru area contains pyrite that will be exposed to re-injected aerated water that will from acid and mobilize heavy metals and selenium thereby contaminating the aquifer?

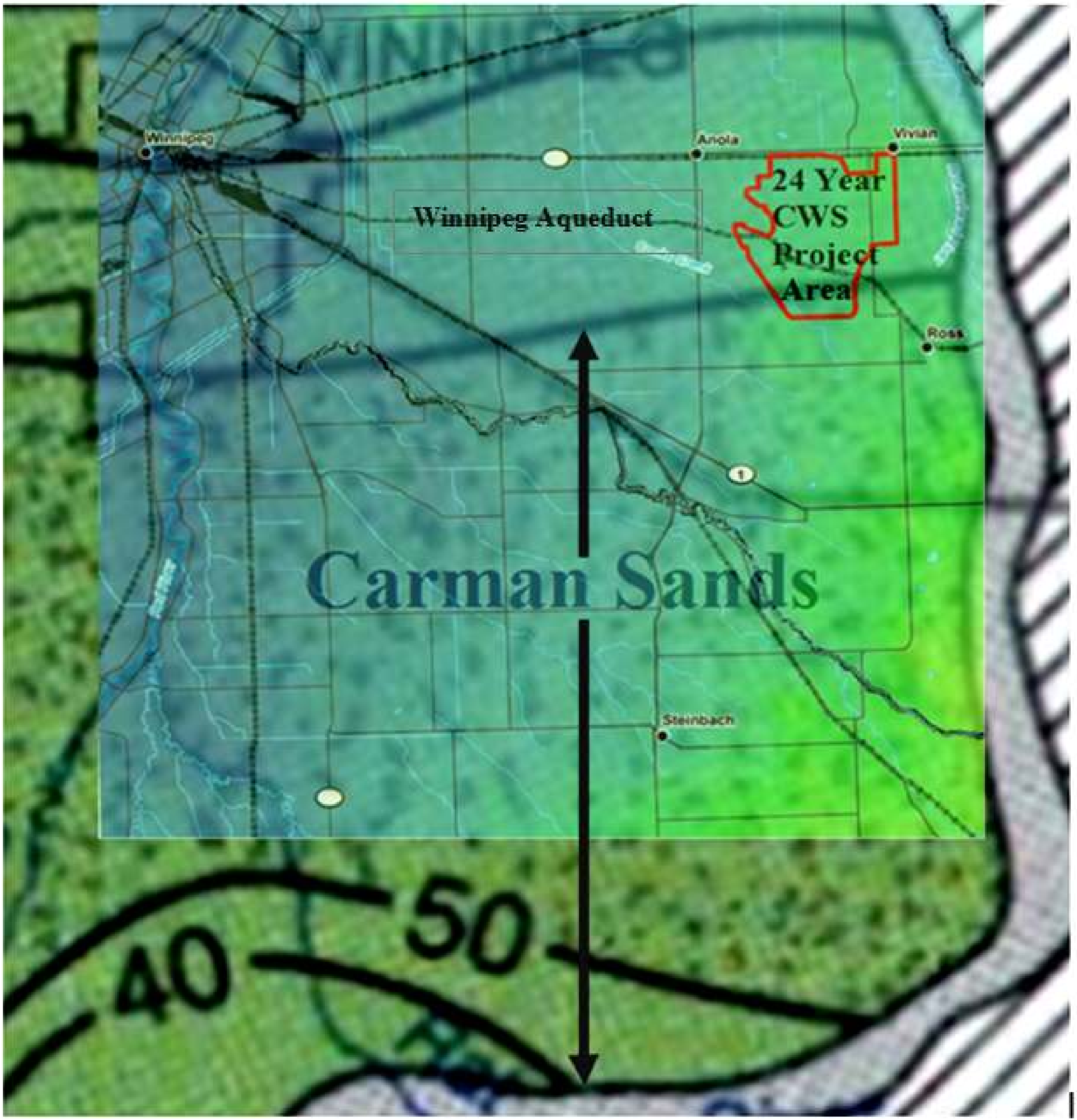

Figure 4. CWS 24 year project area overlaid on the map of the extent of the Carman sands (green specked area) south of Vivian MB.

