MANITOBA CLEAN ENVIRONMENT COMMISSION

HEARING

VIVIAN SILICA SAND EXTRACTION PROJECT

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Transcript of Proceedings
Held at Mennonite Heritage Village
Steinbach, Manitoba
TUESDAY, FEBRUARY 28, 2023

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TUESDAY, FEBRUARY 28, 2023

UPON COMMENCING AT 09:29 A.M.

THE CHAIRMAN: Chair. Good morning. I have no objections to starting a minute early, given the hush in the room, and everyone seems to be prepared. So, welcome today, too our agenda for the morning is pretty straightforward. The intent is to clear up -- now, clear up's the wrong word. Our intent is to finish dealing with the Geo technical team, and I understand they have prepared a number of slides, and they would like to present those slides. So, I think I will turn it back over to Steve, Arash, and Doug, and then when they've presented their slides, I guess Byron you can come on up, and we'll get on with questioning. So, over to you guys.

MR. BUNDROCK: Good morning. Steve Bundrock with Stantec. So, yesterday we had some requests from questioners in particular about the strength of the Winnipeg shale. We had indicated that we hadn't done a formal assessment of the Winnipeg shale. In the case of Geo Tech, we'd assumed zero strength. We just removed it from consideration as not providing any strength, but we did complete an informal assessment last night, so we're going to talk a little bit about that.

Also, there were multiple questions about the Carman Sand about our design assumptions for the Carman Sand. So, we're going to spend some time talking a little bit about that. There were some requests to further clarify the extraction plan. So, Laura's going to spend some time talking about the extraction plan, and then just a few other clarifications.

So, beginning with the Winnipeg shale strength. As many of you know, this is one of the area aquitards. It's also well known to be a generally weak layer. So, we spent a little bit of time last night to addressing the strength of the Winnipeg shale. We looked at five bore holes, we look at the rock mass ratings, so that's a -- that's a measure of the strength of the rock mass based upon identifying, mapping the -- the joints, the discontinuities in rock core, and we also looked at three bore holes' point load test results.

So, as you recall yesterday, I mentioned that we collected many, many rock core samples from bore holes, and we tested their strength using a point load tester. So, we looked at those last night, and you can see the results here. The results are that the -- the rock mass ratings in the Winnipeg shale, they're typically 50 percent of the competent limestone values. Competent limestone values may range as high -- the RMR is maybe as high as 90. RMR in the Winnipeg shale were typically half of that.

More or less, we also looked at point load testing rock strengths for the Winnipeg shale, and those were even lower, comparatively 20 to 30 percent of the strength of competent limestone. So, we think that our assumption that we should not rely upon the Winnipeg shale to support the overlying overburden -- to serve as a cap rock, we think that assumption is well supported by -- by the data, and it's also supported by many other studies.

The other thing that's important is to recall the Winnipeg shale is -- is friable. That means it's -- it's susceptible to disturbance during the sand extraction process, it's susceptible to -- to falling apart. And so, again, we didn't rely upon it to provide support when assessing cavern stability.

And now, moving on to talk about the Carman Sand strength. We spent quite a bit of time talking about this yesterday. Lots of questions about this, about how we developed our design basis. And so -- and there were also some questions about the potential to collect intact samples. A lot of the questions were driving at why didn't we collect intact samples. To understand the properties of the Carman Sand, as we mentioned, we did investigate a number of methodologies to collect intact samples.

Typically, as mentioned, I think it was Hartmut yesterday who suggested sonic drilling. You can also use Shelby tubes, so you can direct push a tube, which sometimes which will allow you to collect an undisturbed sample. We did assess the potential to collect samples using that approach. Because of the disturbance associated with drilling, even sonic drilling, which involves vibration, we -- we were quite confident that the vibration and/or the rotation would disturb the samples.

As you recall, this material is poorly cemented at best. We went into this assessment many years ago assuming that it was not cemented at all. In fact, we found that it's actually at least poorly cemented, and as we mentioned earlier, it stands up at vertical or extra vertical in some cases.

So, yesterday the question was asked if we had considered ground freezing. So, some of you are perhaps familiar with ground freezing. Typically involves using a type of injection while drilling multiple wells, maybe ring wells, some folks may have even heard of the Jansen Mine in Saskatchewan. Very large freeze well project. It's relatively invasive, involves lots and lots of wells, and injection of the subsurface to freeze the surface -- just freeze the subsurface, excuse me. And as a result, you can initially collect a sample which is frozen. We describe it as intact, however, the freezing process also in most cases would generate expansion, particularly in a location such as this where we have water present.

So, we think it's a -- a very reasonable assumption that freezing the saturated sand would in fact disturb it to begin with, and then when you go to complete testing on the strength of that material, in theory you would be attempting to test an unfrozen sample, and as soon as you thaw the sample, typically the cohesion would breakdown, and you would end up with a slurry sand, very similar to what we have on the surface. That said, we'll continue to explore opportunities to -- to collect undisturbed samples.

Moving onto the next slide. The Carman Sand strength. We think we actually have very reliable data on the Carman Sand strength. As a result of the side scan sonar survey, in particular, one of the things we failed to identify yesterday, partly because it was so unsuccessful at the time, we thought it was unsuccessful, was the standard penetration testing, and I'll talk about that in a little bit, but I'm just going to walk you through how we built up the Carman Sand strength.

So, starting with the initial numerical analysis, which was completed back in 2018, we used an angle of repose of 31 degrees, and the question was asked yesterday, why didn't we just take some sand out of the hole and test it. In fact, we did. We -- we looked at the angle of repose, and it was standing up at 31 degrees. So, we used that assumption to start with for the initial modelling. As you know, some time later we did successfully complete side scan sonar survey, which returned what we know to be very high resolution results, which showed vertical and/or overhanging sand sidewalls.

During the investigation analysis and

design process, we also did standard penetration testing. Some of you are probably familiar with this. It's completed during drilling, use a weighted hammer, it's a standard weight hammer, and there's a calibration that you can -- that you can use based upon blow counts. So, they'll lift up the hammer, and they'll drop it down on top of an advancing rod, and then based upon that, they can calibrate -- we can calibrate and determine the strength of the deposit. So, they will repeatedly drop that hammer and try to advance it through the deposits.

Surprisingly, when we tried to advance that hammer through the Carman Sand, we found that in fact it was much more competent than we expected it to be. In fact, it returned refusal. You'll sometimes see refusal in -- well, you'll certainly see it in rock, in competent rock. You might see it in extremely compact glacial till. In this case, we saw it in the Carman Sand, and -- and we -- we didn't just test the top of the deposit. We could've been in some other rock formation, perhaps we could've been in the shale. Instead, we advanced it further down into the hole to confirm that we were in fact in the sand deposit, and we tried advancing again, and you can see here on the right in the table, these two holes that in one case we had -- right off the bat we had a number of blows, 105, and they managed to advance it about six inches. The target is to advance it 18 inches. This case, we got six -- six inches.

Typically, actually they far exceeded where they should've called the hole. They should've said this is -- this is extremely hard rock. They should've stopped at 50. Typically, we talk -- we stop at 50. They kept trying, but it remained hard. And then they completed multiple additional tests. In every single case they exceeded refusal. So, our assessment of that result is that the strength of the sand deposit is quite a bit higher than the 31 degrees.

So, we also know that we have kaolinite down hole, we know that we have some compaction influences, we know that we have some at least weak cementation as a result of the kaolinite, and it's demonstrated by the side scan sonar survey. And just for the group's awareness, we did -- during the design process, we did spend some time researching shallow sea cemented sand deposits similar to the Carman Sand, and those have undisturbed friction angles which may range from 38 to 45 degrees.

So, ultimately we started out with a conservative value of 35 degrees for the friction angle of the Carman Sand. And then as you recall based upon the side scan survey data, which showed vertical to overhanging sand, we used that in the FLAC model, and you know, we saw that we had a wall that was standing up actually at 90 degrees and overhanging in some cases. So, we knew 35 degrees obviously is not accurate. So, something else must be going on, and that we understand to be cohesion. And so, that's where the back calculation came into play. We used that back calculation to very accurately calculate a cohesion of 220 KPA.

And then just the final -- final note. The strength of the Carman Sand we expected to change from the undisturbed condition to the disturbed condition. We understand that deformation will occur during the extraction process, and we've accounted for that in the FLAC model. We're -- we used a shear weakening model. We can talk -- Arash can talk at length about the shear weakening model if there's questioners who'd like to discuss it, but suffice it to say that it does consider the reality that the Carman Sand is going to be disturbed during the drilling process, the extraction process. And so -- and so, we need to account for that in our model.

We had a question yesterday about the strength of the sand that was used for modelling, so we included this table here. I'm not going to talk through these numbers, but it's on the public record, and if there are additional questions about it, we can address those questions, but just be aware, these -- these are the numbers that were ultimately picked for modelling. We understand these numbers to be well supported by data, and to be reasonably conservative.

So, again, based upon everything that I've mentioned so far, just wanted to remind the group, yesterday we were talking a lot about a friction angle of 65 degrees. In fact, the friction angle is the result of a 35 degree friction angle, and a -- a cohesion of 220 KPA. That's where that 65 degrees comes from. It's actually a geometry, rather than being a friction angle. So, it's an important distinction.

And just by way of summary, we -- we know that the approach used to determine the friction angle and the cohesion was reliable. In particular, we actually favour the use of a full scale test, the sonar scan and the back analysis to identify properties. We think this is a highly accurate way to -- to determine friction angle and cohesion. And to confirm -- and for everyone's awareness, a typical shortcoming of the engineering process, we might design large underground mines, large underground openings, we might design large pit walls and large dams, and in most cases, we end up completing those designs based upon point data. You have multiple bore holes, multiple lab tests, and they're all completed on samples that are comparatively small. In fact, these systems, these underground mines are much more complex than what a simple piece of point data can convey. So, engineers, if they have the opportunity, every single engineer would like to construct a full scale model of -- of the deposit, of the underground mine, and of course we know that's generally not possible. In this case, we actually did have effectively a full scale model, and we were able to collect data directly from that process. We expect that that data therefore would be much more accurate, much more representative of the combined system, which involves friction angle, which involves cohesion, which of course involves water.

And with that, I'm going to turn things over to Doug. He's going to talk just a little bit about why cohesion is important.

MR. MCLACHLIN: Thank you, Steve. Doug McLachlin. So, I just wanted to raise the -- there were some discussions yesterday about sand present on a beach, which -- and -- and that was a question, why would we not consider it to be beach sand. And so, as we -- as was discussed earlier, soil properties are different. They -- they don't just have a phi angle, they also have cohesion, and as was discussed earlier, our assessment was able to back calculate values for both C and phi. So, that's shown on the left hand side of this -- this slide, and this is standard soil mechanics, and I encourage you, if you're interested, you can ask more about it, but what we determined, if -- if you look at the right hand side at the cavity, the dimensions of that cavity, you'd probably be able to put -- fit maybe two people standing head -- head -- on -- on each others shoulders in that cavity. So, it's about ten metres high, so maybe a little bit more than that, and you would be looking against a face that is actually overhanging. And the interesting thing is that that is not what you'd experience if that were just beach sand. It would not be able to stand up like that.

So, one of the things that's taking place is cohesion, and that can describe it. You think of clay

-- when you put clay -- you could actually take soft clay and put it up and have it be vertical. So, that's what cohesion gives you. It allows you to be able to mold clay, let's say a pot. In this case here, we actually have overhanging conditions, which we believe is likely also some cementation, very weak cementation, which is also supported by the standard penetration test results that we got, which showed very dense -- very dense material. And if -- if you're interested to learn more about the standard penetration test, you can just Google it.

So, basically what it means is that any soil that has over 50 blows per foot, .3 metres, is considered very dense. This material has much, much higher blows. It's very dense material, and the likelihood -- the reason for that is that it's -- it -- there's a very small, less than one percent kaolinite there. It's been underground for thousands of years being compressed by all of the weight above it, and that has caused very weak cementation that holds it together, so that's why it stands up so well. Next slide.

Something else we talked about yesterday is what's going to happen in the long term. So, let's just discuss some of those points. First of all, the duration of extraction is in the order of several days. So, it's very short term in terms of how long that deposit has been there. It's been there thousands of years. We're disturbing it for a relatively short period of time. After extraction and sealing of the bore holes, the groundwater conditions will equilibrate, they'll go back to the way they were previously. This is important because all of the forces that were associated with the sand extraction related to the -- the air injected -- the air, and -- and the water movement, and the soil movement, the sand movement will stop. It will be sealed off, and they'll be typically a minimum of 160 feet. So, if we looked at that previous slide, if you are at the top of that -- that side -- the sonar scan, there's 160 feet between you and ground surface, and it's going to be completely sealed off, okay?

Another thing is that all of the pillars, which is the -- the -- the remaining Carman Sand between the extraction areas, will be under the confining pressure of the overlying soil and rock. And again, as I said, typically it's 160 feet or more confining pressure above that Carman Sand. So, the undisturbed Carman -- Carman Sand comprising the pillars is very dense, weakly cemented, and it will support the -- the pillars will provide the support needed.

So, based on the observed properties of the Carman Sand, the overhanging and vertical side walls, the geotechnical modelling, an additional five metres has been recommended for allow -- allowing additional sloughing of the sand, and that's reasonable, and it's conservative, okay?

MS. WEEDEN: So, this is Laura Weeden speaking for Sio Silica. We just wanted to provide, sorry, thank you, a little bit more context to how this process came about because I think as Feisal mentioned, you know, things first kind of started in 2016, 2017, and now we're in 2023. So, and the Geotech change to table nine happened fairly recently. So, we -- we tried to provide a bit of context in this version of a Gantt chart. So, as you can see here in the -- I'm trying to -- in the lower bottom two rows here, we've got a conceptual model for both the geological model and the Geotech model, and this has been -- additional updates have occurred multiple times. So, the initial kind of conceptual model is developed in 2017 following some coring work and some exploratory drilling, and then it was -- it was further updated again following recommendations that we received from Stantec for additional drilling and work to be done, and at the same time, the extraction process was being developed. So, we have a couple of different types of wells that are drilled. We have done coring wells, we've done geological bore holes, which is more of an exploratory drilling, we're taking samples as we go, and then we're doing extraction testing, which is a different type where we were -- we were testing the actual method of extraction and refining that. And over time, the refinements of the extraction method have allowed us to reduce the size of the well, they've allowed us to change from steel casing to PVC casing. We've -- we've found that you don't need an excessive amount of force to remove the sand. You -- we can do this with very minimal air, we don't need any aggressive activity. It -- it actually just -- it does flow to the well, and it comes to surface, and it really is just a prolonged version of what you would normally see when you drill a water well in -- in your backyard, which I'm sure many people have had drilled on their property.

And so, you know, really the -- the defining change here that we saw was when we were finally able to do a successful sonar, and that was -- that was in the summer of 2021. At that point, we had already filed our extraction EAP filing, and it was already going through the process of public review. And so, the original application had been done with the previous Geotech model, which was still using that 31 degrees, it was still using -- that was where the -- the seven well cluster came from. When we were able to take that successful sonar, we were able to remove a larger tonnage than we had originally been able to because as Feisal mentioned yesterday, our -- our original tonnage, you know, 2019, 2020, we were able to extract more than around 2,000 tonnes, then we were able to extract 3,000 tonnes, and finally around 4,000 tonnes in the most recent extraction, which was in summer of 2021.

Once we gave all of that data to Stantec, this is really where that -- that table nine with the new parameters that we're now following came from, and as -- as was described yesterday by Brent, that triggered some additional updates to our geological model, and some further wells that were done this past summer, and then a model update on that geological model so that we could apply that new table nine recommendations and parameters that were given to us by Stantec with our new extraction plan, and that's the extraction plan that was filed in

January. Next slide please.

So, you -- you may or may not have seen this -- a similar diagram to this. This was -- this diagram was -- has been modified now to follow more like our current extraction plan, but the original version of this was in the EAP, and it would've had seven -- a seven well cluster, and then it was changed to a five well cluster.

So, we talked a little bit yesterday about how we may have clusters with one well, we may have clusters with two wells, and that's very dependent on the geology based on that table nine and the parameters, so we wanted to kind of give a bit of a birds eye view. This is just an example. It -- it may or may not look like this. It does mean that those clusters where we have one well, we might need to have more rigs operating at the same time to remove the same amount of tonnage that we had originally anticipated with a seven well cluster. We continue to maintain the same separation though.

So, the -- the -- the overall span that's in that table nine, that's -- that could contain more than one well, but the separation between each one of those clusters, which is the -- the -- the larger blue circles and the little yellow dots inside are -- are the number of wells, that must be long term distance, 60 metres at minimum, and short term distance, 70 metres, regardless of the number of wells in each one of those clusters. So, our design is all based on maintaining and not exceeding the allowable span in table nine, which is per cluster, regardless of the number of wells, and then the 60 metre spacing in between each one of those clusters.

So, now if we zoom in on the next slide please, this is just a 3D representation of the description that Brent gave yesterday about the multiple straws in one cup idea. So, you can see in this example, this is five wells, this is the maximum number of wells that we would anticipate, and our intention is to drill the least number of wells possible. So, maybe it would be four, or three, or two, but the -- the idea here is that there's a little bit of overlap with each one of those wells of the extraction, but they -- those wells all combined together do not exceed the overall allowable span in table nine, and again, dependent on the cap rock and the overburden thickness. So, we wanted to kind of try to clarify that a little bit more.

MR. MCLACHLIN: Doug McLachlin. So ---

THE CHAIRMAN: Chair. Let me just intervene here. We have gone -- while the information is much appreciated, we're 30 minutes deep in what I thought was going to be something much briefer. How much longer do you have? Okay.

MR. MCLACHLIN: Thank you, chair. Doug McLachlin. So, these are the last two slides. First of all, this goes back to our original presentation on the level of review that our geotechnical assessment has undergone, both internally within Stantec, their senior reviewers, AECOM, our senior reviewers, and also CEC's reviewers. All of these people are registered engineers, they have a standard of care to protect the public, and I just wanted to highlight the level of rigour that our geotechnical assessment has gone through. Next slide.

So, in summary, the project was designed from the beginning for no subsidence. The factor of safety of two has been selected, which is reasonably conservative to ensure that -- to -- the -- that subsidence will not occur. We are currently at a stage where this is the level of assessment that would be typical for something that would be applying for a licence, environmental assessment licence, and it's not necessary that we have all the details of the TARP available at this time, Trigger Action Response Plan, but we will be moving forward post issue of the licence.

Subsidence monitoring will continue -- will occur before, during, and after extraction activities in the long term. We have a full scale model of the Carman strength based on now the side scan sonar, which as was mentioned by Laura, we just fairly recently had. We were able to update our -- our model. Winnipeg shale in summary was not relied upon for the stability calculations. And finally, the underground room and pillar mines often have groundwater that has to be controlled and pumped down. In this case, we don't need to pump down the groundwater, but just wanted to highlight that as well. Thank you.