5. Geochemical Analysis

The geochemical analysis of samples taken from well cores Bru 95-8, Bru 121-1 and Bru 146 and sand samples from the Winnipeg aquifer were not protected against oxidation by air. Nevertheless some samples showed substantial arsenic, selenium and aluminum concentration. The acid base accounting test to determine the potential for acid formation from sulphide were also compromised however the results were inconclusive. CWS conclude that the shale should be considered as potentially acid generating (PAG).

Figure 4-2 shows a scatter plot of wt% total sulphur versus sulphide indicating that the sulphur content was dominated by sulphate. This is consistent with the oxidation of the samples where the sulphide concentration would be oxidized to sulphide. If the sulphur were originally sulphide before oxidation the original sulphide concentrations would be many times higher. This means that the total acid potential will be underestimated and that the NP/AP ratios determined by the CWS analyses are too high.

The core logs obtained by MB groundwater throughout the Bru all show shale layers at various depths below the extractable sand layer. This is confirmed by figure 2-A of the hydrogeological report that shows a shale layer at the base of the sand layer in the Winnipeg formation. No samples were taken and analyzed of these lower shale layers. Aerated re-injected water would be in contact with theses lower shale layers from the Black Island member known to contain pyrite. Oxidation of the pyrite in these lower shale layers would create acid and mobilize heavy metals contaminating the aquifer.

The hydrogeological report also documents concretions that will be screened from the sand. The paper by Schrieber and Riciputi (2005)[10] states;

"*Throughout the Black Island Member we find irregular iron sulfide concretions that follow burrow trails. They consist of a mixture of pyrite and marcasite in clusters and coarse aggregates with rounded quartz grains ''floating'' in the sulfide matrix."*

This illustrates the concretions will contain large amount of sulphide and be acid generating. The concretions were not sampled and analyzed by CWS.

Another form of concretions, documented by Watson to lie in layers in the Winnipeg Formation, is oolite nodules containing pyrite.[14] Photographs of the oolite nodules found in extracted sand piles near Vivian are given in my report of August, 2020 submitted for the public review of the Vivian Sand Processing Plant. There is no doubt that these pyritic oolite nodules documented by Watson are found in the Vivian area.

According to the hydrogeological report two of the three samples in the Red River Carbonate and one sample in the shale exceeded screening criteria for selenium. Selenium is commonly found absorbed in sulphide minerals.[8] Oxidized selenium (selenates) are very soluble and toxic to aquatic organisms and humans.[7,8] The concentrations of selenates in the samples are consistent with oxidation from selenium in pyrite in the samples and are consistent with the samples being compromised by oxidation by air.

The selenium in the shale in the aquifer will be exposed to re-injected aerated water. The selenium will be oxidized to form soluble selenates that will contaminate the aquifer.

The ALS reports show all three shale samples for Bru 121-1 Bru 146 and Bru 95-8 having high As (arsenic) concentrations of 20.4, 13.3, and 24.2 ppm respectively despite the air oxidation that would create acid that could leach out As. Properly protected core samples would likely show even higher concentrations of arsenic. Given that the maximum allowable concentration of As in water is 0.01 ppm, these high As concentrations along with the evidence for acid generating pyrite in the shale represents a severe risk for As contamination not only of extracted samples but more importantly of the aquifer. The re-injected aerated water would cause the formation of acid from sulphide in the shale, and sand (marcasite), sand concretions, and oolite that would mobilize the arsenic.

Proper re-sampling to protect against air exposure and oxidation is likely to reveal the presence of selenium associated with the pyrite in the samples.

Questions:
Will CWS engage an independent expert to gather core samples and sand samples from representative locations in the Bru area that will be protected against oxidation and have the samples re-analyzed? Will CWS have properly protected samples of lower shale, concretions and oolite nodules analyzed? If the re-testing demonstrates that the samples contain significant amounts of sulphide and heavy metals that will likely contaminate the aquifer when the cavities are filled with re-injected aerate water will CWS abandon their operations in the Vivian area?

6. Numerical Groundwater Model

The CWS hydrogeological study in the numerical groundwater section states;

"*It was beyond the scope of this assessment to develop a water balance for the regional aquifer system in the context of existing and future groundwater use. The numerical groundwater model assesses the short-term response of the aquifer to the stresses of groundwater and sand withdrawal. Streams, lakes, regional groundwater use and groundwater levels along the boundaries of the model domain are assumed to stay constant with time*."

"*Scenarios 1 and 2 assess the possible range of re-injection of groundwater after solids are removed from the production fluid (0% and 50% of slurry volume re-injected) from the sand extraction process. These scenarios that consider the reinjection of all groundwater are presented for comparative purposes only and note that the hydrogeological assessment is based on a hypothetical conservative scenario involving zero reinjection of water. CanWhite does not intend to discharge any water to ground surface. The Winnipeg Shale is inferred to be considerably weathered and assumed to degrade (increased hydraulic conductivity) in Scenarios 1 and 2 when locally disturbed/unsupported from below due to extraction of the Winnipeg Sandstone*."

Even though CWS claims that no discharge of water will occur from their processes, water will be lost from the aquifer in the 15% water retained in the sand stock piles at the processing plant as described in the EAP for the Vivian Sand Processing Plant. In addition water will be removed with the carbonate and shale drill cuttings and from the concretions that are separated out at the extraction site by vibrating screens. The volume of such waste and the entrained water in the waste is not determined in the CWS hydrogeolgical report. The groundwater model does not determine the sustainability of the groundwater removal from the aquifer. This should be an essential feature. A study by Kennedy and Woodbury (2005) determined by 2025 the sandstone aquifer would be beyond sustainable water use due to growth alone.[16] Extra draw on the aquifer from the CWS operations are likely to be unsustainable.

Questions:
Will CWS determine the total withdrawal of water from the aquifer from all sources including water retained in the sand stockpiles piles and in all waste streams including waste from vibrating screens and drill cuttings at the extraction site? Will CWS determine the affect of these withdrawals on the sustainability of the sandstone aquifer?

The numerical model used for the groundwater study does not evaluate the actual operational activities of the extraction. The modelling only details with hypothetical situations where 50% and 0% of the water withdrawn from the aquifer is re-injected. These scenarios will not occur as, according to CWS, no water will be discharged by the project.

During the sand extraction as shown in figure 2-A of the hydrogeological report water is re-injected near the top of the aquifer through the exterior tube of the well pipe and sand plus water moves up the central tube further down in the aquifer at the bottom of the well pipe. At the bottom of the pipe the fluid pressure will be less than the surroundings. Where water is injected near the top of the reservoir the fluid pressure will increase from the injection.[18] Water in the aquifer will flow from high fluid pressure to lower. Some of The re-injected water will circulate toward the bottom of the extraction well pipe where the fluid pressure is lower.

In the hydrogeological report it is admitted the shale layer separating the aquifers is compromised by the pumping activities and the creation of a cavity such that the shale is unsupported. The calculations in the report of February 2021 reviewed by Dr. Ingraffea demonstrate the shale will slake into the cavity created. The carbonate aquifer will be directly exposed to the sandstone. In the far-field of the carbonate aquifer the fluid pressure will be lower than at the re-injection site. Some of the re-injected water will flow into the carbonate aquifer. The carbonate aquifer has a higher transmissivity than the sandstone so water will preferentially move into the carbonate aquifer. The re-injected water will be aerated and react with sulphide in the shale aquitard, with the shale layer lower in the formation, with sand concretions and oolite nodules, and with the marcasite of the sand to form acid and release heavy metals. Selenium measured in the geochemical analysis will be oxidized to a soluble from contaminating the aquifer. Microbes that survived the ineffective UV treatment will be able to proliferate in the aerated water in the sandstone cavity. All these sources of contamination will be able to migrate in the carbonate aquifer driven by the high pressure zone for re-injection. This simultaneous reinjection of water and withdrawal of sand and water in the air lift extraction tube of the well was not modelled.

The scenario of re-injected water entering the carbonate aquifer is consistent with the complaint of brown water in a well nearby where CWS was extracting sand at Centre Line Road near Vivian MB. The brown water occurred only at the time of CWS sand extraction. This incident is documented and analyzed in the What the Frack Manitoba February 2021 report.[2]

The effects of CWS re-injection should be comparable to the effect of waste water injection into a limestone aquifer in Florida. Calculations for the Florida injection indicate that by mid-1974 pressure effects from waste injection extended radially more than 40 miles (64 km) from the injection site.[18,19] The contamination induced in the aquifer from aerated re-injected water could be expected to reach the discharge of the carbonate aquifer to the Red River and Lake Winnipeg in just a few years. The contaminated discharge to hydraulically connected streams of Cook's Creek and the Brokenhead River would be much sooner. Contamination would spread north westward through the carbonate aquifer along the discharge path.