THE CHAIRMAN: Chair. Thank you very much. Okay. So, we'll resume with the order of questioning, and Peter has just got me back on track here, so thank you for that. MSSAC, I believe you're up next. Very good, Jason. Please come to the front. And we're going to do things just a little different. So, state your name and spell it please.

MR. MANN: Good morning. Jason Mann, J-A-S-O-N M-A-N-N, representing or working with MSSAC. So, I have a number of questions, and I've written them, so I'll read from my notes and paraphrase along the way. A lot of it relates to the things that have been talked about yesterday, today. So, I'll start with the first one. So, 65 degrees as a slope was chosen as that long term stable slope within the sand void space, and as you described, various Geotech parameters, cohesion strength were back calculated from that observed condition with your image of a side scan. Today was the first I heard that your friction angle was 35 degrees, so that was helpful to hear this morning, but I didn't hear any discussion about sensitivity analyses, and the Geotech modelling on those parameters, including that angle of repose, and what that would mean for the project. That 65 degree slope case is notable because it's the most favourable to minimize your span lengths, and I appreciate that's what you've observed, but I didn't hear anything about sensitivity analysis. So, is this considered the long term representative case when, again, haven't seen any sensitivity analyses presented, or even a comparison or check against angles of repose that might exist in the literature for a similarly poorly cemented sand? So, based on that 65 degree slope and the parameters you backed out, why is that the chosen condition when it may not be the most conservative case? Or I'll ask it in a different way. If you haven't presented a sensitivity analysis, how do we know what is the conservative case?

MR. ESHRAGHIAN: Arash Eshraghian with Stantec. Just to -- just to clarify. The 65 degrees is not just the friction angle, right? It's a combination of friction angle and cohesion. They work together to provide that stability. The 35 degree friction angle component we believe is a conservative assumption based on comparison we've seen in our deposits. So, seen our deposits, we believe they had -- they were reported friction angles above 38 degrees, so we adopted 35 to start with, but the cohesion component has been back calculated based on the side observation. So, the sum of these two is a conservative assumption by itself. We have not completed sensitivity on its own based on variation of -- of these parameters, but based on the way I explain to you, we believe it's a conservative assumptions already, but we could do a sensitivity on resistance to -- to prove that as well, and it will be in the next step or next stage of the -- of the design review.

MR. MANN: Jason Mann. So, thank you for your answer, and I understand all of the things you told me, but it's standard practice to demonstrate a sensitivity analysis, and -- and I don't believe that's been shown, nor has it been put into context about why the parameters have been chosen that you just described. So, I think to your comment it is important, and it is something that needs to be done, which it sounds like you suggested will be done and presented.

MR. BUNDROCK: Steve Bundrock. Agreed. Sensitivity analysis will continue to be done. Recall the slide that Laura showed earlier that identified the path of geotechnical analysis and design. Recall that we began with the 31 degree friction angle. There was a literature review during that time as well to understand the range of material properties, possible material properties for a deposit of this type. There were multiple investigations to understand those material properties, and then multiple iterations of design. So, by one interpretation you might consider that we've been conducting continuous sensitivity analysis from the very beginning of this project. It's also very reasonable to expect, as you suggested, that at the next level of design, at the detailed design level, of course you would complete sensitivity analysis. You would assess the most likely case, the reasonable worst case, everything in between and on the margins.

MR. MANN: Jason Mann. So, I think just to close this question, I think what's important is that the sensitivity analysis -- so, I appreciate the description of how you've arrived to where you've gotten to, but I don't believe that that's been shown, shared, demonstrated, and I think that's important to properly evaluate the project and what the design looks like. So, that sensitivity analysis, at least in my view, would be very important to -- to share and to demonstrate in detail. If -- if you would wish to say more on that one, that would be great, otherwise I'll move to my next question.

MR. BUNDROCK: Steve Bundrock. I would just add that, yeah, I believe that the public, particularly if they haven't signed a non-disclosure, they don't have access to the complete geotechnical analysis, which includes some of that information. It's also true that previous geotechnical analysis is likely not on the public record. Is that -- that's correct. Yeah. So, in the future, it's reasonable to expect that of the detailed level of design that very fulsome sensitivity analysis would also be carried out and documented.

MR. MANN: Jason Mann. So, just to close again, it's critical that fulsome detail is shared such that this project can be evaluated properly, and if some of that's not on the public record, it certainly needs to be. I'll move to my next question.

So, in discussion yesterday and in looking at the side scan sonar data, it's clear and it was discussed that the base of the void space that's created with your single well extraction partially infills with sleuth sand, settles to a flat floor. And so, the question around this is that is it -- is it reasonable to assume that the 65 degree slope angle seen in the upper portions of that vertical section of sand is representative when first and foremost you weren't able to image the bottom of the void space because it infills? So, you don't know what that looks like below the flat floor. And is that 65 degree slope characteristic of the full vertical section in the sand zone when, yes, you see it in the upper portion of the sand where your side scan sonar could imagine it? But we know that the bottom of the void space infills with flowable sand. So, is there variability in the consolidation state, cementitious state of the sand vertically in that section? And I'll have some follow up questions related to your SPT and other discussions this morning, but that's fundamentally my -- my question. Is there variability in the consolidation state, cementitious state of that sand vertically when, again, you can see part of it standing up in the upper part of the void space, but the bottom infills and flows, and is backfilled with sand?

MR. ESHRAGHIAN: Arash Eshraghian, Stantec. It is true that sand may be flowable when it's disturbed, but in undisturbed condition it's not flowing, there's only in formation. There is cementation and cohesion to look through -- through that process, therefore we don't believe that entire Carman Sand is flowable then in the in situ condition. It will be disturbed by the extraction, and that's why it can flow into the -- to the extraction well, but it won't be flowable beyond that immediate extraction disturbance on -- around that -- that well. So, that's all based on our -- our understanding that the wall will be semi circular actually. It seem similar to tunneling in a -- in a -- in a relatively uniform deposit that you create a -- a circle due to extraction, and the stress condition itself. It create that compression to hold that circle. We are doing extraction with a different method, although we don't directly see that -- that shape, but it's reasonable assumption that the similar shape will be developed due to horizontal and vertical stress conditions in the -- in the sand. So, we believe it's still the assumption is -- is valid.

MR. MANN: So, let me ask a related question. Jason Mann. If the carmen sand was cemented and -- and stood at 65 degrees or better throughout the vertical section of the sand that you're extracting via your process, wouldn't you expect a clean void space, clean walls, and that you would be able to produce the sand that you've disturbed via your airlift method? Or at least most of it versus having a pretty significant amount of sand sleuthing into the bottom of the voice space. So, to me that would lead me to think that there's a difference in cementitious state, consolidation state, or some other thing going on. And so, I'm wondering what your thoughts are on that.

MS. WEEDEN: I'm just going to respond

because I ---

THE CHAIRMAN: Chair. Can I get you folks to kind of lean into your microphones. We're having some difficulty hearing you over here.

MS. WEEDEN: Oh. Hi. This is Laura Weeden. Is this better? Okay. So, I'm going to respond specifically to the sonar because that was a -- a field test, and we tested returning the water to the aquifer at the same time, and I think it's been mentioned and understood that we are planning on filtering the water before we return it in the future. However, when we did the test, we were chlorinating the water and returning the water back to the aquifer, and it did contain fines, and it takes time for those fines to settle, and when we return those fines, the sonar picks those fines up like a brick wall, even if it's just a tiny little bit. So, there -- it does actually take up some of the size of that cavern with a layer of fines, and it is -- we do find that it can be several feet, and we can tell the difference because we can see it with the sonar versus tagging it with an actual tag line, which wouldn't pick up fines. So, I just want to clarify that piece.

MR. MANN: Thank you. Jason Mann. So, that's a reasonable explanation. So, what did the tag line tell you? Because that would've been my next question.

MS. WEEDEN: Laura Weeden. I -- I guess I'm trying to understand what you mean, like what was the extra depth?

MR. MANN: Correct. So, if you realized your sonar was blind to the base of that void space, I probably would sound it with a tag line or some other method, and I'm curious what that result was.

MS. WEEDEN: Laura Weeden. It's about ten feet in difference from actual sand to the top of where the fines have settled.

MR. MANN: Jason Mann. So, that's an important distinction because I don't believe anywhere that that's been described, and if someone was interpreting your sonar results, they could very easily be interpreted that that is sand and not other material. Dirty water, finds, otherwise. So, I think that's a critical thing that needs to be described and -- and better -- better described as a -- as an understanding for the project. I've got related questions if -- if you're ready or I'll wait.

So, related questions, and -- and thank you for sharing the SPT results today. I think that was helpful. My question would be did you find there was -- so, I heard that there's basically refusal, spoon refusal, so that's important, but was there any variability with depth, was there a difference in results with depth, or did you just try the SPT at the upper part of the sands, found you got refusal, and that's the extent of that data collection? Sorry. I don't know if I stated my name. That's Jason Mann.

MR. BUNDROCK: Steve Bundrock. The results are here. This is where we completed our testing. You can see that we advanced what -- as much as 30 feet into the deposit and completed testing at -- at those -- those intervals, and there was limited variability. Typically, we're encountering refusal.

MR. MANN: Thank you. Jason Mann. I -- I can see those being a little closer here, but thank you for your answer. Basically, throughout the vertical section you had refusal on the spoon. Related question. What was recovered, if anything, in the spoon?

MR. MCLACHLIN: This is Doug McLachlin. So, reviewing photographs of the split spoons this morning, very little recovery. So, it was basically just very chips or little bit of, you know, chips of material, but no continuous recovery.

MR. MANN: Thank you. Jason Mann. Related question. The sand deposit earlier this morning was described as being confined, and we know it's under lane by a -- a series of strata above it. The sand itself is a reasonably uniform and rounded in shape. The silica itself is quite hard. It's well consolidated I'm sure, perhaps over consolidated. Cemented or not, would you expect in that condition that you would penetrate it with an SPT?

MR. MCLACHLIN: Doug McLachlin. So, as I mentioned earlier, standard penetration tests is a measure of the density of soil, but it also can measure sort of the cohesion in -- in a -- soil with cohesion, you would say very hard or you could say very dense. So, in this case because it is a sand, we -- we would call it very dense material. And so, that -- the information that was -- was obtained from the standard penetration test supports the fact that this is first, very dense, but then when we're starting to see the overhanging of the -- the sand deposit, once extraction takes place it's quite possible that there is significant cohesion including potential for very, very weak, poorly cemented as well.

MR. MANN: Jason Mann. So, no, appreciate that, and for that sand to stand vertical or overhang, certainly there is some amount of cementation, however, I would argue that with an SPT based on the fact that it's a hard material, it's uniform, it's very dense in place, I would surmise that you wouldn't necessarily know it was cemented or not because you couldn't penetrate it with an SPT. That's just my point of view, and you've given me an answer from your point of view on that perspective. Related question, and probably the last one in this -- in this section. Did you try another method of recovering that sand? And I'll -- I'll give an example. Did you try to triple tube core it? Because if you control your water properly, you can recover a lot of unconsolidated soil with that method. So, perhaps you would note that the full vertical section of the sand is cemented, perhaps you'd note that some parts of it are cemented, and some of it washes out so you know that it's not. So, question is did you think about triple tubing it, did you triple tube it? That's really the question.

MR. MCLACHLIN: Doug McLachlin. So, I understand speaking with Sio and -- and Sio you can provide more information. They had looked at alternative types of drilling. Sonic drilling was mentioned as one option. I leave it to Sio, do you -- did you actually consider triple tubing?

MS. WEEDEN: This is Laura Weeden. We spoke to a number of coring companies asking for solutions, and not a single company said we believe we can collect a core. So, we did not attempt.

MR. MANN: Jason Mann. Thank you for your answer. You don't know until you try it, but I'll leave it there.

MR. BUNDROCK: Steve -- Steve Bundrock. I -- I just wanted to add, Jason, it's a good point. Triple tube often times will collect reliable samples in challenging deposits like this. We do use those, however, in this case I think what came back from the drilling companies at the time, they thought that they had a -- an unconsolidated deposit, and they were not optimistic about their ability to collect any -- any samples.

MR. MANN: Thank you. Jason Mann. Your side scan sonar data was collected over months of time if I -- if I've interpreted correctly at most, and it resulted again as we've talked about, your slope angle of 65 degrees. Considering that the data you've collected so far is over -- and I think it's over three, four months worth of time in terms of your side scan sonar runs, do you concur, or do you believe that that 65 degree slope and the parameters you've back calculated from it is representative of the long term condition, years, decades, multiple decades, when the data you've collected and -- and pulled together is based on only months worth of time of that -- of that void space sitting in situ?

MR. ESHRAGHIAN: Arash Eshraghian. Yes, we believe that the side scan sonar data with different timing so far confirm our understanding of how far the wall can progress freely, and also confirm our most representative failure mode of the cap rock as well, which was the bending failure mode that shows a trapezoidal shape of the failure as being developed, and it's reading our estimated fraction zone in the -- in the cap rock. So, yes, it's represented here.

MR. MANN: Jason Mann. So, I'm -- I'm not sure how without some amount of sensitivity analysis or looking at possibilities that you can state that based on months worth of data collection you feel like that's going to be representative of years or decades of an open void space condition. So, I -- I don't really have another question, but I just am uncertain on how you can make that connection.

MR. DUNCANSON: Mr. Chair, Sander Duncanson here. While -- while the panel is conferring if -- if they want to respond, I -- I've been doing my best to sit back and let people ask the questions they want to ask and not interfere in any way, but I just wanted to point out, I mean, of course this part of the process is for parties to ask questions of Sio. Mr. Mann is not giving evidence this week. I expect he will be next week, and he'll be under oath then and we can ask him questions, but I just wanted to point out the -- the opportunity is -- is to ask questions, not to make statements or share his points of view, which there's another point of the process to deal with that.

THE CHAIRMAN: Chair. Thank you for that. The point is well taken.

MR. MANN: Jason Mann. Yes, thank you for that. I will stay in bounds. Another question I have is related to the side scan sonar data of BRU92-8, which was collected over a few months worth of time, and if I recall the -- the first image, the blue line work on that drawing was the main void space, and the second image taken a few months later, the red line work was I believe three or four months later. The side scan sonar demonstrated in this case that there was loss of the roof of that void space, in particular the shale aquitard, some of the limestone perhaps. Again, geotechnically as been well stated, the -- the shale is not relied upon for strength or any other geotechnical reason, and it's understood that that shale may not remain in place. In this case it did not remain in place, based on that side scan sonar. So, when I -- when I look at that side scan sonar, there's about -- vertically about ten feet of strata lost in the roof of that void space, and I would just be interested to understand -- the question would be I guess what would stop that process of collapse of the roof of the void space over the longer term, based on the analyses that -- that you've done, and your interpretation of the geology?

MR. ESHRAGHIAN: Arash Eshraghian. So, this failure that you observed from the cap rock is well equivalent to our bending failure mode case. So, as the unsupported layers of the -- the layered limestone start -- start falling down, they leave cantilevers at the side. So, this progress to a smaller and a smaller span of unsupported layer limestone. So, eventually this will converge and create a -- an underground arc if you -- you wish to call it. So, that's our assessment of the progress of the failure, then we do expect this failure stays within the limestone. It won't reach to the top of the limestone that caused, you know, subsidence on the ground surface eventually. So, the design of the size of the cavity is such it's limited its size that -- to limit this failure within the limestone that is specifically designed for that process. So, it's not diverging from our process.

MR. MANN: Jason Mann. Thank you. I don't think I have another question related to that. A general question is -- can maybe takes a few steps back before talking about the analysis of -- of the data and the geotechnical work. So, there was a description by the panel of the bore hole data used and compiled for the work that was done for the project. Geotechnical holes, water well holes, other drilling. My question is how many of these bore holes were inclined bore holes?

MR. BUNDROCK: None of the bore holes were inclined bore holes.

MR. MANN: Jason Mann. So, I -- if I understand you, they're all vertical bore holes.

MR. BUNDROCK: Which -- Steve Bundrock. Yes, correct, they were vertical bore holes.

MR. MANN: Thank you. Jason Mann. So, when the televiewer was used down hole, great tool to image and -- and measure discontinuities or fractures, but with the work being done within vertical bore holes, the structure of the rock largely captured here would be what is characteristic of a horizontal orientation. It's well known here in Manitoba that bedding plane partings for example are a horizontal discontinuity common in the limestone rock. It's one of the flow pads that form the aquifers in the carbonate rock. It's also known that they are pervasive vertical to subvertical joints within the carbonate bedrock, also conduits for flow, and often occurring at spacings that could be exposed within the spans, the roof spans that we're talking about here at 50 to 60 metres. Those vertical joints basing's often are -- are less than that, and all of these discontinuities geologically have been influenced by karst that has occurred in the past, what we call paleo karst. So, my question is related to these vertical discontinuities, which are pervasive and are important and are everywhere in the province of Manitoba in the carbonate bedrock. What data exists or drilling done to resolve these vertical discontinuities within the region of the project, and are there any other data sets that maybe haven't been shared that were looked at in this regard?

MR. BUNDROCK: Steve Bundrock. We agree that there's potential for -- good potential for at least some vertical discontinuities in the formation. As you know, the presence of vertical jointing is -- is not continuous in all places in Manitoba. The spacing between joints varies. We -- we do have eight bore holes that were Geotech, we have an additional 40 plus geological bore holes, some of which include information on structure, and none of those encountered persistent vertical jointing. We absolutely agree that there is potential that exclusively vertical bore holes can miss the presence of vertical jointing, however, the fact that we have not encountered it in any bore holes to date is an indicator of the likelihood that spacing is likely not close, is more reasonably not close, and may not be continuous. And you would probably also note that in the analysis and in the slide that we presented yesterday, it is our intention to complete several angled bore holes following permitting to close that gap. It's an important gap to close, and it's absolutely correct that we need to retain the span as intact, and in order to do that we have to manage not only horizontal, but vertical jointing.

MR. MCLACHLIN: Excuse me. Doug McLachlin. Just want to add onto that because you did mention karst. And so, one of the things that will take place in every extraction location as part of the initial drilling, there'll be confirmation of the thickness of the overburden, thickness of the competent limestone for the design, and also if there were to be any evidence of karst, that would be identified at that point, and Sio's intention would be not to extract in karst -- areas of karst.

MR. MANN: Jason Mann. Thank you for those answers. I appreciate you recognizing that gap because as mentioned, all of the bore hole data to date is vertical, and also the discussion on karst, I may have a follow up on that. I think more of a comment than anything. I think what's important is that even with vertical drilling, you know, you might encounter a vertical feature, you might encounter vertical paleo karst feature, and if you look at the subtotal of the data available in the region of the project, you may find that there are the odd number of bore holes that record very thin to know carbonate strata, often that's a result of chasing one of these vertical paleo karst infill features, or you might be too far east. I don't know, but it's just an important thing to note, and I appreciate the comment that there'll be work done it sounds like, if I interpreted that correctly, at each cluster location to understand the geology to plan for the cluster and it's extraction, if I interpreted that correctly. Question related to that, and it goes to my next question as well. You know, geology varies, conditions can vary. I think it's important that work is done in advance of a cluster to understand site specific condition. How will a change in variability at a cluster to cluster basis be managed or administered by Sio in terms of planning how that cluster will be advanced, and sand extracted? Because you likely will find differences on conditions between clusters. So, I'm curious on how that might be part of the production plan, or where that will be captured, and -- and how will that be administered, you know, on -- on the ground as an operation.

MR. BUNDROCK: Steve Bundrock, and Sio may want to build on my answer, but our understanding of the process is that they currently have a set of design recommendations, which they are held to follow. So, based upon their initial drilling, they would design their well spacing accordingly, following those design recommendations. If they have a variation from those design recommendations, then that steps over to the Trigger Action Response Plan, and additional assessment would be required and adjustment. And in some cases, it could preclude drilling in that location, or it would modify the number of wells that they're able to drill, or the amount of extraction that they're able to carry out.

MR. BULLEN: It's Brent Bullen with Sio. I just wanted to add to Mr. Bundrock's comments. As mentioned earlier, you know, part of our -- our extraction methodology and field development is the actual verification of till, limestone thickness, you know, the indications that were within the model parameters before we'd actually start any type of extraction activities. You know, should we see an unacceptable limestone thickness or a parameter that's outside of the model, obviously we would not look at an extraction attempt at that location, and we'd move to a different one, and take those parameters into the model, you know, which I think was shown quite well in the presentation yesterday from Stantec on cap rock thickness anticipation. You know, a lot of this goes back into feeding into our ongoing TARP response plan as well.

MR. MANN: Jason Mann. Thank you for that answer. So, the -- the TARP plan is important, and if I heard correctly then this variability and site conditioned planning for safe -- within bounds of Geotech rules, extraction plans will be captured in that TARP and will be part of how the operation goes forward. So, that TARP plan is -- is a critical piece of information certainly. That probably actually captured a couple other questions that I had.

I have one other that I thought I heard

yesterday that from the panel that based on new configurations and planning for well clusters, which I understand can vary, it could be one well, three wells, five wells, some other number versus a set number per cluster is -- is in the planning stage now, and that may speak to some of the variability in the things we've been talking about, which are very, very important. I thought I heard that based on that approach to how a well cluster will be development there was some feedback that went back to the groundwater group to rerun or to refine the groundwater model. I thought I heard that, I could be wrong. If so, I don't believe that's been presented anywhere to describe how the groundwater response may differ, and I know this is the Geotech group, but if that feedback has gone to the groundwater group, my question is whether that new information or revised groundwater information will become available?

MS. WEEDEN: This is Laura Weeden. So, you're correct. You did hear that. The -- the data was given to AECOM to rerun the model, and those model results will be presented in the presentation. As you can imagine the timeline with the hearing approaching, there is no formal final document that has been released yet. So, the results are contained in the PowerPoint, which are -- will be handed out at the time of the presentation by AECOM. It is Sio's intention to release an additional document, but our extraction plan was -- the timeline was a little short. So, it will be new information.

MR. MANN: Thank you. Jason Mann. Thank you for that answer. So, one last question I think. I -- I could've asked this one earlier perhaps. So, again, it goes back to the number of wells per cluster, which has been revised during the hearing process, and now plan to be advanced in a staged manner like we've touched on and described here. My question is whether that is a reflection of the -- the state of knowledge on the geotechnical or geological data side, or other uncertainties, or is there some other reason for that change in -- in the well numbers, and how they'll be advanced at a cluster to cluster basis.

MR. BULLEN: It's Brent Bullen with Sio Silica. The main difference was the production increase efficiency. We were able to see the production efficiency on a -- on a well bore, a single well bore go through 4,000 tonnes. So, we saw an immediate reduction of the overall wells, and we continue to see that, and we actually anticipate the worst case scenario of five well cluster, but it may very well be produced within three wells as we see our advancements in production.

MR. MANN: Thank you. Related -- Jason Mann. Related question. So, you -- you mention that the -- the change in well numbers is related to efficiency, and I would interpret that to be the -- the tonnage that you were able to produce from a single well advanced into the sand formation. I -- I might be interpreting it wrong, but I would imagine that that would've been one of the prime focus areas for Sio in determining the feasibility of a project like this, and it would be a key no go, go decision on whether you would pursue the project. So, in other words, you would know from the first series of wells that you drilled what the production or efficiency would be based on the formation and the testing that you had done. So, it's not clear to me on why the number of wells per cluster would change when you would relatively know on a single well basis from the work you've done to date how efficient it is or isn't. And so, again, I -- I would ask is it truly about the efficiency of a single well production rate, or is it about the variability and the geology, the sand formation, or some other related issue that now has changed the approach to how the cluster will be advanced?

MR. BULLEN: It's Brent Bullen with Sio Silica. A couple comments in there, and a -- a question that I heard. The determination was based on the production efficiency. You know, the other question actually comments around financial viability of the project. You know, our initial production was based on 2,000 tonnes per well and -- and initial modelling was done at, you know, 2,200 tonnes per well. It was economically viable at that point. So, I hope that answers your -- your first question in there.

The second really is just the efficiency of production. If you look at table nine of the work that was done by Stantec, it gives you the maximum allowable void. That void, it's a very simple volumetric calculation on the amount of material that can come out of the ground that gives you the tonnage of sand that's producible, and whether we produce all of that with that one, two, three, four, or five wells, we have to work within that to find void space, and we feel it's a good thing to have a reduction of wells. We've proven up a 28 and a half percent reduction from our first -- first go around, and it's just a production increase efficiency. The void spaces are defined. That's geotechnical, and we will just operate within them, and reduce the wells accordingly.

MR. MANN: Jason Mann. Thank you for that answer. I think I have one -- maybe one last question, which sort of has developed in the -- in the dialogue that we've had, and how -- and I think importantly there'll be an approach to look at site specific conditions at each well cluster, and -- and planning inside of the -- the TARP, or the response plan on how to execute that cluster. And -- and again, I think for me it comes back to variability that -- that will happen, and -- and will exist in an actual system and a site like this. Even in measuring the void spaces generated by a single well test, there are different shapes, sizes, configurations. It's variability. So, is it fair to say then that the TARP plan would capture an approach to safely execute a cluster of wells based on the bounds of geotechnical design and information that's known and developed for the project, will the TARP capture a safe procedure to go forward and execute a cluster on a cluster to cluster basis, and -- and have the guidance on what to do and what not to do to ensure that based on the fact that there's variability here, that a cluster will be -- be able to be executed safely?

MR. BUNDROCK: Steve Bundrock. That's a resounding yes. The -- there -- keep in mind that the TARP is not required at this stage. We have -- we've discussed the TARP, we've actually developed preliminary TARP's. I mean, in effect the -- your allowable span will feed into the TARP, you should expect that that would become much more detailed, that the monitoring plan would become much more detailed, that the triggers associated with the monitoring plan and all the elements of the triggers would become much more detailed, and that we continue to develop our understanding of -- of all aspects of the project, and all of those would feed into the TARP.

MR. MANN: Jason Mann. Thank you for that answer. I don't think I have any further questions at this time.

THE CHAIRMAN: Chair. Thank you very much. I think that the exchange wins the award for the least number of times someone didn't give their name. So, well done. We can see if we can top that going forward. I only counted two instances, so awesome. Let's take our break now, and I believe the last questioning will come from MBEN. So, we'll take our break now, and then you'll have a -- an uninterrupted go at it, Byron. Ten minutes, and that's a short ten minutes. So, we will turn the -- excuse me. Chair. Sorry for that interruption. We'll now turn the floor over to MBEN. So, if you haven't previously, state your name and spell it please for the -- for the transcribers in Toronto.

MR. WILLIAMS: Good morning members of the panel. For the transcriber, Byron, B-Y-R-O-N, Williams, W-I-L-L-I-A-M-S. And members of the panel, we've of course been listening carefully to the discussion today and as well as yesterday. We'll try not to duplicate areas of inquiry. To the extent we do, it will either be to raise a new point, or further to Mr. Duncanson's point. Sometimes there were preambles that aren't evidence. And so, we may be asking questions of clarification to make sure things are actually on the record as evidence. Thank you.

Still Williams speaking, and good morning, Mr. Somji, Mr. Bullen, Ms. Weeden, Mr. McLachlin, Dr. Eshraghian, and Mr. Bundrock, and just for you, I from time to time will be directing specific questions to a member of the panel, but always feel welcome to join in and gang up on me if that's what -- what you prefer to do, and I'm just mindful of the competitive business that you're in, and potential commercial sensitivity. And so, I do not expect to ask any questions that require commercially sensitive information, but if I inadvertently do so, you'll just stop the inquiry, and I'll chat it over with your lawyer. And so, just be mindful of that, but I'll do my best not to trench upon that area, okay?

Most of my questions will be to AECOM or Stantec, but just to give Sio Silica -- Sio Silica some practice, and I will ask a few questions from you in -- in a few minutes. For AECOM, groundwater in the vicinity of the project is typically sourced from aquifer zones either within the red river carbonate formation, the limestone, or the Winnipeg sandstone formation, agreed?

MR. MCLACHLIN: This is Doug McLachlin. So, this panel is a geotechnical panel, and it's to review the geotechnical assessment, the stability of the cavern, the design. There will be a water panel, and so I would defer that to colleagues who are on the water panel.

MR. WILLIAMS: Williams speaking.

Sir, I'm quite familiar with that, but as a basic groundwork for this -- for this for -- for you, this is something you're familiar. You know that these sources of groundwater are from those two aquifers, agreed? This is not contentious.

MR. MCLACHLIN: This is Doug McLachlin. I'm a geotechnical engineer, and I'm working on the geotechnical assessment as part of this panel. We have AECOM colleagues who are on the groundwater panel, and they will be addressing all the questions related to groundwater.

MR. WILLIAMS: Thank you. In terms of the extractive activities to Stantec, the focus of the extractive activities will be at the -- focused in the Winnipeg sandstone aquifer, agreed? You're going into the sandstone, that's where you're pulling the ---

MR. BUNDROCK: Steve Bundrock. It -- that's correct. We're in the Winnipeg formation in the sand.

MR. WILLIAMS: And to Sio Silica and mindful of your company overview yesterday, you've told

Manitoba that you envision a multi-generational mining project, agreed?

MR. SOMJI: Yeah. That's correct.

MR. WILLIAMS: And from Williams, you expect to be mining silica from the sandstone aquifer for at least 24 years, agreed?

MR. SOMJI: It's Feisal Somji from Sio. Yes, that is our anticipation.

MR. WILLIAMS: And I'd like to turn to AECOM figure 1.1 revised. And this question obviously can either go to Sio Silica or to AECOM. If we look at figure 1.1, Williams speaking, we can see that the 24 year project is bounded by the purple, agreed?

MS. WEEDEN: This is Laura Weeden from Sio Silica. Yes, the outer purple outline is the 24 year anticipated mine life.

MR WILLIAMS: Williams here. And the initial target of your multi-generational project is silica sand from the Winnipeg sandstone aquafer southwest of the hamlet of Vivian, correct? First ---

MS. WEEDEN: Laura Weeden. Yes, it's south and southwest.

MR. WILLIAMS: And if we look into the top right corner, the northeast corner of figure 1.1 revised, and recognizing that this is from your original application and not your revised application, we'll see the area bounded in red is the initial target that it was the subject of the Environmental Act Proposal, agreed?

MS. WEEDEN: Laura Weeden. Yes.

MR. WILLIAMS: And we'll come back to this in a minute, but you amended your initial plan in January of 2023? Williams speaking.

MS. WEEDEN: Laura Weeden. Yes, as ---

MR. WILLIAMS: That was my fault, Ms. Weeden. I apologize.

MS. WEEDEN: As a result of the updated table nine.

MR. WILLIAMS: Williams again. And Ms. Weeden, after the first four years of extraction, you intend to progress further from the processing facility each year within blocks of land adjacent to previous extraction wells, correct?

MS. WEEDEN: Laura Weeden. Yes, however, I will note that this is more a permitting discussion, which is slated for a different panel.

MR. WILLIAMS: Williams. Ms. Weeden, if we look at the -- at the broad multi-generational project encompassed in the purple, it would be fair to say that the initial project for which licensing was sought is a relatively small proportion of that, agreed? About -- about a sixth, and I'm sorry for cutting you off.

MS. WEEDEN: Laura Weeden. I'd have to calculate if a sixth exact, but yes. Again, I think we're kind of on the permitting discussion right now.

MR. WILLIAMS: Just a couple more questions, Ms. Weeden, and I'm mindful of your caution, but we're trying to be efficient as well. I wonder if we can go to the notice of -- of the revised extraction plan please. And specifically, page four. Williams speaking. Ms. Weeden, if we look at the revised extraction plan, you'll see an area bounded in yellow, and you'll agree that that was the area that was provided in the initial environmental assessment proposal presented to the department, correct?

MS. WEEDEN: Laura Weeden. Yes.

MR. WILLIAMS: And the area in pink, Williams speaking, is your current extraction plan as amended in January of 2023, agreed?

MS. WEEDEN: Laura Weeden. Yes.

MR. WILLIAMS: And again, recognizing permitting comes in a couple days, that's a relatively small proportion of your overall 24 year multi-generational plan, correct?

MS. WEEDEN: Laura Weeden. Yes, that -- that new revised extraction plan is a slightly less surface area than the original yellow outline.

MR. WILLIAMS: Just a couple more questions to Sio Silica, and we'll be directing your attention to slide 13 of your company overview, exhibit H002. And focusing on this slide, Sio Silica. When you discuss the taxes, the payrolls, the royalties, and the municipal charges flowing from the Vivian Project, you were presenting them on this slide as over the 24 year lifespan, agreed?

MR. SOMJI: This is Feisal Somji from Sio. Yeah. As per the slide notes, it's over a 24 year mine life, and that's a -- that's a typical analysis that's generally done in all mining projects looking at a -- a 24, 25 year mine life.

MR. WILLIAMS: Thank you. And if we turn to slide 14, Williams speaking, still of exhibit H002, the company overview. Again, when you're talking about the 1.4 billion dollars in capital and operating expenses, again, you're looking at the multi-generational project, the 24 year mine life, correct?

MR. SOMJI: Again, this is an analysis done for a 24 year mine life. That's correct.

MR. WILLIAMS: I'm not sure if the -- Williams speaking. I'm not sure if this question goes to AECOM or to Sio Silica, but in the course of this proceeding, the proponent has referenced and reply -- and relied upon four reports of Stantec, including Stantec 2019, Stantec '20, Stantec 2021, and Stantec 2022, correct?

MS. WEEDEN: If you are talking about the references listed -- sorry, it's Laura Weeden. If you're talking about the references listed in the EAP, that -- that is correct.

MR. WILLIAMS: And specifically in the segment on geology, section 6.21 of the EAP, Sio Silica references and relies upon exclusively Stantec 2019, Stantec 2020, and Stantec 2021, agreed? Williams speaking.

MS. WEEDEN: Laura Weeden. I'm going to have to double check because ---

MR. WILLIAMS: Will you accept that subject to check and then we can come back to it if -- if -- if the answer is ---

MS. WEEDEN: I would like to just double check.

MR. WILLIAMS: Thank you. It's section 6.21 under geology and topography. Williams speaking.

MS. WEEDEN: Laura Weeden. Mr. Williams, can you please repeat the question?

MR. WILLIAMS: For the purposes of your EAP and specifically referring to section 6.21, geology and topography, the proponent sited and relied upon Stantec 2019, Stantec 2020, and Stantec, 2021, agreed? Williams speaking.

MS. WEEDEN: Laura Weeden. Yes.

MR. WILLIAMS: Indeed, for the purpose -- Williams speaking. Indeed for the purposes of your EAP, Environmental Assessment Program, Proposal, EAP, we'll use that acronym, anyways, you did not have Stantec 2022 available, correct?

MS. WEEDEN: Laura Weeden. Correct. We filed the EAP in 2021.

MR. WILLIAMS: For Stantec and referring specifically to the family of reports being Stantec 2019, Stantec 2020, and Stantec 2021, as part of the analysis that stands, that did, you analyzed the cap rock, and explored extraction cavity sheer failure model stability, agreed?

MR. ESHRAGHIAN: Arash Eshraghian. Agree, yes.

MR. WILLIAMS: And for AECOM or -- or Sio Silica, for the purposes of section 6.21, geology and topography, you can -- included that the impacts to geology were assessed as being minor, correct?

MS. WEEDEN: Laura Weeden. AECOM permitting team did the assessment. So, that question would be better suited for the permitting team when they're sitting up here.

MR. WILLIAMS: It's a pretty fundamental point going to geotechnology, isn't it? That the impacts are -- were -- were minor? Williams speaking.

MR. BULLEN: It's Brent Bullen with Sio Silica. Some of the questions you have are best suited for some of the experts that aren't sitting here, and they'll be made available to you at the appropriate time. It's not perfectly -- I don't think it's acceptable to ask questions outside of scope that's going to be covered in some of the committees when we're making them available to you.

MR. WILLIAMS: Stantec -- Williams speaking. Stantec 2019, Stantec 2020, and Stantec 2021 have not been filed on the record of the CEC proceeding, agreed?

MS. WEEDEN: Laura Weeden. Agreed.

MR. WILLIAMS: And to Sio Silica, and Sio Silica is not prepared to provide these earlier Stantec reports being 2019, 2020, and '21, even to hearing participants if they agree to sign a non-disclosure agreement, agreed?

MS. WEEDEN: Laura Weeden. I believe that was covered in one of the motions that was sent prior to the hearing, and I will note that those documents have been sent to the mines branch. So, the mines branch has seen them, but they are -- we are not prepared to release them at this time.

MR. WILLIAMS: And it would be correct, Williams speaking, to suggest that within the Stantec family reports of 2019, 2020, and 2021, there was geotechnical modeling information that was relied upon by Sio Silica for the purposes of its -- of it's proposal under the environment act, agreed? Williams speaking.

MS. WEEDEN: Laura Weeden. Yes. The section 6.2.1 that you were referring to largely contains the -- or the geotechnical excerpt from that larger document that mostly contains financial information.

MR. WILLIAMS: Williams speaking. You're not suggesting that within section 6.2.1 that the -- the sheer scale modelling performed by Stantec is -- is presented in that material, agreed?