Questions:
Will CWS model the simultaneous re-injection and water plus sand removal to obtain meaningful groundwater flow results for the CWS extraction process? Will CWS model the migration of contaminants formed in the sandstone aquifer through the degraded shale aquitard and through the carbonate aquifer?

7. Mixing of aquifer waters

The hydrogeological study admits that the aquitard preventing the mixing of aquifer waters could be compromised. The What the Frack report of February 2021[2] peer reviewed by Dr. Ingraffea determines that the shale layer will slake into the cavity created by sand extraction. The hydrogeological study attempts to down play the consequences of mixing of aquifer waters. In the area where the flow regime will be from the carbonate to the sandstone, iron and likely hardness are expected to increase but not to a harmful extent.

A group of residents near Vivian have already filed a formal complaint with Manitoba Water about increase in iron in their well water and other detriment since CWS exploration drilling activities in the area. Obviously the residents do not accept such changes to their water. The complaints of the residents were not investigated and summarily dismissed by the Director of MB Water stating that iron has been found historically in the well water. However mixing of aquifer water, even if not harmful, is not allowed according the Groundwater and Water Well Act regulations.[17]

Question:
Will CWS respect the regulations of the Groundwater and Water Well Act and terminate plans to extract sand in the Vivian area where mixing of aquifer waters cannot be avoided with the CWS extraction methods.

8. Well Seals

The EAP states that all the hundreds of wells drilled per year will be sealed according to government regulations. The hydrogeology study admits that the shale layer could be compromised by the excavation activities. Spalling of the shale into the excavation cavity would compromise seals across the shale aquitard. The limestone thickness in the eastern Bru area is below the minimum thickness to prevent subsidence as specified by the EAP according to Stantec studies that were not available. The limestone thickness over the entire Bru area is insufficient for limestone stability according to a report by Waltham and Fookes (2003)[1]. Instability in the limestone will compromise all the well seals in the carbonate aquifer. Subsidence of the till into the extraction cavity in the sandstone described by the USGS will compromise the till seals.[3] Massive seal failure in the hundreds of CWS wells drilled per year would result in serious aquifer contamination from surface run off carrying chemicals and microbes such as fecal coliform from septic fields and animal feces.

Question:
How will CWS prevent well seals from failing due to subsidence that has been demonstrated will assuredly occur?

9. Accidents and Malfunctions

CWS admits the possibility of slurry line failure and leakage. The EAP states;

"*An accidental release of slurry or return water may also occur if a break or crack occurs in the slurry and/or water return line. Accidental releases, depending on the type and quantity of substances released, have the potential to affect air, surface water, groundwater and soils, with consequential effects on vegetation, aquatic resources and possibly human health and safety. Slurry and water return line will be inspected on a daily basis, and after extreme weather events, to check for leaks and/or breaks in the line. If leaks or breaks in the line are detected, appropriate spill containment and clean-up measures will be applied as soon as feasible and the line will be repaired or replaced.*"

The slurry line and water return lines are specified to have a maximum flow rate of 24 cubic meters per minute in the EAP for the processing plant. A slurry line break would cause a massive spill far beyond the capacity of any spill containment measure. With only daily inspections a slurry line break could discharge for hours before detection. No automated leak detection and pump shut down system is specified in the EAP. Slurry line wear due to the abrasive nature of the sand is common. An external inspection will not reveal such wear.

Literature studies on sand erosion of HDPE pipe indicate wear of the order of 20 mm per year can be expected. Curves and joints are particularly susceptible to wear.[20] Using the relationship that the flow rate of the line is the product of the interior area and the fluid velocity, using the 24 cubic meters per minute flow rate specified in the EAP for the processing plant, the flow rate for the main 14 inch slurry line is estimated to be 6.11 m/s. An article in the Oil Sands Magazine states;[21]

"*An absolute maximum flow of 6.0 m/sec is normally tolerated, but only on a very infrequent basis. Since slurry lines are prone to sanding, guidelines for minimum slurry velocities are normally established in order to prevent sanding. A typical normal minimum is 3.0 to 3.5 m/sec.*"

This evidence illustrates slurry line wear and subsequent failure is very likely.

The joints connecting smaller slurry lines to the main 14 inch slurry line may be particularly susceptible to wear.

A presentation by Dacon technologies state;[22]

"*Since mines started using HDPE lines for Tailings transport, erosion in the bottom of these lines have been an issue.*"

For 85 mm HDPE pipe the erosion rate was about 3 mm/month and for 110 mm HPDE pipe the erosion rate was up to 11 mm month. Dacon technologies describe inline inspection and automated leak detection methods.

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. Breakage rate in a slurry line would be expected to be much greater.[23]

As described in a submission for the French drain alteration posted on the Manitoba EAB Public Registry 6057 on April 8, 2021, soluble contaminants such as iron, arsenic, selenium and the highly toxic acrylamide monomer will continually build up in the slurry and return water line. A spill would release these toxins to the environment. A large spill would migrate into the Brokenhead River or Cook's Creek. Contaminants could penetrate the carbonate aquifer through permeable aggregate cover and quarry excavations. Continued use of this water for a 24 year period with the use of over winter storage tank is simply untenable. CWS does not acknowledge the need for treatment of this recycled water to remove contaminants and resupply with fresh water. No plan is made for the waste steam that would be generated.

Questions:
Will CWS install leak detection on their lines with automated pump shut down? Will CWS use interior wear inspection tools at regular intervals to determine the extent of slurry line wear? Given that contaminants will continually build up in the slurry and recycle water lines, will CWS develop and supply a recycled water treatment and associated contaminant waste generation plan?

10. The Winnipeg Aqueduct

As illustrated in figure 4 the Winnipeg aqueduct traverses the entire 24 year CWS project area. The slurry lines will eventually have to cross the aqueduct likely multiple times. The aqueduct is known to have cracks that allow infiltration of surface water.[25] Slurry line spills near the aqueduct could contaminate Winnipeg's drinking water supply with arsenic, selenium, other heavy metals and the highly toxic acrylamide monomer.[24]

Questions:
Has CWS informed the City of Winnipeg of the requirement of the slurry lines to cross the Winnipeg Aqueduct and described safeguards that will mitigate the potential for contamination of the aqueduct water? Has CWS obtained a legal agreement with the City of Winnipeg and the Government of Canada to cross the aqueduct considering that the aqueduct crosses provincial boundaries and is therefore federal in scope?

11. Section 35 Indigenous Consultations

The project will have a devastating impact on the traditional lands of indigenous peoples in the 24 year CWS project area. On average 56 well clusters per year with a diameter of 54 meters will be cleared. Slurry lines will be cleared between the clusters that are 60 meters apart. The slurry lines will be moved every 5 to 7 days requiring use and movement of vacuum trucks. The evidence presented here illustrates that large sinkholes will develop that could contaminate the aquifer with bacteria and chemicals in runoff. The sinkholes will cause a permanent destruction of traditional land and natural drainage. Large spills from the slurry and return water lines are to be expected. The spills will carry contaminants such as arsenic selenium and toxic acrylamide that will drain into nearby water courses such as the Brokenhead River destroying fish and fish habitant. The contaminants will be carried downstream.

Question:
Will CWS immediately ensure that the Crown undertake comprehensive section 35 consultations with the affected First Nations and Métis?

The consultations must proceed before licensing is complete.

12. Noise

The EAP states;

"*Noise generated by Project activities (e.g. extraction well drilling; operation of vehicles and machinery such as pumping stations) has the potential to adversely affect wildlife (Section 6.5.2) and could result in nuisance noise to people living within the Local Project Area. Project components expected to generate noise that may contribute to noise levels at the nearest points of reception (e.g. nearest residence, i.e.133 m from a well cluster area) are listed in Section 2.8. Example noise sources associated with Project activities include mobilization of extraction well drilling equipment, drilling of wells and operation of pump stations. The following measures will be implemented to reduce noise generated from Project activities: • Vegetation clearing will be minimized to the extent feasible. • Project activities will setback a minimum of 100 m from nearest residences. • Mobile equipment and vehicles will be kept well maintained and will be fitted with mufflers, and other noise mitigation equipment as required. • Unnecessary idling and revving of engines will be avoided. • Additional noise mitigation measures will be applied (e.g. portable noise barriers) as required. In consideration of the above measures to minimize noise levels due to Project activities, it is anticipated that potential noise levels at the nearest residences will be adequately attenuated. Noise disturbances to wildlife are expected to be moderate in the vicinity of Project activities but are not expected to measurably affect wildlife populations within the Interlake Plain Ecoregion within which the Project is located.*"

The EAP does mention compressor noise. The mitigation measures such as portable noise barriers are not adequately explained. No actual noise measurements have been made and reported.