MS. WEEDEN: Sections -- Laura Weeden. Section 6.2.1 contains a small summary, yes. I will note that the current Stantec 2022 supersedes all of the other previous models.

MR. WILLIAMS: Williams speaking. And thank you for that. And in fact, Stantec would agree that the 2019, 2020 Stantec report, and the 2021 report have been overtaken by Stantec 2022, correct?

MR. BUNDROCK: Steve Bundrock. Yes, that's correct.

MR. WILLIAMS: You no longer rely upon those earlier Stantec reports for the purposes of the EAP, agreed?

MR BUNDROCK: Steve Bundrock. 2022 does supersede those other documents, however, the previous information does contain the previous reports, have design basis information, they're effectively building blocks towards the 2022 final revision. Our intention with 2022 was to provide a comprehensive standalone report.

MR. WILLIAMS: Thank you. If we can turn, it's Williams speaking, to Silica's response to public comments, and specifically to the exert from the

Stantec 2022 report, table two attachment A around PDF page 86, and I actually want to go to the first page of that document. Thank you. The executive summary. To Stantec, and backing away from the specifics of this report for a second, in terms of typical failure mechanisms for crown pillars, Carter in 2014 sets out a -- a number of categories to analyze those typical failure mechanisms, agreed? At a high level, that's pretty basic.

MR. ESHRAGHIAN: Arash Eshraghian. Yes, I agree.

MR. WILLIAMS: And again, leaving aside Stantec 2022, as part of its earlier reports for Sio Silica, Stantec previously analyzed the cap rock and extraction cavity sheer failure mode stability, agreed?

MR. ESHRAGHIAN: Yes, sir. Sorry, Arash Eshraghian. Yes, that's right.

MR. WILLIAMS: And doctor, I apologize, that was me cutting you off. That's Williams being rude inadvertently. As part of that earlier analysis by Stantec 2019, 2020, and 2021, you also made some simplistic assumptions in terms of the subservice excavations, agreed?

MR. ESHRAGHIAN: Yes. Arash Eshraghian. Yes.

MR. WILLIAMS: But in those earlier reports, Williams speaking again, being Stantec 2019, Stantec 2020, and Stantec '21, you did not examine the bending tensile failure mode, correct?

MR. ESHRAGHIAN: Arash Eshraghian. Yes, correct.

MR. WILLIAMS: And so, what you did in -- Williams speaking, in Stantec 2022, excuse me, is model an -- at least a couple of categories of risk of failure modes, including the sheer failure mode and the bending tensile failure mode, correct?

MR. ESHRAGHIAN: Yes. We further developed the shear failure mode as well. The last three added the -- the bending failure mode category.

MR. WILLIAMS: And as set out, Williams speaking, in the famous Stantec table nine of

Stantec 2022, Stantec now concludes that the bending tensile is a controlling failure mechanism to determine the long term allowable span, agreed?

MR. ESHRAGHIAN: Arash Eshraghian. Yes, I agree.

MR. WILLIAMS: Williams speaking. And -- and perhaps we could go just a couple of pages onto table nine, which I believe is at Stantec page 33. Thank you. Williams speaking. Sticking with table nine, and in estimating the extraction disturbance zone dimensions, you assumed extraction depth was 20 metres, agreed? It's right in the footnotes if Stantec is wondering.

MR. ESHRAGHIAN: Arash Eshraghian. Yes, that's the revised depth for extraction. That was 20 metre. That was a revised depth, 20 metre.

MR. WILLIAMS: Okay. And -- and thank you, doctor. And just -- I think I heard you say that that was a revised?

MR. ESHRAGHIAN: Yes, that's correct. The earlier versions, they had simplified assumptions for the shape, as well as depth, and in this version, we refined the depth, and also side wall.

MR. WILLIAMS: And in the earlier assumptions, what was the assumed extraction depth, doctor? Williams speaking.

MR. ESHRAGHIAN: Arash Eshraghian. I can't exactly recall. It was maybe 10 or 15 metre. We can check in.

MR WILLIAMS: Yes. And -- and Williams speaking, to the panel, I'll ask for an undertaking to provide from the previous analysis the extraction depth assumed in the modelling. Thank you. Is that undertaking satisfactory, Mr. Duncanson?

MR. DUNCANSON: It's Sander Duncanson speaking. That's acceptable, Mr. Chairman.

MR. WILLIAMS: Williams speaking. And -- and doctor, you noted -- I -- I'll suggest to you that the other change in assumptions was with the extraction zone side wall, is that correct?

MR. ESHRAGHIAN: Arash Eshraghian. Yes, that's correct.

MR. WILLIAMS: And Williams speaking, for the purposes of Stantec 2022, you're assuming that the extraction zone side wall slope is 65 percent, which you calculate based upon a friction -- 65 degrees, excuse me, which you calculate based upon a friction angle of 35 degrees, and then -- and as well as the estimated cohesion of 220 kilopascals, agreed? Williams speaking.

MR. ESHRAGHIAN: Arash Eshraghian. Yes. That was back calculated by calculation model. Yes.

MR. WILLIAMS: Williams speaking. We'll come to the back calculation briefly in just a second. In terms of the previous analysis, can you share what the extraction zone side wall slope was estimated to be in the -- in the -- in the reports prior to Stantec 2022?

MR. ESHRAGHIAN: Arash Eshraghian. There was -- there was assumed a slope based on assumption of disturbed sand. After we did the side scan sonar data, we revised that assumption to 65 degree. That was the process.

MR. WILLIAMS: Williams speaking. And just in -- in terms of the assumed aslope of the -- of the sand in the previous study, what was it, 35 degrees?

MR. ESHRAGHIAN: Arash Eshraghian. It was 31 degrees.

MR. WILLIAMS: Williams speaking. And I don't mean to repeat the very interesting conversation you had with Mr. LeNeveu and Dr. Hollander yesterday, but would it be correct to suggest that to estimate the possible cohesion component of the sand strain -- sand strain, the sand deposit strength was back calculated using the sonar survey data on the post extraction cavity, agreed?

MR, ESHRAGHIAN: That is -- Arash Eshraghian. That is -- that is correct in a sense, but there was a -- like a refinement process. It's not just based on side scan sonar data. We consider it as a full scale test in place, and we believe this is accurate assessment.

MR. WILLIAMS: Williams speaking. And I don't want to get into too much detail on this, but the point you're trying to suggest is that there were additional refinements I think is -- that's what I heard you say, sir?

MR. ESHRAGHIAN: Arash Eshraghian. What I'm trying to explain is there was a process. It was not just assumption. It was a full scale test. We see it as a full scale test.

MR. WILLIAMS: And in essence what you did sir was you took the -- the sonar from the short term slope, and you made certain assumptions, and taking into account a -- a residual -- a residual value whenever it was strained to 0.05 percent? I'm probably going into too much details here, so I'm going to pull this question. Williams asking a better -- oh, sorry sir. Yeah. Getting too far into the weeds. Williams speaking. Your back calculation was based upon the sonar from a single bore hole being BRU92-2, agreed?

MR. ESHRAGHIAN: There was additional information directly and indirectly feed into the assessment as well. For example, our SPT data that we shared this morning, the experiences with similar sand deposits in similar environment, so experience with those material properties, and the -- the side sonar data provided information for a full scale test -- (inaudible) full scale test, and all these added to the refined back calculation of the -- the Carman Sand parameter. So, all of these were -- were considered. It's not just single point. But when all these parameters, they -- they're in agreement, we get more and more confidence in -- on the -- on the estimation. Yes.

MR. WILLIAMS: Williams speaking. And sir, in terms of the solar -- sonar, excuse me, analysis that you relied upon, focusing exclusively like that -- on that, that came from a single bore hole being BRU92-2, agreed?

MR. ESHRAGHIAN: Arash Eshraghian. It's actually two bore holes. They showed similar behaviour 92-2 and the other one was 92-8 I -- I believe, but we selected -- we -- we selected 92-2 for detail analysis.

MR. WILLIAMS: Thank you. I wonder if we can go now back to the notice of revised extraction plan, Williams speaking, January 2023, PDF page four please. And to Sio Silica, again, just to orientate ourselves, Williams speaking, outlined in yellow is the original proposed extraction area submitted in the EAP, agreed?

MS. WEEDEN: Laura Weeden. Yes.

MR. WILLIAMS: And I'm perhaps going to torture, Williams speaking, my understanding of colours, but in the pink is the revised extraction plan.

MS. WEEDEN: Laura Weeden. Yes.

MR. WILLIAMS: Williams speaking. I was afraid you were going to -- to correct me on my colours but thank you for not doing so. And Mr. Bullen may have answered this earlier, but if we look in the top left corner of the -- the -- the -- the visual, we see that Sio Silica is no longer planning in the first licence to extract from BRU93, Williams speaking, agreed?

MS. WEEDEN: Laura Weeden. Correct.

MR. WILLIAMS: Williams speaking.

Ms. -- Ms. Weeden, in terms of BRU93, what makes it unworthy of -- for extraction?

MS. WEEDEN: Laura Weeden. I think this morning when I went over that chart that explained sort of the iterative process that we went through, I mentioned that we did some additional exploration drilling, and we updated our geological model, and when we did that, that yellow area of 93, we hadn't drilled any wells in that area, and we focused our drilling further south. So, we haven't had a chance to do additional drilling in that area. So, we decided to move further south.

MR. WILLIAMS: Williams speaking. And Ms. Weeden, just so I'm -- I'm clear, you updated your modelling by Stantec 2022 and some additional analysis, agreed? That was my fault.

MS. WEEDEN: Laura Weeden. So, we have a Geotech model that was updated, that's the table nine that we're talking about. Over the summer we also updated our geological model, which was shown in the PowerPoint yesterday, maybe slide four or five, that colourful map, that was updated this summer following the update from the Geotech so that we could refine our extraction plan. So, when we did our additional drilling, we -- we did not have a chance to drill in the 93 area. So, we chose to go with areas that we were more certain because we had drilled more wells in that area.

MR. WILLIAMS: With regard to BRU93, were you uncertain whether that region met the revised parameters provided by your geotechnical consultant team?

MR. BULLEN: Brent Bullen of Sio Silica. Can you ask that question again please?

MR. WILLIAMS: With regard -- Williams speaking. With regard to your decision to abandon BRU93 and the reference to uncertainty, were you uncertain whether that region met the revised parameters provided by your geotechnical consultant team?

MR. BULLEN: It's Brent Bullen with Sio Silica. We actually feel it actually meets our economic -- or sorry, not economic, our geotechnical parameters, but we always do a drill ahead, and we look at the areas where we actually have had activity. It's sound for us to approach the process of getting our first four years licenced in areas that we're very comfortable, we meet all the parameters. We'd like to do further work, but we did not drill that area. So, it's just a -- a question of verification on drill, but we feel the area will meet with the parameters of the geotechnical modelling, but it's just more prudent to go ahead. I think you even said it yourself in the opening statements, you know, you need to be cautious as you move ahead. So, you know, in your three points. We are cautious, we're cognizant of how we proceed, and we're going in areas where we have absolute certainty that we meet the parameters and model that we can see so far.

MR. WILLIAMS: I forgive you, Mr. Bullen. Williams speaking. With regard to BRU93, what changed between you being confident in extracting from that area in the original proposal, the Environmental Act Proposal, to lead you to decide to abandon it? Like what changed in terms of your level of confidence?

MR. BULLEN: It's Brent Bullen with Sio Silica. Just to correct. It's -- it's not a level of confidence. It's not that we lack a confidence in BRU93. We've not abandoned BRU-93. We chose a methodology of the first four years in our revised plan that actually works on sound economic planning of movement of material. So, when you look at the stage stepped approach that we've provided in the new mines approach mining plan, we start with single wells, we go to dual wells, we look at building up, and we do south -- as we go south, it's just more efficient to just keep everything in a line as you're moving your sand. There's -- it's just an efficiency, but 92-3 is -- is not an abandoned platform for us. It's not a write off. And ---

MR. WILLIAMS: And just for the record, sorry, I believe you meant to say BRU, Williams speaking, 93, rather than 923?

MR. BULLEN: Brent Bullen. You're correct. I thank you for the clarification.

MR. WILLIAMS: To Stantec, Williams speaking, you are familiar with the term full scale extraction test, agreed?

MR. BUNDROCK: Yes, agreed. Steve Bundrock.

MR. WILLIAMS: Indeed, you recommend that Sio Silica, Williams speaking, undertake a full scale extraction test in the executive summary of Stantec 2022, correct? It's a Stantec recommendation.

MR. BUNDROCK: Steve Bundrock. So, yes, there is a recommendation for full scale testing while considering that full scale is intended to -- it's targeting a volume, which is representative of construction level work. We've also discussed the need to assess multi well.

MR. WILLIAMS: Williams speaking. And thank you for that answer. And sir, just to make sure that I understand it, what you're saying is that in seeking to understand the term full scale extraction test, you understand it to involve both multiple wells, as well as a certain volume, agreed?

MR. BUNDROCK: Yes. Steve Bundrock. Agreed.

MR. WILLIAMS: Williams speaking. And is full scale extraction test arcane tool of a Geotech art, is that a commonly used nomenclature, sir?

MR. BUNDROCK: Steve Bundrock. Full

scale testing, yes, is a common nomenclature. In the case of Sio Silica's project, it is a site specific usage. What full scale testing might entail at a -- say in one underground mine versus another underground mine would vary.

MR. WILLIAMS: Williams speaking. Now, the recommendation for full scale extraction tests was made in January of 2022 in the Stantec 2022 report, agreed?

MR. BUNDROCK: Yes, agreed. Steve Bundrock.

MR. WILLIAMS: Williams speaking. Did Stantec make any prior recommendation for full scale extraction testing in the series of reports being Stantec 2019, Stantec 2020, or Stantec 2021?

MR. BUNDROCK: Steve Bundrock. There were not recommendations at -- in those previous reports for full scale testing. We were working through an iterative process at that point, which typically involves single wells to develop our understanding.

MR. WILLIAMS: So, in the analysis underlying Stantec 2019, 2020, and 2021, there was no examination of multi well extraction clusters in those reports, agreed?

MR BUNDROCK: Steve Bundrock. So, Stantec was aware of Sio's preliminary plans to complete multi well extraction, however, in those earlier reports we were not assessing multi well configurations. We were considering those configurations and building up our understanding of the area geotechnical conditions and extraction conditions to feed into the design.

MR. WILLIAMS: Williams speaking. And similarly, in Stantec 2022 there was no examination of multi well extraction clusters, agreed?

MR. MCLACHLIN: This is Doug McLachlin. Thank you for the question. So, the design that has been done by Stantec is the geotechnical design that comes up with the safe allowable span, and that information is provided then to Sio, and then with their development, they can determine based on the efficiency of each well how many wells can extract that void space. So, the work that's done by Stantec is independent of how many wells it will take to remove that amount of sand at any individual extraction location.

MR. WILLIAMS: Williams speaking. I'm sure that answer is helpful, but I just want to have my question answered. And in terms of Stantec 2022, just so I'm clear, there was no examination of multi well extraction clusters, agreed? Simple point.

MR. BUNDROCK: Steve Bundrock. So, answering your question directly, we don't agree. In fact, in one case we completed subsidence monitoring for a multi well configuration. We also considered the interaction between wells, which is -- is considered and -- and reported. Whether or not we -- yeah, and to further clarify, we did not run a model of multi well configurations.

MR. WILLIAMS: Thank you. Williams speaking. In using down -- excuse me, in using down hole side scan sonar data to develop design parameter, Stantec assumes that the results of that down hole side scale -- side scan sonar of the cavity after mining is representative of the probable behaviour of the void during full scale mining, agreed?

MR. BUNDROCK: Steve Bundrock. Yes, agreed.

MR. WILLIAMS: Williams speaking. In using sediment monitor data to develop design parameters, Stantec assumes that the result of settlement monitoring to data are representative of probable settlement during the full scale mining and the long term, agreed?

MR. BUNDROCK: Steve Bundrock. Yes, agreed.

MR. WILLIAMS: To Sio Silica, Williams speaking, it would be fair to suggest that Sio Silica wants to be first out of the gate in terms of Sio's -- or in terms of silica extraction in the region, agreed?

MR. SOMJI: I don't think it's a fair assessment to say we want to be the first out of the gate. We're following a normal course business plan and timeline, and it's -- it's looking to try to produce a product that is increasingly in demand worldwide.

MR. WILLIAMS: And with no --

Williams speaking, with no judgement involved, Sio Silica opposed public release of the entirety of Stantec 2022 in part because you had concerns that it could be used by a competitor in the development of a competing project, agreed?

MR. SOMJI: It's Feisal Somji. I agree that we -- we were restrictive on the release due to a competitive nature. I don't know what you mean or -- or if you could define what you mean by a competitor in the region, which is what I think you said.

MR. WILLIAMS: Williams speaking. Let me try it a different way sir just to make sure that we're on the same page. Sio Silica was opposed to releasing Stantec 2022 in its entirety because it was concerned that the information in it could be used by a competitor seeking to enter the silica extraction market in the same approximate area where -- where you're seeking to -- to -- to act.

MR. SOMJI: It's Feisal Somji. We do agree that it's because we were worried about a competitive nature by our peers, however, it could be used in a variety of competing projects, not just within

Manitoba, but outside as well.

MR. WILLIAMS: Williams speaking. But it was reasonably foreseeable to you that that information cold indeed be used by a competitor in Manitoba and in this region, agreed?

MR. SOMJI: It's Feisal. I think I've answered that question.

MR. WILLIAMS: Well, just so I'm clear sir, are you saying you don't expect potential competitors for silica extraction in this region?

MR. SOMJI: It's Feisal Somji here. I didn't say that. What I said is we were worried about competitive behaviours both within Manitoba and outside of Manitoba.

MR. WILLIAMS: Thank you. I appreciate that, and I may have asked the question imprecisely previously, so I appreciate the clarification.

THE CHAIRMAN: Chair speaking. We are rounding the area. How are we doing?

MR. WILLIAMS: Williams speaking. I'm pretty confident that we'll be closing this cross examination on or about 12:30, if that works for the panel.

THE CHAIRMAN: Chair. Thank you very much. That would be excellent.

MR. BUNDROCK: Steve Bundrock. Maybe out of order. Can I pause for a washroom break?

THE CHAIRMAN: Chair.

MR. WILLIAMS: Williams speaking. That may effect my estimates.

THE CHAIRMAN: Chair. So, we have our full panel back. So, let's get back to it please. Mr. Williams, the floor is yours again.

MR. WILLIAMS: Williams speaking. And -- and thank you, Mr. Chair. To Sio Silica, you were seeking a patent for your sand extraction method, agreed?

MR. BULLEN: Brent Bullen. Agreed.

MR. WILLIAMS: And in essence, you're trying to patent the apparatus for extraction from unconsolidated sandstone formations, is that right, sir? At a high level.