Currently as of Aug.18, 2021 CWS drilling and sand extraction activities are occurring in a quarry site south and west of Vivian as shown in figure 5. The local residents have been complaining of excessive noise. The sand piles are uncovered. Local residents have noticed dust blowing from the sand piles. Drillers and quarry workers and nearby public are likely exposed to silica dust.

Question:
Will CWS record and report noise levels of such quarry operations and take adequate measures to avoid exposure to silica dust in such operations?

Figure 5. CWS sand extraction activities in a quarry site near Vivian MB Aug. 18, 2021

13. CWS Vivian Railway Yard

The CWS Extraction EAP states;

"*The sand Processing Facility and associated infrastructure, including the rail loop and interconnection with the existing Canadian National Railway, are being reviewed by Manitoba Conservation and Climate (MBCC) as a separate project requiring a separate Environment Act Licence to proceed. Therefore, the Processing Facility and associated infrastructure components are not assessed within this Environment Act Proposal*."

The CWS railway loop, railway yard and load out facilities are intimately connected to the Project and will have cumulative effects such as noise, vibration and drainage that will interact with the Processing Plant and extraction noise vibration and drainage. In order to properly account for cumulative effects the projects must be assessed together.

We are not aware of a separate licence process for the CWS railway yard and CN railway spur line connection.

Questions:
Will CWS explain the timeline for the CWS Vivian railway licensing process and the necessary technical and public review process?

Will the CWS Vivian railway yard and loop and the CN spur line require a certificate of fitness and approval by the CTA? Will CWS follow the CTA guidelines for approval to construct a railway line including the following;[26]

"*Before you submit your line construction application, you are expected to engage the people in the localities (communities and others as described in the Key terms below) that would be affected by the proposed line. You should use this engagement process to:*

- ***discuss the proposed railway line and understand what impacts its construction and operation would have, whether negative or positive; and***
- ***identify appropriate measures for addressing localities' concerns.***

You are expected to engage the Indigenous groups and peoples your proposed line could affect. Their views and concerns are part of the interests of the localities that the CTA will consider when assessing the application. Be sure to document all engagement results and include this documentation in your application

Once you have identified relevant localities, including any Indigenous peoples, you are expected to discuss the proposed railway line with the appropriate municipalities and other government bodies. The purpose of these discussions is to help you identify:

You should use a variety of methods to promote your engagement activities to a broad range of stakeholders within the localities. For example, you could:

- ***request that the municipalities post a public notice on their websites;***
- ***broadcast a notice with local radio stations;***
- ***place a notice in local newspapers;***
- ***place a notice of the planned information sessions on the bulletin boards of public buildings, community halls, social organizations and service clubs;***
- ***advertise the information sessions within the newsletters and websites of local associations and service clubs;***
- ***use various social media platforms such as Twitter, Facebook or other internet sites or mobile applications;***
- ***include information in material distributed by municipal counsellors to their constituents; and/or***
- ***directly contact persons who will be affected (for example, by hand-delivering notices to relevant businesses and residences).***

Include maps and plans that are made to scale, labelled, include a north arrow, and have a comprehensive legend that defines the symbols used.

- ***Maps should depict the location of the proposed railway line and associated infrastructure in relation to their geographic surroundings.***
- ***Plans should capture all of the geometric features of the proposed railway line and other important railway line components and be prepared and dated by a qualified engineer.*"**

15. Traffic

Questions:
Will CWS specify the size and number of trucks per day required to transport the screened out waste such a concretions and the drill cuttings from the extraction area to the licensed disposal site? Will CWS identify the licensed disposal site?

16. Licensing

The CWS Extraction EAP states,

"*CanWhite is currently applying for an Environment Act Licence for extraction activities up to and including 2025 because advancements in extraction methods and operations are expected to increase efficiency and reduce overall footprint after 2025. This will be explained in subsequent Notices of Alteration for the future potential extraction years, with the information and review process for Notices of Alteration of an Environment Act Licence for the Project being as required under Section 14 of The Environment Act. Therefore, the scope of this Environment Act Proposal is limited to the proposed activities and Project spatial extent up to and including 2025.*"

Any project alterations such as slurry line crossing of the Winnipeg Aqueduct after 2025 could be considered as minor alterations and thus avoid public and TAC technical review.