MR. BULLEN: Brent Bullen, Sio Silica. The patent is actually for unconsolidated material from an aqueous born or fluid born formation below grade.

MR. WILLIAMS: Williams. Thank you for that answer, which was much better than the question. So, thank you. And Sio -- William speaking again. Sio Silica wants to patent your invention because if granted patent protection, it would stop others from making, using, or selling your invention for a certain period of time, agreed?

MR. BULLEN: Brent Bullen. Agreed.

MR. WILLIAMS: If we could turn to second round information request of the Clean Environment Commission number 14. And specifically, appendix A to -- to that response.

MR. BULLEN: Brent Bullen. Can you just specify the -- what I'm looking at here?

MR. WILLIAMS: I was going to situate you, and we're going to actually go to page -- PDF page three of this, but this is the response second round information request of -- of this Clean Environment Commission, number 14, sir. Does that assist? And specifically I'm going to direct your attention to the results of the sonar. Is that helpful, Mr. Bullen?

MR. BULLEN: Yes, it is. Thank you.

MR. WILLIAMS: And sir, at a high level as part of its activities on this extraction process, Sio Silica commissioned sonar surveys at the BRU928, and BRU922 extraction wells, agreed?

MR. BULLEN: Brent Bullen. Agreed.

MR. WILLIAMS: Williams speaking. And for the purposes of our conversation, Mr. Bullen, just to situate you, we're going to focus on the results from 928, okay? And sir, you would agree, William speaking, that BRU928 was surveyed during extraction after 3,500 tonnes had been removed, correct?

MR. BULLEN: Brent Bullen. Agreed.

MR. WILLIAMS: Williams speaking. And that would be called operation one, correct?

MR. BULLEN: Brent Bullen. Correct.

MR. WILLIAMS: Excuse me, Williams speaking, BRU928 was again surveyed after extraction of 4,200 tonnes was seized again. Sorry, let me try that again, let me ask that better, Mr. Bullen. As operation two, sonar surveys were taken after the extraction of 4,200 tonnes from BRU928, agreed?

MR. BULLEN: Brent Bullen. Agreed.

MR. WILLIAMS: Williams speaking. And sir, there were follow up surveys performed at one month post extraction, and that was known as operation three, and at four months post extraction, which was known as operation four, correct?

MR. BULLEN: Brent Bullen. Correct.

MR. WILLIAMS: And sir, it is these reports from those surveys, operations one through operation four, that we can find in appendix A, agreed? Williams speaking.

MR. BULLEN: Brent Bullen. Agreed.

MR. WILLIAMS: And directing your attention to PDF page three, sir, you'll see at the top of this page the title, "Mean Radius", agreed?

MR. BULLEN: Brent Bullen. Agreed.

MR. WILLIAMS: And the term mean here is not some commentary on the temperament, but it -- mean is referring to the average radius, agreed?

MR. BULLEN: Brent Bullen. Agreed.

MR. WILLIAMS: In essence, what this graphic provides is a display of the mean radius of the cavern found in operations one and two based upon sonar, correct?

MR. BULLEN: Brent Bullen. Correct.

MR. WILLIAMS: And sir, if you direct your attention to the bottom right hand corner of -- of this -- of this page, you'll see that operation one is depicted by a blue line, correct?

MR. BULLEN: I apologize. My copy's in black and white, but I'm ---

MR. WILLIAMS: Sir -- sir, with your lawyers permission, I'll approach you with a colour copy, which may expedite things. And just for the panel and for Mr. Duncanson, I have shared with Mr. Bullen PDF pages three, 10, and 17 in colour just to assist the discussion.

MR. BULLEN: Do you want this back?

MR. WILLIAMS: Mr. Bullen, I'm going to give that to you. That'll be our contribution to Sio Silica. Sir, again, directing your attention to the -- just one second. We'll just wait for the panel to have the display before it. Sir, just going back to the question now that we have the documents before everyone.

You'll see in the bottom right hand legend of PDF page three that operation one is depicted by a blue line, correct?

MR. BULLEN: Brent Bullen. Correct.

MR. WILLIAMS: And operation one, again William speaking, was a sonar survey taken part way through extraction after the removal of 3,500 tonnes, agreed?

MR. BULLEN: Brent Bullen. Agreed.

MR. WILLIAMS: Williams speaking. Operation two, sir, is depicted by the red line, correct?

MR. BULLEN: Brent Bullen. Correct.

MR. WILLIAMS: And again, operation two was the sonar survey taken immediately following the conclusion of extraction or -- or in a short time after the conclusion of extraction with the total sand extracted prior to operation two being 4,200 tonnes, agreed sir?

MR. BULLEN: Brent Bullen. Agreed.

MR. WILLIAMS: And just to orientate ourselves, sir, to this chart, the scale on the left side of it depicts depth underground, correct? On the Y axis.

MR. BULLEN: Brent Bullen. Correct.

MR. WILLIAMS: And of course it's labelled, Williams speaking, in increments of 10 feet, agreed?

MR. BULLEN: Brent Bullen. Correct.

MR. WILLIAMS: And the dotted lines mark increments of five feet, and each little dot marks increments of one foot, correct?

MR. BULLEN: Brent Bullen. That's what I see on the grid. Yes.

MR. WILLIAMS: And sir, Williams speaking, we see the same scale and labelling on the X axis along the bottom, correct?

MR. BULLEN: Brent Bullen. Correct.

MR. WILLIAMS: Williams speaking. And sir, directing your attention to the zero foot mark -- mark on the X axis, that signifies that that was the location of the bore hole, agreed?

MR. BULLEN: Brent Bullen. Agreed.

MR. WILLIAMS: Williams speaking. And sir, if you take -- if we go straight up from there at a depth of 180 feet, you'll see two blue triangles, which signify the location of the end of the extraction casing, agreed?

MR. BULLEN: Brent Bullen. Agreed.

MR. WILLIAMS: Williams speaking. And what this graph is intended to do, sir, is present the mean or average radius of the cavity created by the sand extraction in operations one and operations two relating to BRU928, correct?

MR. BULLEN: Brent Bullen. Correct.

MR. WILLIAMS: Any by presenting this

average radius, Williams speaking, in combination with the depth presented on the Y axis, we get a sense of the size and depth of the cavity created by the sand extraction, agreed?

MR. BULLEN: It gives us a indication of the size of the -- the cavity that we can actually sonar at that time.

MR. WILLIAMS: Thank you for that. And sir, directing your attention along the line at 100 -- a depth of 184 feet, we see based upon this table that the cavity both for operation one and operation two appears to have a bottom at a depth of 184 feet, agreed?

MR. BULLEN: The 184 feet is indicated bottom of the sonar capacity.

MR. WILLIAMS: And sir, if we move vertically up from that, the ceiling for both operations one and two would be at a -- would be at a depth of roughly 165 to 166 feet, agreed?

MR. BULLEN: Brent Bullen. Agreed.

MR. WILLIAMS: And without wanting to get too precise in the math, Williams speaking, the average radius of operation one would be about 28 feet, agreed? At its widest point, sir.

MR. BULLEN: And I know. I know. I'm looking at it. It's just you have a curvature, so you've got -- you know, you've got a -- a width of 25 to 27 feet. So, I mean ---

MR. WILLIAMS: Thank you. And that's a better answer than the question. Operation two, the width would be a little wider, right? Agreed?

MR. BULLEN: Brent Bullen. Agreed.

MR. WILLIAMS: Now that we've orientated ourselves, we're going to scroll to PDF page ten please. Williams speaking. Mr. Bullen, directing your attention again to the legend in the bottom right corner, you'll agree that this page shows us the same information, but it is for operation two and operation three, correct?

MR. BULLEN: I apologize, Mr. Williams. I was just conferring. Can you please ask that question again?

MR. WILLIAMS: Yes. And no need to apologize, sir. Directing your attention to the legend in the bottom right hand corner, you'll agree, Williams speaking, that it is performing the same type of analysis, but now we're looking at operation two and -- and operation three.

MR. BULLEN: Brent Bullen. Correct.

MR. WILLIAMS: And again, operation three would be about a month later than operation two, correct?

MR. BULLEN: Brent Bullen. Correct.

MR. WILLIAMS: And sir, again, the blue line being operation two is the same information as we saw for operation two on PDF page three, correct?

MR. BULLEN: Brent Bullen. Correct.

MR. WILLIAMS: And the red you'll

agree, Williams speaking, represents operation three, correct?

MR. BULLEN: Brent Bullen. Correct.

MR. WILLIAMS: And sir, what we're seeing on -- on this page being PDF 10 is that the -- over the course of the month between operation two and operation three, the cavity has changed shape, agreed?

MR. BULLEN: Brent Bullen. Correct.

MR. WILLIAMS: Williams speaking. So, if you look at operation two, the floor was one 184 feet roughly, and the ceiling at 165 to 166 feet, correct? Same as it was on the last page.

MR. BULLEN: Brent Bullen. Correct.

MR. WILLIAMS: By contrast, operation three in the red, we see that the -- the -- the floor is at about 183 feet, but we see the top of the cavity opening up such that the opening extends up to a depth of 161 feet approximately, agreed sir?

MR. BULLEN: Brent Bullen. Agreed.

MR. WILLIAMS: Williams speaking. Just above the middle of the page on the right hand side, Mr. Bullen, you'll see in green, language referring to the shale formation. Do you see that, sir?

MR. BULLEN: Brent Bullen. I do.

MR. WILLIAMS: And what that tells us is that there was a -- a shale formation as represented by the green line at 166 feet, correct?

MR. BULLEN: Brent Bullen. I think you meant to say 166? It sounded like 156.

MR. WILLIAMS: Oh. Then thank you for correcting me. Let me ask that again. The shale green line is at 166 feet. Williams speaking.

MR. BULLEN: Brent Bullen. Correct.

MR. WILLIAMS: And when we look at the red line being operation three above the green line, that tells us that the cavity has opened up into the shale formation, correct?

MR. BULLEN: Brent Bullen. Correct.

MR. WILLIAMS: And moving to the top of operation three, it looks like there's approximately five feet of height in the cavity that is a result of shale rather than sandstone fallen into the cavity, agreed?

MR. BULLEN: I see a small portion of it at five feet. Sorry, Brent Bullen speaking.

MR. WILLIAMS: Williams speaking. If we can now turn to page 17 please. Mr. Bullen, again, and for the last time I promise you, directing your attention to the legend in the bottom right corner, you'll agree, Williams speaking, that we see operation three in blue being one month after the extraction, and operation four in red being four months after the extraction, correct?

MR. BULLEN: Brent Bullen. Correct.

MR. WILLIAMS: And focusing on operation four, sir, in the red, you'll see the bottom of the cavity appears to be at approximately 162 feet, agreed?

MR. BULLEN: Sorry, you said of operation four?

MR. WILLIAMS: I suggested, Williams speaking, that operation four, the bottom of the cavity as depicted in red appears to be at about 162 feet?

MR. BULLEN: Brent Bullen. Correct.

MR. WILLIAMS: And again, referring your attention to operation four in red, it is opened up as high as a depth of 149 feet, agreed?

MR. BULLEN: Brent Bullen. Agreed.

MR. WILLIAMS: And sir, at a high level, Williams speaking, you see the cavity migrating upward as the material above it falls and fills up the bottom when we compare operation four versus operation three, correct?

MR. BULLEN: I can see the cavity opening -

- Brent Bullen. I can see the cavity opening up above. I can't comment on the migration of material though.

MR. WILLIAMS: Sir, directing your attention again to the right of PDF page 17, you'll see, sir, that there are two lines now for shale formation, Williams speaking, and suggesting to you one at a depth of 166 feet, and one at a depth of 156 feet, agreed?

MR. BULLEN: Brent Bullen. Agreed.

MR. WILLIAMS: And sir, what the two green lines tell us, Williams speaking, and suggesting to you is that the shale formation in this location at the time of drilling was about ten feet thick, correct?

MR. BULLEN: Brent Bullen. Correct.

MR. WILLIAMS: And sir, with the upper portion of the shale formation being at 156 and the red line depicted -- depicting operation four being at 149 feet, it is clear that the cavity has now migrated from the shale into the carbonate limestone layer, agreed? Williams speaking.

MR. BULLEN: Brent Bullen. What I see is a new cavity with a base floor at 161 feet -- 162 feet. Brent Bullen. If I'm looking at operation four.

MR. WILLIAMS: And Mr. Bullen, what I'm suggesting to you is when we look to the ceiling, Williams speaking, of operation four, it is now moved through the sale formation and into the limestone carbonate, agreed sir?

MR. BULLEN: Brent Bullen. Agreed.

MR. WILLIAMS: Williams speaking. Approximately the highest eight feet of the cavity are now surrounded by limestone, rather than sandstone or shale, agreed?

MR. BULLEN: Define the highest peak. I mean, obviously there's a portion of it above. Yes. Sorry, Brent Bullen.

MR. WILLIAMS: And Mr. Bullen, it's probably just because it's late in the morning, but I think you said yes, and I just couldn't hear you.

MR. BULLEN: Sorry, Brent Bullen. I thought I answered the question. Maybe ask me the question again.

MR. WILLIAMS: The top eight feet of the cavity, sir, are now surrounded by limestone, rather than sandstone or shale, agreed?

MR. BULLEN: Brent Bullen. I see seven feet above the shale. So ---

MR. WILLIAMS: So, you're -- you're just correcting me, Williams speaking, you're saying seven feet instead of eight feet then.

MR. BULLEN: Brent Bullen. I just want to make sure we're both looking at the exact portion of the diagram you're trying to refer to on my questioning.

MR. WILLIAMS: Williams speaking. Have subsequent sonar scans been undertaken at BRU92.8?

MR. BULLEN: Brent Bullen. No.

MR. WILLIAMS: Williams speaking.

What is the thickness of the carbonate limestone at this location?

MR. ESHRAGHIAN: Arash Eshraghian. The thickness of limestone at this location is 14.9 metre.

MR. WILLIAMS: Thank you. And in terms of the -- what is the remaining thickness of competent limestone at this location?

MR. ESHRAGHIAN: Arash Eshraghian. The -- the comparison between the shale location and the top of the cavity shows approximate seven foot, or almost less than around two metres of limestone has been collapsed. So, we have additional 12 metre of limestone also above.

MR. WILLIAMS: And doctor, I think I heard you say there was 12 -- 12, and if I misheard you, I apologize.

MR. ESHRAGHIAN: Arash Eshraghian. Total limestone thickness is 14.9 metre. Two metres has been collapsed so far, so more than 12 metre is -- is remaining.

MR. WILLIAMS: Mr. Chair, and to the panel, and to the Silica panel as well, I just have a few short snappers left to finish -- finish us off, and Mr. Bullen, I thank you for your kindness, Williams speaking, in going through that material with me. It's much appreciated. And Mr. Chair, if you'll give me just a second to gather my notes, I'm referring to ---

THE CHAIRMAN: Chair. Can I ask what your anticipated duration remaining is? We -- we may be well to break.

MR. WILLIAMS: I'm going to guess, Williams speaking, about ten to 15 minutes.

THE CHAIRMAN: Chair. We are adjourning for lunch. We'll regroup in 45 minutes.

THE CHAIRMAN: Chair. Welcome back, everyone. I think we'll get started. So by way of a little preamble, Byron has indicated he has a question or two left. Those will be short snappers, and then there is a desire to go in camera. And so the process for that would be that anyone that has not signed an NDA regarding the Stantec 2022 report -- and I will leave it to Sio Silica to be the arbiter of who -- who does and who doesn't get to remain in the room, or at least we'll have a discussion, then we'll -- we'll proceed from there. So there'll be a short break after Byron, you're done, and then we will pick it up.

MR. WILLIAMS: Yes. Williams speaking, and good afternoon to the panel. And my apologies, we probably could've finished up at 12:32, so for any inconvenience, I'm sorry for that. I would like to direct the -- the -- the panel to your Geotech assessment summary PowerPoint from yesterday, which would be Exhibit H-001. And specifically to page -- Slide 7. And on Slide 7 -- Williams speaking, I would direct your attention to Table 3 and the LaMaque Mine -- L-A-M-A-Q-U-E, Mine -- and suggest to the witnesses that the LaMaque Mine is an Archean, A-R-C-H-E-A-N, Greenstone hosted orogenic, O-R-O-G-E-N-I-C, load gold deposit mine. Would you agree with that?

MR. BUNDROCK: I'm sorry, I can't confirm that, but ---

MR. WILLIAMS: Williams speaking. I'm suggesting to you that that is a gold mine and -- and doesn't involve extraction and boring -- piercing of limestone. You're not in a position to agree or disagree?

MR. BUNDROCK: Steve Bundrock, I'm not in a position to agree or disagree because I'm not familiar with that specific mine. It is a mine that Stantec has worked on. Myself and Arash in particular have not worked on there -- that particular site.

MR. WILLIAMS: With thank you to the panel and -- and to the Clean Environment Commission, those are our questions. Thank you very much.

THE CHAIRMAN: Chair, thank you very much. So, we will now go in camera. So, let's sort of take five minutes to execute that. If you have not signed an NDA, a Non-disclosure Agreement with Sio Silica, I will ask that you please leave the room. We will reconvene after about 45 minutes of questioning is my anticipation.

(OFF THE RECORD: 1:25 P.M.)
(ON THE RECORD FOR IN-CAMERA PROCEEDINGS: 1:38 P.M.)

(OFF THE RECORD: 2:13 P.M.)
(ON THE RECORD: 2:20 P.M.)

THE CHAIRMAN: Following discussions this morning, the CEC has further questions that we would like to ask of the Geotechnical Panel before they're dismissed and we sign in the Hydrogeology and Geochemistry folks. So on behalf of the CEC, Hartmut, over to you.

MR. HOLLANDER: Hartmut Hollander. First of all, I'd like to thank you for the work which you have done yesterday to -- to add some data, and I wanna come back to your -- what the sampling of the sandstone. You measured -- mentioned this morning that it is not possible with freezing that you get a disturbed samples because of the expansion of the water. And I would like to mention that this was done a couple of times and they've shown that inside the inner side of the core, this is not happening. So if I reference here to the work of (inaudible) Professor of -- in hydrology at the Technical University of Jena, he did this even in unconsolidated soul -- sense at the -- in the Danube River at fully saturated conditions, and you will find a lot of papers in this directions where they analysed in the end the -- the sediments talking about fines, we talk about gravel, we talk about sand. So, that is something which is possible. My question here is, you did start what engineers do, we use good models, we use physical based models and when we don't have this data, we calculate them, and that is what you also fairly discussed yesterday is that you estimated this parameter. Still there was a lot of discussion whether that what -- what -- what you estimated is that what also would be there in situ. So, there are potentially ways. Also, we talked today about triple lining. Whether Sio would be interested or would be agreeing to that, that this data -- yeah, evaluated and added to your calculations.

MR. BUNDROCK: Steve Bundrock. Hartmut, can you clarify the data and the particular data you're looking for -- you're asking?

MR. HOLLANDER: Yeah. So, in the end, one of the things which we always discussing in this geotechnical part is, how -- how large could be this -- this void come after some time of settling? So, you have done your sonar measurements after one month, four months, and certainly also shorter after -- after this interaction. But what happens after one year, two years? And so we rely there on your models which is fair, that's what -- what -- what we do in the end to predict something, but certainly for this prediction we want as good data as possible so that we can support our modeling results. And when we discuss here about total duration of 24 years for this mine, I think it would be worth to -- to get a good understanding whether that what you back calculated there is also that what we will find in the -- in the field.

MR. MCLACHLIN: Doug McLachlin. So yes, we mentioned that there will be a -- a -- a TARP, Trigger Action Response Plan. As part of that, there will be ongoing assessment of the -- the size, the slopes in the -- in the cavity and -- and that sort of thing. That information will be provided to the regulator, yes.

MR. HOLLANDER: So that means you will continue the site sonar in this void which you have -- which you have used after longer time period?

MR. BULLEN: It's Brent Bullen. On the existing wells, we don't know if we can go back in and sonar them at this time. The reason we didn't do further sonaring when we originally were working on the modelling, is we are at a point where we were not allowed to continue future and current work in the field 'cause we were getting ready for the CEC and the Mines Branch had actually asked us to cease operations until we -- 'til further time. So, you know, we missed -- we've missed that opportunity on this well, on 92-8, but you know, as was mentioned on the chart plan going forward, obviously it's part of future work.

MR. HOLLANDER: Thank you. Hartmut Holland again. I would like to come to a second topic. We saw today of the -- the collapse of the caprock, in this case the shale and also partially the -- the limestone. I would like to ask whether that, what we saw in the limestone, was the area of a fractured limestone or whether it was a camp competent limestone?

MR. ESHRAGHIAN: Arash Eshraghian. We expect a portion of limestone in contact with shale will be -- is -- is to some degree fractured. So, most of these failed material that you see here is potentially the fractured limestone.

MR. HOLLANDER: Hartmut Hollander. Thank you. You were so kind yesterday to support us with some well construction reports. And I look here at the one which is from Brew 961, and this is just an example I expect. But if you look at the material description, it is written, Till, till, gravel with boulders, till, gravelly till, gravel, limestone, shale, sandstone, shale. So, there is no information about the fractured zone, how large they are. My question is -- and this was done by Friesen Drillers -- is this information available for every well and is it also available to the public, where the fractured zones are?

MR. BULLEN: It's Brent Bullen with Sio Silica. Just -- I'll get back one sec here. These -- these are actual well construction reports that are filed with the well regulators, and they are available. You know, we made it available 'cause it was clear that Mr. LeNeveu through his access to information, for some reason didn't have them, but they are a filed report that's -- that's made available to the public.

MR. HOLLANDER: Hartmut Hollander. Thank you very much. I have one more question on that, so on -- so on this one is giving the drilling team, and the first one who is the leading person is Manson Friesen (ph 00:07:36) in this case. Manson Friesen is not a professional engineer, and also not a professional engineer -- geoscientist, I mean, sorry. Who was supervising this well?

UNKNOWN SPEAKER: Sorry, can you rephrase the question? 'Cause I -- I ---

MR. HOLLANDER: Yeah, so yesterday I asked a question whether the boreholes -- the 48 boreholes which you did were supervised by a professional engineer or professional geoscientist, and they are generally also signing off on the borehole report. The one which is stated in this report here is Manson Friesen and Brenton of Lasnik (ph 00:08:13). And generally, the first person should be the one who is the key person, and I know that Manson Friesen is not a professional engineer, not a professional geoscientist.

MS. WEEDEN: This is Laura Weeden. So, I just wanna clarify -- the well construction reports are filed by the water well drillers who drill the wells separate from that, and all of the wells that are drilled, you don't -- they didn't need to be a professional engineer, professional geologist to drill the well and file the well construction report. This is a normal operation for water well drilling in Manitoba. We did have a professional geologist on site from Sio at the time of these wells being drilled.

MR. HOLLANDER: Okay. So, Sio was supervising every of these wells? Oh, sorry -- Hartmut Hollander. Was Sio supervising every of these wells when they're drilled?

MS. WEEDEN: Laura Weeden. Are you asking if Sio supervised all wells or just this one?

MR. HOLLANDER: All the ones which you use for your analysis.

MS. WEEDEN: Laura Weeden. Either a professional engineer, a professional geologist from Sio, or -- and/or a professional engineer, professional geologist from Stantec or AECOM was present during all of the wells that were drilled.

MR. HOLLANDER: Hartmut Hollander, thank you very much. My last block of questions is related to -- also the failure of the shale. You were presented with the mitigation plan and the aversion to abandon wells. So under the Drilling Regulation of The Mines and the Mineral Acts, you have -- there are regulations how to drill and to seal a well. And the sealing of the well is described as the -- or related to that closing this -- this annulus in that area where the shale is. When the shale collapses, os there another way how geotechnically you can stabilise this borehole and close this afterwards -- after the -- yeah, after you finished mining?

MR. BULLEN: It's Brent Bullen from Sio. We'd like to defer that question to the water side because it's part of the water.

MR. HOLLANDER: That's fair, thank you very much.

THE CHAIRMAN: Chair. Thank you very much. I believe we are done with the geotechnical team. So, let's proceed to swear in the next team.

(OFF THE RECORD: 2:32 P.M.)

(ON THE RECORD: 2:35 P.M.)

THE CHAIRMAN: Chair. Are we ready to proceed? Very good. So, I forgot to thank Steve, Arash, and Doug for their time spent with us. So, thank you. So, Peter, over to you.

MR. CROCKER: Secretary. So, we'll just go down the -- the line of the new -- of the new panel. So, you can please state your name starting at my right, please.

MR. HARVEY: Dougall James Miln Harvey.

MR. MILLS: Ryan David Mills.

MR. ELEMINE: Cheibany Ould Elemine.

MR. MEUZELAAR: Tom Meuzelaar.

MR. CROCKER: Secretary. So, you've all chosen to affirm. Do you, Ryan, Miln, Cheibany and Tom, solemnly affirm that the evidence to be given by you shall be the truth, the whole truth, and nothing but the truth?

MR. HARVEY: I do.

MR. MILLS: I do.

MR. ELEMINE: I do.

MR. MEUZELAAR: I do.

MR. CROCKER: Secretary, thank you.

THE CHAIRMAN: Chair, thank you very much. So can I get an estimate of how long this presentation is?

MR. MILLS: Ryan Mills. It's approximately an hour and 15 minutes or so.

THE CHAIRMAN: Chair. All right, so we're 30 some minutes from sort of our mid break. So let's go halfway through it and we'll take a brief break and finish it up and we may even get into some questions.

MR. MILLS: Thank you, Ryan Mills. So thank you everybody, panel, and -- and our participants here for -- for joining us today. I'm a hydrogeologist with AECOM and -- and I've been with the company approximately 20 years. I'm happy to -- to hear this many people interested in groundwater, I'm not quite used to that. So, I'll be here leading -- leading off the presentation and then I will pass it to -- to Miln and then Cheibany for the various sections of our -- of our hydrogeology and geochemistry assessment.

THE CHAIRMAN: Chair. Can I get you to lean in or speak up a little bit please? Let's not be timid.

MR. MILLS: Ryan mills. With that, I'll introduce the technical panel. And that consists of myself, Ryan Mills, I'm a -- a professional geoscientist with a background in Earth -- Earth sciences and -- and mining and water supply. I'm registered here in Manitoba as well as Alberta and British Columbia. On my left, your right is -- is Dr. Miln Harvey, he has a doctorate in -- in civil engineering and hydrogeology, focused on groundwater modeling. He's a registered professional engineer here in Manitoba as well as Ontario, Nova Scotia. On my right, Dr. Elemine also has a PhD, this time in geochemistry, and he is registered as a professional geoscientist in -- in several provinces. And Dr. Tom Meuzelaar has a doctorate in -- from the Colorado School of Mines focusing on geochemistry. He is an independent reviewer that was engaged specifically to critique our work and evaluate whether or not we had met industry standard and whether or not there were any improvements that could be leveraged into future phases of the work. In addition to those present here today, there were others that were engaged previously along the -- the process of the evolution of this work. Namely, Dr. Grant Ferguson, who has a PhD from the University of Manitoba, completed his PhD work around the vicinity of Winnipeg on this aquifer system. He is now a professor at the University of Saskatchewan with a background in hydrogeology and geochemistry. And so, we engaged him for his specific knowledge in this area and this system that we are here to speak of today. And -- and we received his comments and disposed of those comments throughout the -- so, he reviewed our draft report and we addressed those comments to his satisfaction in the completion of the finalization of our work. A number of other people named here, many of them registered in -- in British Columbia or other provinces, all with backgrounds and advanced degrees in geosciences and engineering, contributed not only to the field work and the data collection of the raw data, but also the analysis, interpretation, numerical modeling and reporting of that work, including several levels of internal and external review throughout the -- the process of work. And so that is a matter of due course in the preparation of any technical deliverables that we undertake, and we're -- we're happy to say we added additional levels of rigour on the project by engaging external reviewers. We also conducted this work with a view of the local acts and regulations that pertain to -- to -- to the practice of geoscience and engineering and -- and water resources in general in Manitoba and mining. Namely we have the Mines and Minerals Act, we have the Environment Act, and we have the Groundwater and Well Act, and the Water Rights Act. And so, there are -- there are others that were also considered, this is a -- a summary list of those most relevant to our work. They are supported by several regulations including the Drilling Regulation, the Groundwater and Well General Matters Regulation and -- and the Well Standards Regulation that I'm -- I'm sure we'll discuss more. We followed -- during the -- the collection of the data, we followed industry standard methods listed there. And -- and also in the interpretation and numerical modelling and geochemical modeling aspects of our work, we considered both provincially and internationally recognized guidelines that were followed in the -- the completion of the work. You know, these are guidelines that are developed for application in industry and -- and those were followed by experienced professionals, and -- and -- and many of them are listed here. So with that, I'll move into a -- a brief description of the field investigation that was undertaken. It is, you know, covered at length in the -- the -- the hydrogeology and geochemistry assessment. And the goal of the -- the field investigation was to, you know, characterize the subsurface, estimate aquifer properties, and do that by replicating a field scale, you know, pumping quantity on the aquifer. And we also wanted to see if -- if water quality may or may not be impacted by -- by these activities. And so, you know, we -- we undertook a drilling investigation to install instruments in the carbonate aquifer, the -- the shale and the sandstone aquifer. We completed a well survey, we logged those boreholes, we surveyed them, we collected soil and rock samples for laboratory testing and field characterization, we installed a pumping well and several observation wells that incorporated existing private domestic use wells in the area. So, some homeowners allowed us access to their wells, and those were instrumented to monitor both groundwater levels and groundwater quality. And then we conducted some slug tests, and slug tests -- sorry, aquifer testing -- that consisted of initially slug tests where we estimated local scale hydraulic properties or hydrogeological properties of the aquifer in proximity to those individual monitoring wells to understand maybe the spatial distribution of hydraulic properties throughout the aquifer, based on the wells that we've -- we'd -- we'd installed recently. Then we conducted a step test to help understand the -- the rate at which we might be able to pump the -- the newly installed pumping well, and -- and then conducted or undertook a 72 hour or 68 hour constant rate pumping test to simulate, you know, the impacts of -- of -- of -- of groundwater extraction over a period of several days. And this is -- this is sort of analogous to sort of a -- a -- a -- a medium scale, you know, groundwater well. Based on the results of -- of that field data that was collected over the period of approximately a one month field investigation, that information in addition to data obtained from a very extensive literature review, you know, including review of perhaps 30 papers or more and academic references and -- and papers that had been produced and doctorate thesis -- theses and otherwise. We synthesized a conceptual hydrogeological model for the project area. And really the conceptual hydrogeological model, we've heard the term model quite a bit over the past few days and there will be more models discussed. The conceptual hydrogeological model describes a conceptual understanding of the groundwater flow system and it is based on incorporation of several different sources of data. That includes regional geologic mapping of quaternary sediments and -- and bedrock. It includes information obtained from both federal and provincial borehole and well databases. It includes measured groundwater elevations from that borehole -- those same borehole databases and our field investigation. It describes a conceptual understanding of hydro stratigraphy and groundwater flow directions that integrates both these regional studies that have been conducted by others and our work. And then it -- it conceptually describes the interaction between groundwater and surface water systems -- so, streams and rivers and lakes -- and then characterizes measured groundwater quality from the Provincial Observation Well Network and wells that were sampled as part of our investigation. This is what the end product of that looks like in -- in three dimensions. So, you are looking at a conceptual representation of a three dimensional geologic model and the -- the different colours represent the different geological units. Working from the bottom up, you see the pink which is the Precambrian Canadian Shield rock. Above that we have the Winnipeg Sandstone in yellow. Above that we have the Winnipeg Shale that we -- we've heard discussion of in black. Above that in green is the Red River Carbonate formation, and of course the quaternary sediments above that. When we think about groundwater flow, we -- we have included a figure prepared and presented many times over in the academic literature that shows the -- the -- the sedimentary sequence in the overall basin and we're focusing in on the red box. So, we -- the red box is -- is conceptualized or it -- it -- it -- it considers the area to the east of -- of -- of the Red River, and -- and out to the Sandilands area to -- to the east of here. So, there are two regional groundwater flow systems in southern Manitoba, one that flows to the east and northeast from recharge areas in the northern US, and that is primarily on the west side of the Red River. And then there's a -- a second intermediate system in southeastern Manitoba where we're all sitting today, and that groundwater recharges in the Sandilands area and flows to the -- the west and northwest toward the Red River and the Red River Floodway, primarily with some discharge to Lake Winnipeg. These two flow systems are thought to converge near the Red River or beneath the Red River, and they -- that also marks a -- a -- a -- a separation between on the basis of water quality, with fresher water to the east of the Red River, and more saline water to the west. The mapped groundwater elevations also support -- support that conceptualization. And with that, I'll pass -- pass the presentation to -- to Dr. Harvey, to my left, to discuss the -- how that conceptual model was translated into a numerical model.

MR. HARVEY: So, what Mr. Mills describes is all of the data and historical information we have to conceptualize the groundwater flow system. A conceptual model can tell us everything about what's happened in the past, but it cannot predict into the future. In order to do that, we need to do a numerical model, and a numerical model is simply a mathematical representation of our conceptual model that allows us to make predictions. So, the numerical model that we developed was a regional scale groundwater flow model developed using commonly used industry software called FEFLOW. FEFLOW is just an acronym that means Finite Element Flow, and it's used by many consultants to do similar groundwater modeling studies. The model domain is considered regional because it's approximately 3200 square kilometres. And if you -- you take a look at the image on the right, you can see the black line represents the outer boundary of our model domain. From southeast to northwest, it's approximately 80 kilometres, and from northwest to south -- sorry, northeast to southwest, it's approximately 40 kilometres. The modelling process translates the conceptual model into a numerical -- numerical framework that allows us to calculate groundwater levels, draw down, and groundwater flow paths, and to simulate future responses to either natural or anthropogenic changes to boundary conditions. In developing the model, we represent the hydrologic boundaries as natural boundary conditions. For example, groundwater recharge is where water enters the groundwater flow system and groundwater at rivers and extraction wells, we have groundwater water exiting the groundwater flow system. FEFLOW is commonly used to do this type of hydrogeological analysis. It's commonly used for developing numerical models to do this kind of hydrogeological analysis. And I'd like to -- I'd like you to think about a weather forecasting model. This is somewhat similar to a weather forecasting model, only a lot more reliable. We have very good -- we have all the data we need, and very good data to help us develop the conceptual model, which then is translated into a mathematical representation that makes us to make -- that allows us to make predictions into the future, somewhat similar to a -- a weather forecasting tool. So, that -- the groundwater model domain. The model domain was defined using natural hydrologic boundaries. As Mr. Mills mentioned, to the -- the southeast, we have the Sandilands recharge area. That's where a good portion of the water enters the intermediate flow system -- groundwater flow system in the -- the southeast of Manitoba. To the northwest -- or northeast and southwest, we've got the Hazel Creek and the Seine River, two natural water bodies where discharge occurs. And ultimately to the northwest, we have the Red River and the Red River Floodway, which are considered groundwater flow divides in previous modelling studies, and we've used these as the -- the -- the place where groundwater and the intermediate flow system naturally discharges. So, these boundary conditions are where water naturally enters and exits the -- the groundwater flow system that we're trying to model. And these boundary conditions are far enough away from our area of interest -- so our area of interest for the project is the red polygon in the middle. Note that it's at least ten kilometres away from any boundaries, and that's important from a modeling perspective because we do not want our boundary conditions to be impacting any of our predictions. So, that's the reasoning for the -- the regional scale size of this model domain. As Ryan mentioned, the conceptual model has four hydro stratigraphic units that are of interest. We've got the quaternary sediments, and in the model, we represent that with three layers -- Layers 1, 2, and 3. So, that -- quaternary sediments are the -- the -- the sand, silt and gravel, the unconsolidated material that sits above bedrock. Layers 4,5 and 6 are the sedimentary bedrock layers, and that's the Red River Carbonate, which is Layer 4, the Winnipeg Shale which is Layer 5, and the Winnipeg Sandstone which is Layer 6. There is Layer 7 in the model, which is the Precambrian bedrock, but because its connectivity is very, very low, it contributed very little water to the -- to the intermediate groundwater flow system, and so we consider it to be a basal aquitard. In other words, a place where groundwater is -- is essentially -- it's essentially a no flow. In order to confirm that the -- this mathematical representation of the hydrogeological environment does a good job of simulating observed conditions, we do what's called model calibration. And model calibration is simply a way of adjusting the parameters and boundaries in the model so that we can match historically observed groundwater conditions, like water elevations in monitoring wells -- we can match those to the value simulated by the tool. If -- if our modelling tool can predict what we observe in -- in the conceptual model, then we deem it to be an acceptable tool to make predictions into the future. We -- we decide or we -- we judge how well we have calibrated by using some -- some industry standard calibration statistics. The first one we look at is the mean error in -- of all of the observations of -- of groundwater head, and there were approximately 2500 observation wells from which we have groundwater elevations. On the right hand side there is a map which shows a lot of little dots. Every single one of those dots represents some kind of water well or observation well in which we have an observation of groundwater head. So, we have to match 2500 groundwater heads in the inset map -- or sorry, in the inset Excel spreadsheet -- or Excel graph. In this image, you can see a little graph showing some dots -- some dots on a graph. That -- that graph, the horizontal axis is observed groundwater head from our conceptual model, and the vertical axis is simulated groundwater head from our model -- from our -- from our numerical model. If they match, then a -- a -- a point on that graph will exactly fit on the one to one line. So, we're trying to adjust model parameters and boundaries in order to get all of our observation points to -- to match the one to one line. And -- and if you go into the report, the Hydrogeological and -- and Geochemistry Assessment Report, you will see a larger version of this map that -- or of this graph that shows a very good -- fit -- fit -- visually, we get a very good fit between simulated and observed. The statistics that -- that help us to describe that are mean error, which is approximately three metres. So, for a regional model that's very good, it should be approximately zero metres. We want our mean error to be about zero. To describe the spread of the data points away from that one to one line, we have the normalized root mean square error, which common industry standard is

-- is less than ten percent, for a good model, it should be less than five percent. We achieved 1.7 percent. So that means it's a very, very good clustering of all of these data points along the one-to-one line. We also wanna know if up and down that line -- we have data points that are clustered very close to the one-to-one line -- and we use the correlation coefficient to -- to help us to define that. A good correlation coefficient in any analysis should be greater than 0.9. It should be in -- in -- in a very good analysis it should be greater than 0.95, and we achieved 0.99. And then finally, a numerical model, which is a mathematical representation of -- of the groundwater flow system, has water that enters and exits the system. So, in any mathematical model, what enters should equal what exits, and that's called a mass balance. So, the -- the industry standard for a mass balance is less than 0.1 percent, and we achieved a mass balance of less than -- well, of 0.003 percent. By these statistics, we have what's considered to be a very well calibrated numerical modeling tool. The one other thing that we want to do when we're comparing our numerical model back to our conceptual model, is to compare the calibrated parameter values in this -- in the numerical model, to the range of possible input parameters that were estimated from all of the field testing and historical information. So, I've created a -- a nomograph, which is a little Excel graph showing four columns. And each of those columns represents a hydro stratigraphic unit which we're representing the numerical model. So, on the -- the -- the first column is the quaternary sediments, the second column is the Red River Carbonate, the third column is the Winnipeg Shale, and the fourth column on the right is the Winnipeg Sandstone. The -- the black line with the two dots on the end is the -- the range of -- of values that that have been provided in previous studies for the parameter value for hydraulic connectivity. And the red dots -- the red dots with little -- little yellow centres, are the values of calibrated parameters in our -- in our numerical model. And you can see that for each of the units, the -- the value that we calibrated to give us our best possible modeling tool is all within the expected range of -- of -- of values from the conceptual model. So, this means that model predictions are simulated within expected bounds of the conceptual model, and the model is therefore a useful tool for simulating future conditions and evaluating impacts on groundwater quantity. A number of times throughout the previous discussions we've talked about sensitivity. Sensitivity is important in the groundwater modelling process. It's the next step that we complete when we're developing our -- our numerical model.