Question:
Will CWS in the interest of transparency and proper independent technical review of any future Project alterations apply for a license for the full period of 24 years and include all anticipated future alterations in the current EAP?

17. Missing reports

The following reports that are not yet produced provide critical information required for the approval process. The mine closure plan is especially important and under the Manitoba Mines and Minerals Act should have been filed by CWS before the commencement of advanced exploration activities.

Waste Characterization and Management Plan
Water Management Plan
Progressive Well Abandonment Plan
Erosion and Sediment Control Plan
Groundwater Monitoring and Impact Mitigation Plan
Mine Closure Plan
Re-vegetation Monitoring Plan
Emergency Response Plan
Heritage Resources Protection Plan
Stantec Reports

Question:
Will CWS produce the above follow up plans as part of the EAP?

References

1. Speleogenesis and Evolution of Karst Aquifers The Virtual Scientific Journal ISSN 1814-294X Engineering classification of karst ground conditions, republished from : Quarterly Journal of Engineering Geology and Hydrogeology, 2003, vol. 36, pp. 101-118. A. C. Waltham and P. G. Fookes https://digital.lib.usf.edu/content/SF/S0/05/46/71/00001/K26-04222-seka_pdf4513.pdf

2. Evidence for Aquifer and Slurry Line Contamination and Land Subsidence From Vivian Silica Sand Extraction Wells, D. M. LeNeveu, March 2021 https://www.flipsnack.com/7CDD5666AED/canwhite-sands-extraction-method-and-potential-impacts.html

3. USGS Water Science School, Sinkholes, https://www.usgs.gov/special-topic/water-science-school/science/sinkholes?qt-science_center_objects=0#qt-science_center_objects

4. Government of Western Australia Department of Health Ultraviolet disinfection of drinking water, June 27, 2016 https://ww2.health.wa.gov.au/Articles/U_Z/Ultraviolet-disinfection-of-drinking-water

5. Water Research Centre, Drinking Water Treatment with UV Irradiation, Brian Oram, PG., B.F. Environmental Consultants Inc., 15 Hillcrest Drive, Dallas, PA, 18612 https://www.water-research.net/index.php/water-treatment/water-disinfection/uv-disinfection

6. The Narwhal Explainer: What the Heck Is Acid Drainage, and Why Is It Such a Big Deal? https://thenarwhal.ca/author/jimmy-thomsonJimmy Thomson, Dec 9, 2017 https://thenarwhal.ca/what-heck-acid-rock-drainage-and-why-it-such-big-deal/

7. Selenium Oxidation and Release during Washing of Agricultural Seleniferous Soil Samples., American Geophysical Union, Fall Meeting 2019, abstract #H41J-1835 December 2019, Pallud, C. E. , Le Vagueresse, L. M. M.,Wasserman, N., Schilling, K., Johnson, T. M., Dhillon, K. S. https://ui.adsabs.harvard.edu/abs/2019AGUFM.H41J1835P/abstract

8. Selenium binding to iron sulfides. Clays in natural and engineered barriers for radioactive waste confinement - 4 International meeting Book of abstracts, (p. 1011). France. Finck, N., & Bosbach, D. (2010). https://inis.iaea.org/search/search.aspx?orig_q=RN:46136101

9. Core alteration and preservation From AAPG Wiki from Methods in Exploration, Wellsite methods, Core alteration and preservation, AAPG special Volumes, 1992, Caroline J. Bajsarowicz https://wiki.aapg.org/Core_alteration_and_preservation

10. Pyrite and Marcasite Coated Grains in the Ordovician Winnipeg Formation, Canada: An Intertwined Record of Surface Conditions, Stratigraphic Condensation, Geochemical Journal of Sedimentary Research 75(5):907-920. Jurgen Schieber, Lee Riciputi November 2005 https://pdfs.semanticscholar.org/c726/0c14eefc435745019d169ed8f741ed4da6df.pdf

11. Transport stability of pesticides and PAHs sequestered in polyethylene passive sampling devices, Environ Sci Pollut Res Int. 2016 Jun; 23(12): 12392–12399. Carey E. Donald, Marc R. Elie, Brian W. Smith, Peter D. Hoffman, and Kim A. Anderson https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4893994/