So, we did a sensitivity analysis in which we adjusted each of the input parameters. So, recharge zones, the values of the recharge, the hydraulic connectivity of the most important units, the carbonate, the shale, and the sandstone. And by adjusting them by small amounts, we determined how that impacted the simulations. That does two -- two things for us. One, it identifies the very important data that we have to check to make sure we have the model that's best characterized so that we can be making valid simulations of -- of our output. And also, if we have an understanding of how small changes in these parameters impact output, we can make more conservative decisions on operational design. Would you like to take a -- a break now?

UNKNOWN SPEAKER: It is 3:00, but I'd like to get a natural break. Are you (inaudible)?

MR. HARVEY: I'll keep going. It'll be -- it'll be about ten or 15.

UNKNOWN SPEAKER: Ten, or?

MR. HARVEY: Ten or 15. Okay, so the next -- so we -- we've got a -- a calibrated tool. So, we have

-- we have a -- we have a conceptual model where we have enough data to give us a good understanding of the hydrological environment. We've taken that and we created a mathematical tool called a numerical model and now that model is calibrated -- well calibrated, and we did a sensitivity analysis to understand how small changes in -- in -- in input parameters affect our output. So, now we wanna make some predictions. The best way to approach making predictions is to do a series of scenarios which capture both conservative and non-conservative model results. So, we -- we chose five scenarios. The first three scenarios assume steady state conditions, and by steady state what we assume is that all boundary conditions can be represented by a single value which -- which equals the long term average value. So for example, recharge is long term average recharge, and river levels are long term river levels and pumping is long term pumping well rates. The -- in Scenario 1 and Scenario 2, we also considered the degradation of the Winnipeg Shale. And by degradation, I mean that shale has the -- the properties of shale have changed to cause intermixing between the Red River Carbonate and the Winnipeg Sandstone. And then in Scenario 1, we chose zero percent reinjection. And so to -- to let you know a little bit about that, let's take a look at -- for reinjection --

let's take a look at this green flow chart to understand the water that -- the slurry that's pumped out and the amount of water that we can -- can reinject. So, total production of slurry includes both solids and groundwater. And it -- it from -- from testing it's been shown that it's about 50-50. So, 50 percent of the slurry is solids, so we really only have 50 percent of the slurry available to reinject, so we're at 50 percent right now. And then when you drain a porous media, you can only drain enough water -- you can't drain the -- the -- the -- a certain amount of the water which is retained within the -- the -- the pore structure. So, we have specific retention which is kept and for -- for this sand, it's about 15 percent. So, 15 percent of the 50 percent water that's available is retained in the sand that goes to the -- the -- the facility and only 85 percent's available for reinjection. Of that 85 percent of the 50 percent of water available, we reinjected either zero or 50 percent. Zero, obviously it's a very conservative value because Sio plans to reinject all the water they produce, but to make good conservative decisions, they've chosen -- we've chosen to simulate zero percent reinjection. We've also chosen to -- to simulate 50 percent reinjection to give you an idea of how reinjection in -- reduces the -- the impact of -- of pumping. In order to simulate where the -- the --

where we can -- in order to simulate the distribution of -- of impacts, we've assigned observation wells to the model and when we -- when we turn on the -- the production wells, we can then see the -- the spatial distribution of -- of a drawdown. So, we're doing that -- that assessment of -- of impacts using observation wells that we've assigned in the model. On the -- this image shows -- it shows two things. On the right hand side, we see an aerial image showing some dots, and you've seen these dots before -- they represent the operational plan for the wells. Now this happens to be for the 2021 operational plan. So, we have a full record of -- of all the simulations that -- that take into account this operational plan. And the colours are -- it's colour coded to -- to show the times when wells are active and when they stop being active. So, you will note a couple things. On the -- on the left-hand side there are three graphs, and each of those graphs -- the bottom axis is time. So when you start on the left, you start at time zero, and as you move over to the right, you're moving forward in time. The middle -- the -- the upper graph shows pumping, so each of those -- the -- the red line shows when the wells are on and when the wells are off. This is an important point. The wells are only operating from early spring through summer to late fall. There is a period of time in the winter for when all wells cease operating, and we're gonna see from the results that this has a -- a -- a very concrete and distinct impact on -- on recovery. The groundwater levels will recover when the wells -- when these wells are off. So, the impacts are actually temporal impacts and we'll talk about that in a minute. You can see in the bottom two graphs -- so, in the middle graph we have the impacts to the Red River Carbonate, and in the bottom graph we have impacts or drawdown impacts to the Winnipeg Sandstone. When you have -- this scenario here represents zero percent -- it's -- so it's simulation -- simulation number -- Scenario 1 with steady state -- no, sorry, apologize. It's Simulation 4 where we've got transient pumping and we've got connection between the Red River Carbonate through the -- the -- the shale into the -- the pumped aquifer in the Winnipeg Sandstone. So, we do have impacts occurring in the Red River Carbonate, and we have much larger impacts occurring in the -- the Winnipeg Sandstone. Next slide. This is a plan view -- looking down from above, this is a plan view of the -- these model results. In order to present them, we had to pick some points in time. So, the -- each of these images is -- is one static moment in time when we're looking at a drawdown cone or a zone of influence. As I stated a few slides ago, Scenario 1, which includes steady state pumping and connection between the aquifers through the shale and zero percent reinjection is the most conservative simulation or scenario for the Red River Carbonate, because we're allowing more connection between the aquifers so that drawdown impacts can propagate into the Red River Carbonate. So, you can see that the -- on these -- on these images on the left we have Red River Carbonate draw down, on the right we have Winnipeg Sandstone drawdown. And the upper two are for zero percent reinjection and the lower two are for 50 percent reinjection. So, we can see a few things. First of all, when you have zero percent reinjection, you have larger circles. That means there's a greater impact. When you -- when you reinject some amount of the available water, you reduce these impacts. And because we have connection between the Red River Carbonate through the shale into the -- the sandstone, we do see an equivalent amount of drawdown -- or a measurable amount of drawdown in the Red River Carbonate given that the pumping is occurring in the -- the Winnipeg Shale. And one last point to make -- lower net withdrawal rates will reduce the depth and spatial extent of drawdown. In other words, as you increase reinjection, you reduce the impacts to the -- to the drawdown that's created by operational wells. Just recently, we were provided with an update to the operational plan for the wells and the -- the model is the exact same. It contains the same boundary conditions spatially, and it contains the same property distribution. However, it has been updated to include a revised extraction plan, which includes revised extraction locations, extraction rates, and schedule. So, it's the same model, but we've just changed the location of the wells, the -- the well rates, and the schedule of when they're turning on and turning off. And also -- we also had to refine the -- the mesh. So, a finite element model is designed with a mesh and the more you refine the mesh the better it can predict. So, when we put a new well in, we have to refine the mesh. It does not change the property distributions, it just changes the calculation points where we can calculate heads and calculate drawdown and observe it in observation wells. It also has a number of new groundwater observation points -- groundwater observation wells that allow us to understand a better idea -- give us a better understanding of the spatial distribution of drawdown. And we did three -- we are proposing to do -- we have completed and will complete three scenarios. The first scenario is zero percent reinjection of the 85 percent of the 50 percent of the water that's available. So, basically 85 percent of all the water that we can inject, we will. Sorry, I apologize. Zero percent of the water available and then 50 percent of the water available is Scenario 2, and 100 percent of the -- of the water available we will -- will reinject in Scenario 3. We've completed Scenarios 1 and 2, and we will provide those results. We're currently in the process of simulating Scenario 3 and that will be -- be available a little later. And to compare the 2021 and 2023 operational plans, there's two images. On the right -- on the -- the upper image shows how the wells were -- how the operational plan was designed in 2021, and you can see it's changed significantly in 2023. That has no impact on the structure or capability of the model, it's just on how we assign wells to look at drawdown impacts. And as I just stated before, we're gonna -- we're proposing to simulate three scenario -- Scenario 1 is zero percent reinjection, Scenario 2 is 50 percent reinjection, and Scenario 3 is 100 percent rejection. And this is kind of what things look like on the pumping rate graph. So, again on the bottom is time starting at t = 0 and moving forward as you move to the right. On the -- on the right -- on the vertical axis, we see increasing pumping rate. The 2021 groundwater model used the red line in the middle. So, that was how the -- the pumping wells were operated previously. There's been a slight shift in when the wells start and end, and we've -- and the -- the well rates have increased based on new information. So, the 2023 groundwater -- the -- the rates for the wells in the 2023 groundwater model with zero percent reinjection are slightly higher than they were in -- in 2021. And then if you check the -- the pink line on the bottom, you can see that by reinjecting 50 percent of the water, we've reduced the overall pumping impact on the aquifer. This shows -- summarizes the initial results for the 2023 simulations and this is zero percent reinjection. So, it's the exact same type of graph that I showed you for the 2021 simulations, but this time it's with the new well locations, and those are shown on the -- on the right hand side as the -- the -- the coloured dots. You can see once again we've got -- the top graph is Pumping Rate, and then the middle graph is Impacts to the Carbonate, and the bottom graph is Impacts to the -- the Sandstone. The magnitude and timing of injection is similar to 2021, it's just shifted because the well locations have shifted. But it hasn't changed the impact that the -- the wells are having. And we have new information which is new well locations, new observation well locations, so we can get a better understanding of -- of how it is distributed spatially. So new observation wells gives us more information about how it -- it -- the -- the impacts are spatially distributed. So, 50 percent -- when you look at the difference between zero percent reinjection and 50 percent reinjection at the exact same observation wells, you can note that the drawdown impacts are substantially less. So, to summarize on -- on Page 29, we developed -- we developed a conceptual model which tells us all there is -- all of the information that we need to conceptualise the groundwater flow system. And that was -- we have enough data to do that. There's -- there's lots of historical studies and -- and -- and field scale testing that's been done to properly characterize the groundwater flow system. We took that and we created a numerical model. We used industry standard software, we tweaked the parameters and calibrated those parameters to give us a really, really good fit between observed groundwater elevations, and simulated groundwater elevations. We also did -- we also simulated the pumping test, so we did transient analysis as -- as -- as well. The drawdown response for this new model and recovery -- so, drawdown and recovery are consistent with a highly conductive aquifer. So drawdown occurs, but when you turn the wells off, it very quickly dissipates. We usually get 80 percent recovery within two days of shutting the wells down. So the -- the -- the -- the quantity impacts or the draw -- drawdown impacts are very, very transient. They occur quickly and they go away quickly. The location of drawdown impacts is slightly different in the 2023 simulations because we've changed the location and turning on and turning off of the -- the operational wells. That's the only difference. The magnitude and spatial extent of drawdown impacts are comparable to the 2021 study. So, the conclusions and recommendations that we provided in that -- in the Hydrogeology and Geochemistry Assessment Report are still valid. And with that, we'll take a break. And when we ---

THE CHAIRMAN: Chair. So, I agree that is a natural spot to break. So the -- we'll pick up the geochemical analysis in five to ten.

(OFF THE RECORD: 3:15 P.M.)

(OFF THE RECORD: 3:25 P.M.)

THE CHAIRMAN: Okay. Get back to our seats. Miln, are you continuing or who does the geochemistry assessment? We're going to ---

MR. MILLS: Okay. Ryan Mills.

THE CHAIRMAN: Right. So, over to you then, please.

MR. MILLS: Ryan Mills with AECOM. With that, I'll -- we'll move into the presentation of the geochemistry portion of our hydrogeology and geochemistry assessment and pass it to Dr. Elemine.

MR. ELEMINE: Thank you, Mr. Mills. The geochemical assessment of the project focuses on two aspects. One aspect is the characterization of the waste, the waste rock, and the sand. The other aspect deals with the groundwater quality. I will speak about the assessment of the rocks and the sand, and pass it back to my colleague to speak about the water quality.

In this slide, you -- you see the solid phase, and that means the geochemical properties of the solids. And the solids consist of three things, the waste material that will be extracted, which is not useful, and the sand, which is the ore in this case. And the objective is to assess the risk. When these materials are extracted from -- from the subsurface and brought to the surface, they may react with oxygen and water at the surface and release acid and metal leaching. And that's the major problem at mine sites. The objective here is to assess that risk and develop mitigation and control measures to prevent it from happening.

I will step back a little bit and provide a background. These materials that exist in the subsurface, namely the -- the carbonate and the shale, exists in an environment where there is no oxygen and they are saturated with water. This condition precludes the formation of acid and metal release, simply because oxygen is a required element to drive the reaction, and I'll come that -- come to that later. The second bullet I would like to stress is, any metal that could be present in this material in the subsurface should already be present in groundwater in their current conditions. Before I go further in the -- in the presentation, I realize that this topic might not be familiar to many people. So, I put in this slide just to provide some kind of a background and to help in the discussion that will come.

We often refer to acid rock drainage, and metal leaching as a ARDML. Sometimes, you will hear MLARD. And for that to happen, you need three things. You need the sulfide, you need oxygen, and you need water. And I will use the triangle fire as an analogy. For a fire to happen, you -- you need three things. You need your fuel, which is equivalent with the sulfide here, you need oxygen, you have this oxygen, and you need heat. And the heat -- catalyst, in this case, is water. So, these basic three ingredients are required to generate acid rock drainage. However, the process is a bit more complex than that actually is. There are other parameters that affect this process and the extent to which it is to happen. One of them is the reactivity of the sulfide. You can think of that as your fuel, is it dry? Is it wet in case of the -- the fire triangle? The other very important aspect is the microorganism. This process is very, very slow. The rate is very slow without microorganisms being involved. And if I may use the triangular fire again, I will talk -- if you think of it as the wind will affect that fire. In this case, if you don't have microorganisms, the rate will be very, very slow.

So, the reaction that on the left side shows you the oxidation of pyrite. And pyrite is commonly referred to as fool's gold, and it's the one that's the main driver of acid rock drainage. It reacts with oxygen and water. It releases iron. It releases hydrogen ion and that's your acidity. It also releases sulfate and the metal that are usually present in the sulfide. The iron released can subsequently be oxidized, and it further releases more acidity. But it also precipitates what we call iron oxyhydroxide. This -- they are not really minerals, they are amorphous phases. They play a very key role in metal solubility and mobility because they have the ability to capture and precipitate metals from those solutions. So, they basically actually need this process.

On the right side, you have the process of acid neutralization. Thankfully, in nature, there are minerals that act to keep the pH in the neutral condition, and one of them I'm showing here is the calcite. It reacts with that hydrogen ion, it releases alkalinity, and that's the alkalinity that maintains the pH from becoming acidic. They also release calcium, which may react with the sulphate released during the oxidation, and it precipitates gypsum. And we commonly see gypsum as an indication of acid generation and neutralization process where acid rock drainage happened.

The program we designed to assess the geochemical characteristics follows industry standard, and are -- we are listing two of them here that are MEND 2009, which is -- which was developed in Canada by the Mine Environment Neutral Drainage. It become a blueprint around the world. It's been used as a benchmark for a lot of assessment programs. And we use the INAP guideline, which is the International Network for Acid Prevention. Based on these guidelines, we selected nine samples, three from each of the rock types. That's the carbonate, the shale, and the sandstone. But when the samples arrive at the lab, the lab created replicated samples just to make sure that they capture the spatial variability that may exist in the sample. The table in the -- in the middle of the slide shows the recommended guideline for the number of samples that someone should start with for an assessment, and it indicates the number of samples based on the tonnage that -- on the tonnage of the waste rock that is expected from the project. This project estimates that will release less than 4,000 tonnes of carbonate and shale during the five years. And that really is half -- nearly less than half of the lowest level. So, theoretically, you would need about three samples. So, we took nine just to make sure that we are capturing the spatial heterogeneity that might exist within these formations. Those samples were taken from four boreholes that are listed here. The samples were visually examined in the field and in the lab by -- by our team, and they documented them. They were stored in sampling bags, and they were shipped to an accredited laboratory for testing. This laboratory conducted a very rigorous QA/QC program to make sure that the -- the analysis is correctly done and the data is suitable for use for analysis.