12. Technical report and preliminary economic assessment on the Seymourville Silica Sand Project, Manitoba, Canada for Claim Post Resources Inc., NI-43-101 & 43-101F1, Eugene Puritch, P.Eng.,

Richard Sutcliffe, P.Geo., Ph.D.,Yungang Wu, P.Geo., David Burga, P.Geo., Jarita Barry, P.Geo., Kenneth Kuchling P.Eng., David Orava, P.Eng., David Anthony, P.Eng., Michael Esposito, P.E., P&E Mining Consultants Inc., Report No. 292, November 1, 2014 sedar.com

13. Manitoba Energy and Mines Bedrock Geology Compilation Map Series - Winnipeg, NTS 62H Bezys R. and McCabe H.R.,1998 https://www.gov.mb.ca/sd/eal/registries/6119/appendix_a_part1.pdf

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

15. Activities 2016, Manitoba Growth, Enterprise and Trade, K. Lapenskie, 2016 https://www.manitoba.ca/iem/geo/field/roa16pdfs/GS-17.pdf

16. Sustainability of the Bedrock Aquifer Systems in South-Central Manitoba: Implications for Large-Scale Modelling. Canadian Water Resources Journal 30(4): 281-296, Kennedy, P. L. and Woodbury, A.D. 2005.

17. The Groundwater and Water Well Act (c.c.s.m. c. g110) Well Standards Regulation 215/2015, Registered December 21, 2015 Interconnection of geologic formations 3(1) https://web2.gov.mb.ca/laws/regs/current/_pdf-regs.php?reg=215/2015

18. Monitoring regional effects of high pressure injection of wastewater in a limestone aquifer Groundwater, USGS publications warehouse, Glen L. Faulkner and Charles A. Pascale 1986 https://pubs.usgs.gov/wsp/2281/report.pdf

19. Subsurface Injection of Liquid Waste With Emphasis on Injection Practices in Florida United States Geological Survey Water-Supply Paper 2281. John J. Hickey and John Vecchioli https://pubs.usgs.gov/wsp/2281/report.pdf

20. Analysis of Erosion Rate on Discharge Slurry HDPE Pipe in Canal Water Intake PLTGU Grati using CFD Simulation, International Journal of Marine Engineering Innovation and Research, Vol. 2(4), Sep. 2018. 253-260 (pISSN: 2541-5972, eISSN: 2548-1479) 253 Agoes Santoso, Bahrul Ilmi https://www.researchgate.net/publication/328536374_Analysis_of_Erosion_Rate_on_Discharge_Slurry_HDPE_Pipe_in_Canal_Water_Intake_PLTGU_Grati_using_CFD_Simulation

21. Oil Sands Magazine, Hydrotransport Pipelines: Basic Design Principles https://www.oilsandsmagazine.com/technical/mining/hydrotransport/pipeline-design

22. Dacon Inspection Services HDPE Pipeline Inspection Presentation https://www.dacon-inspection.com/wp-content/uploads/2016/12/HDPE-Pipeline-Presentation-2016.pdf

23. Pipe Leakage - Future Challenges and Solutions, Stewart Burn, Dhammika DeSilva, Matthias Eiswirth, Osama Hunaidi, Andrew Speers and Julian Thorton, Pipes Wagga Wagga, Australia 1999 https://www.researchgate.net/publication/44055423_Pipe_Leakage_-_Future_Challenges_and_Solutions

24. Polyacrylamide degradation and its implications in environmental systems. NPJ Clean Water 1, 17 (2018), Xiong, B., Loss, R.D., Shields, D. et al, https://doi.org/10.1038/s41545-018-0016-8 https://www.nature.com/articles/s41545-018-0016-

8#:~:text=The%20presence%20of%20degraded%20polyacrylamide,degradation%20under%20various%20environmental%20conditions.

25. Winnipeg Aqueduct Water-Leakage Repair Winnipeg, MB, Canada Submitted by Vector Construction Ltd. November/December 2013 Concrete Repair Bulletin https://cdn.ymaws.com/www.icri.org/resource/resmgr/crb/2013novdec/CRBNovDec13-WinnipegAqueduct.pdf

26. Canadian Transportation Agency. How to Apply for Approval to Construct a Railway Line: A Guide For Federally Regulated Railway Companies. https://otc-cta.gc.ca/eng/publication/how-apply-approval-construct-a-railway-line-a-guide