This the -- this photo shows a core from Bru 95-8, and it shows the carbonate unit and the transition zone between the carbonate and the shale all the way through the shale unit. The photo on the left shows a chip tray, which is a fragment of the different rocks across a borehole, all the way from the -- the quaternary sediment through the carbonate unit, the shale into the sandstone. On the right side, this is a procedure we use to assess whether material is -- weathered or not, it's to see if we can peel the rock. And as you can see here, it's very easy to push a knife into the shale, and this means that the shale is highly weathered, and all the boreholes we had, they document that it's highly weathered in situ.

These two photos shows the core and the sand, packed in sampling bags, these are standard sampling bags, and zip logs to be shipped in pails to the laboratory for testing. Our analytical program included four different type of tests, the acid base accounting, which is used to determine the acid potential. We used an X-ray diffraction to determine the -- the -- the composition of these rocks and specifically to identify whether there are minerals, potentially acid generating, and the minerals that are likely to neutralize the acidity. We conducted a metal analysis to estimate the metal contained in the rock. Then we did a shake flask extraction, which is a leash test designed to identify the level of acidity and metal concentration that may be released from this material under oxidizing condition, and very quite vigorous, and I will come back to that later laboratory condition.

The table -- this table shows a summary of the first test, the acid base accounting. On the far left side, you have the three main units, and you have an average of the main parameters that we use to assess this -- the data. And on the right side, there is a column called Material classification. After doing this test, we usually did -- classify the rocks into three classes, whether it has very low potential for acid generation, and we call that non-PAG, or it has a high potential for acid generation, and we call it PAG, and there is a grey zone in between, which indicates a level of uncertainty. And if you -- so, in this case, the Red River carbonate and the sandstone were classified as non-PAG because they're very hard. They have very low potential for acid generation, and that's because there is very low sulfur.

In addition to that, the carbonate unit's very -- has a very high reservoir of alkalinity. It's capable of offsetting a lot of sulfur. In the case of the Winnipeg shale, it's a bit more complex. We have a mixture of different classifications. One of the samples had low potential for acid generation, and two were in an uncertain zone. And in this kind of situation, we adopt a very conservative approach, and we decided we're going to classify all the shale as high risk and manage it appropriately to protect the environment.

In this next slide, I will discuss the result of the last test. I won't talk about the second and the third, but I would be happy to discuss any of their results. Based on this test, we noticed there was no acidity at all in this sample because the pH remained neutral. Then second -- there was a very limited metal leaching, and the most noticeable ones are shown on this table. For the Winnipeg shale, we noticed there is a selenium potential release at levels that may exceed groundwater quality guidelines. There was some arsenic. For the Red River, there was only a marginal exceedance of the selenium, and for the sandstone, it was mainly iron, and it was also marginal. When we compare this data to the water quality guidelines for the protection of aquatic life to generally speak about the impact on surface water, we also noticed that aluminum, selenium, and some iron are the main elements that we should be worrying about. Based on these results, we recommended the development of a waste characterization and management plan, and the objective of that is to collect additional samples in order to reduce the uncertainty in our assessment, specifically for -- with respect to the shale. And in that plan, we outline measures for managing the -- these materials in order to protect the environment. I will discuss this plan in more detail later on. For now, I will pass it to Mr. Mills to discuss the groundwater quality aspect.

MR. MILLS: Ryan Mills. And with that, as -- as my colleague indicated, we'll move on to a discussion of the water quality component of the geochemistry assessment. And this involved direct measurements of water quality in the aquifer, built both before, during, and after the assessment involved. It also benefited from extensive literature that had been published by the Geological Survey of Canada, many of Manitoba's legacy of hydrogeologists, as well as the results of our -- our field investigation. And again, the -- the objectives here were to determine the baseline water quality in -- in the aquifers that -- that are likely to be affected within the project area, and -- and relied upon for -- for drinking water. We assessed the effect of operations on water quality by sampling before and -- and after a pumping test. And -- and we wanted to understand the role of the Winnipeg shale in the hydrogeological system. It's not a unit that is typically targeted during water supply well drilling, and -- and hence, we recognize that that may be a bit of a -- a focus of our investigation and -- and would be beneficial to inform our modelling and conceptual model.

The program overall involved collection of 20 water quality samples and duplicates from several monitoring wells, including three private wells. It involved the collection of 13 water samples for isotopic analysis at the University of Saskatchewan. It involved collection of field parameters in the field, and those were used as part of a quality assurance check to validate laboratory data. The water quality samples were then field filtered following best practice and analyzed by ALS Environmental Laboratories, a -- an accredited external laboratory that does these analyses routinely. And the isotopes samples, again, were analyzed at University of Saskatchewan to help understand that -- the history of the water in -- in that shale unit. And then there was a -- a quality assurance and quality control program that consisted, again, of -- of duplicates and -- and matrix spikes and -- and method blanks. The analysis, you know, involved, again, characterization of parameters in situ to describe the water quality in the field, as well as many parameters that broadly describe water quality, and in addition to several parameters that supplement the understanding of existing conditions and -- and the potential for any impacts related to -- to drilling.

When we look at the results with a focus on the origin, determining the origin and chemistry of the water, we determined that with the exception of the shale, the groundwater has a meteoric origin. It has a neutral pH and suboxic redox conditions. And what this means is that there's very little oxygen in the aquifer as it is now, very little to no oxygen. The groundwater is fresh. So that means that it has a very low total dissolved solids concentration in both the carbonate and the -- the underlying sandstone aquifer. And -- and that's in stark contrast with the groundwater in the sandstone aquifer much further west on the other side, especially of the -- of the -- the Red River, and -- and to some, you know, distance east of that. But well outside of the project area, and then very low concentrations of other parameters that would, you know, reflect the -- the end result of weathering and -- and other sources of water. We found that the groundwater met drinking water quality guidelines except for turbidity, which is likely due to that short-term post installation, you know, impact on -- on just suspended sediment that would settle out over time. And then we found that iron and manganese exceeded aesthetic objectives that are really designed -- those -- those values are set because they're above those values. You sometimes see, you know, red or orange staining around sinks and black staining on plumbing fixtures from -- from iron and manganese, which is common and is probably experienced by several people in the -- in this area now. Many of the parameters, however, were well below the detection limit in -- in samples, including selenium, which was notably in contrast to the shake flask extraction, which is on a small scale laboratory test under vigorously oxidizing conditions. We found that the selenium just was not present at levels above detection limits in the laboratory, in 16 out of the 20 samples. And again, here is a similar table summarizing those results. And you see that -- that selenium notably is -- is absent from this. There are a couple of other trace metals that are commonly found in -- in subsurface deposits and aquifers and -- and may also be associated with some of that short-term disturbance.

So then we wanted to overlay and investigate the possible -- possibility of -- of the -- the project activities impacting water quality. And the three methods that we -- we -- or assessments that we undertook as part of that investigation were to, number one, look at the impacts of -- of bringing groundwater from the sandstone formation to the surface, exposing it to an unlimited source of oxygen, which is a highly conservative kind of starting point, and then allowing that to be reinjected in the aquifer, right, where it would once again be isolated from oxygen, but we've assumed that that oxygenated condition persists in an abundance of caution. And what did we find? We found that the pH may slightly increase, and groundwater conditions would become oxidizing if that water was left at surface. We found that in response to those changing redox conditions, that the ammonia, iron, aluminum, and manganese concentrations would -- would decrease. Okay. We found that -- that -- that was as a result of oxidation and formation of amorphous oxyhydroxides. I know it's complex, but essentially it's -- it's iron and oxygen combining to form these oxyhydroxides in -- in -- in --

and that would take the form of one of many minerals, including ferrihydrite, diaspore, and magnetite -- or magnus -- yeah, magnetite -- or manganite, sorry. The amorphous phases are also known, as -- as Dr. Elemine mentioned, that they are known to attenuate metals through coprecipitation. So, that means that the iron and the other elements can coprecipitate and fall out of the water and once again return to their solid form. Okay? So, we're seeing evidence of that through the modelling and especially in the case of selenium. And so this may explain why we see differences between the laboratory data and the real measured data in the aquifer.

However, it's important to note that in spite of the very conservative approach that we took here, this would -- this condition would require an unlimited supply of oxygen to promote these reactions. These -- oxygen is a required ingredient in this recipe, which will not occur in the subsurface. Therefore, the oxidation of sulfide minerals in saturated environments is not a plausible scenario.

The second assessment component of our assessment was to look at the impact of aquifer mixing on water quality. So we're recognizing, based on the results of the geotechnical assessment, that the shale is very weak, and it may collapse and allow for connection between those aquifers. Okay? And so we wanted to investigate the impacts of -- of -- of that possible connection. And -- and so, we recognized that the vertical gradients between those two systems, so the differences in water levels and the possibility of flow exchange between the two aquifers, it may bring some water from the sandstone aquifer up into the overlying carbonate, and it may also take some water from -- if you have downward gradients, from the overlying carbonate into the sandstone. So we looked at those two possibilities. And so, we simulated mixtures of those two waters, and we found that the results were fresh, and they met Canadian drinking water quality guidelines, again, with the exception of iron and manganese, which already exceed those guidelines for aesthetic objectives in the existing baseline condition. From an up -- when we looked at upward mixing, the simulated water quality in the Red River carbonate showed that iron concentrations would decrease below the Canadian drinking water quality guidelines. When the Winnipeg Sands -- proportion of the water was greater than 80 percent. So in other words, if locally, somehow, the -- the water quality comprised 80 percent water from the sandstone and 20 percent water from the carbonate, we would see, you know, concentrations of iron that were below guidelines. And this is not surprising because the water in this -- the -- the sandstone is naturally low in iron concentrations. However, that water has some higher concentrations of manganese, and so when those mixing proportions were greater than 70 percent sandstone water, we found that manganese started to exceed Canadian drinking water quality guidelines. We found decreasing concentrations of chloride, calcium, magnesium, arsenic, iron, uranium, and many other parameters, with an increasing proportion of the -- the Winnipeg sandstone aquifer. And it's not surprising it follows a conservative mixing relationship.

When we looked at the opposite scenario involving downward flow from the overlying carbonate aquifer into the Winnipeg sandstone, we found very similar findings. So, the iron concentrations marginally exceeded the drinking water quality guideline aesthetic objectives when the Red River carbonate proportion was greater than 30 percent, and the manganese concentrations decreased below guidelines when the proportion was greater than 30 percent. So, it's sort of the opposite scenario. And we found decreasing concentrations of sodium, sulfate, and zinc with increasing proportions of water from the Red

River carbonate because they are naturally low in those -- those components. We used all of the information from the conceptual model, the numerical groundwater flow model, the geochemical solid phase assessment, and the water quality component of the geochemical assessment to conduct what we call an impact assessment. So, looking at the project holistically -- holistically. And we classified what are -- what we have determined to be the residual effects on groundwater quantity and quality. And this table summarizes the residual effects after the application of standard and defensible mitigation measures that have been applied widely on other projects globally and -- and -- and within Manitoba. And -- and this describes the residual impacts, and we looked at those residual impacts because this is a highly transient phenomenon. As Dr. Harvey mentioned, we have water level impacts during and shortly after operations until static groundwater levels recover, much like turning a well on and off. And -- and then in that post-recovery phase, we also looked at the residual impacts, right? So, this kind of captures the worst case and -- and sort of the long term scenario. And we found that the magnitude of drawdown could be up to six -- sorry, six metres in the Red River carbonate and 25 metres in the Winnipeg sandstone, assuming zero reinjection of groundwater. So again, a very highly conservative case that does not reflect the planned case, which is -- which involves reinjection of -- of all but 15 percent of the available water. And again, in an abundance of caution, we took that approach. We found that the geographic extent, even with those conservative assumptions, was local. It was temporary. It was reversible because the water levels do recover. And the frequency was periodic. It occurred, you know, during project operations and shortly after project operations, but recovered to static conditions every -- every fall and winter after operation ceased. And the probability of the occurrence of those impacts is fairly certain. We understand this is essentially like operating a water supply well, and we understand how water supply wells operate fairly well. They operate in a predictable manner. The aquifer system is well investigated by ourselves and many others, and the findings are in general agreement within the project footprint. When we looked at the post-closure impact, so, you know, what happens after the project is done, we found that -- we -- we had a difficult time classifying impacts, essentially because all of the impacts dissipate. They recover. So, there's -- it's a neutral direction. We can't classify the magnitude because there is none. We -- we --the geographic extent, there isn't one because the --

the -- the impacts are -- have -- have -- have recovered. And the duration of that -- those impacts is -- is permanent, yes. We recognize that. And -- and the probability of -- of -- of that occurring is fairly certain. We have conducted field testing that demonstrates water levels recover after operations.

When we conduct the same or take the same approach in the view of looking at groundwater quality, you know, the direction was positive to negative. As I described, some of the water quality parameters improved. Others slightly worsened, depending on the assumptions that you take in the direction of flow at the location of each of these connections between the aquifers. The addition of oxygen to the -- the mixture generally will reduce iron and manganese concentrations. It -- and -- and there's essentially very little to no sulfides available for oxidation. The shale is already weathered in situ. And so essentially, the findings show that the -- the -- the duration of those impacts will be temporary. They are reversible, and -- and -- and you know, they -- they occur largely within the -- the project footprint based on our -- our assumptions.

On the basis of that assessment, we

recommended -- in an abundance of caution, we recognize that people rely on this drinking water source from both aquifers and that it is important to -- to, you know, even though we have full confidence in our work, it's important to establish protocols that are able to validate that -- that -- that, and -- and benefit from new learnings along the way. And so, we recommended establishment and -- and -- and implementation of a groundwater monitoring and mitigation plan, which has been provided in draft, a progressive well abandonment plan that has been provided in draft, and a waste characterization and management plan that has been provided in draft, as well as a water management plan, and we have not provided that yet in draft. It typically relies on extensive input from -- from licensing conditions, and -- and you know, it -- it -- it does -- just doesn't make sense to develop that just yet. And with implementation of these plans, the potential adverse effects on groundwater and quantity -- quantity and quality are anticipated to be mitigated. And -- and -- and -- and there's precedent for -- for this. In -- in -- there's a -- a concept of adaptive management in -- in the engineering and geoscience field, where there is always some residual uncertainty. You could have the most qualified people, lots of local experience, there is always the possibility of some subtle heterogeneities that may not have been captured by previous work. But it establishes a framework by which you track that information based on monitoring data. And then you have a framework for responding to the -- the -- those conditions and the monitoring data, and -- and adapting as you go, and that feeds back into project design, et cetera. And we'll get to that in a little bit more detail.

So, this is a -- this slide shows, you know, a cover page for the -- the guidance on adaptive management plans in British Columbia, and it's one that we've applied many times and -- and -- and many others have applied. And -- and really, this -- the purpose of adaptive management is to allow for decisions to be made in the -- in the face of uncertainty, and provides a means to systematically reduce those uncertainties and improve management practices over time by learning from the outcomes of operational activities. And this -- this comes from the -- the -- the Ministry of Environment. And this flow chart here just shows the process by which that feedback occurs. So, just pointing on the screen, we've -- there's a design of a project. You begin to implement a project. You monitor the impacts of that -- that project. That provides information that is then evaluated by qualified professionals. You determine whether or not you need to make any adjustments, and you assess the efficacy of those adjustments and whether -- determine whether or not you need to refine your design. So, it's sort of like a continuous learning approach.

So with that, we moved into -- I'll briefly capture the groundwater monitoring impact mitigation plan. It describes in some level of detail, and again, these are draft documents that -- that we've already received some subtle comments of agreement from independent peer reviewers not on this panel, and -- and -- but -- and also some suggestions that I think are fair and valid that -- that could be incorporated into the -- the finalized versions of these plans, along with license conditions. And so we would of course conduct a water supply well survey to determine the exact locations of -- of monitoring wells and -- and water supply wells in the area. We would monitor the groundwater quantity and quality, and it -- it establishes the location, parameters, frequency, et cetera. It would surround the -- the -- the zone of influence of the project. We would assess field performance against the design goals and objectives to direct that continuous improvement. And -- and groundwater evaluation tools, including the -- the geochemical models and the numerical groundwater model, would be improved based on the results over time. We would establish protocols for receiving and responding to any queries or complaints. We have put forward a draft trigger action response plan that identifies mitigation measures and guides their implementation to, first off, avoid impacts that are unacceptable, and then also, if there are unacceptable impacts, respond to them quickly. And then we're going to assess the effectiveness of those mitigation measures and establish a framework for reporting the findings to the community and regulatory agencies over time.

This is what the trigger or the groundwater level monitoring frequency would look like. On the left, you have the different monitoring zones that essentially establish some background monitoring wells and -- and regional, local, and operational footprint oriented monitoring wells, with generally increased frequency of monitoring close to the operational footprint within the zone of greatest impact and diminished monitoring regionally. And through all phases, each column represents a different phase of the project, and this would continue well beyond the end of -- of project operations.

This table presents the same sort of philosophy applied to groundwater quality sampling. And then that data that those monitoring programs produce would be reviewed on an ongoing monthly and annually -- annual basis. We compare water levels to thresholds. We would compare water quality to applicable criteria. Compare the data to the thresholds established in the trigger action response plan and respond accordingly based on those results. And even in addition to that, we would respond to any well owner queries or complaints that -- that -- that happened or happened to -- to come about. A comprehensive annual report would be produced that documents the operational activities, the water level and water quality results. The summary of the status of those trigger action response plan events, so, where are we in the spectrum of responses? Are we getting close to a trigger? Are we well below a trigger? And then summarize those well owner complaints and responses and action that was taken.

We've also developed a -- a draft progressive well abandonment plan that is intended to meet the regulatory requirements around borehole and -- and well abandonment in -- in -- in Manitoba. Recognizing that, you know, this -- this requires a bit more thinking.

There is some -- some regulatory differences depending on which regulation you look at, but I'll leave that to others to interpret. And really, we just want to make sure that because we know wells are -- are -- can be a conduit for interactions between surface and the aquifer, that they are abandoned promptly after operations and that their status is -- is tracked and -- and checked. With that, I'll pass it to my colleague, Dr. Elemine, to discuss briefly the waste characterization and management plan.

MR. ELEMINE: Thank you, Mr. Mills. So, a waste characterization and management plan has the following objective. It should provide a high level summary of the geochemistry, just in case the reviewer -- the reader doesn't have the complete data set or the assessment report, so you could rely on that information that is provided early on to make an assessment of the material that will be excavated or extracted by the project. It describes procedures for collecting additional samples to improve the understanding of the geochemical properties and reduce the uncertainty in the assessment. It also outlines mitigation measures, and this is the most important part. It's to be able to manage that risk with less or no environmental impact.

And it also outlines measures for monitoring. It is very important, if you implement some mitigation measures, to make it -- to develop a monitoring program to make sure that the -- they meet the performance that was designed for.

This slide shows you the sampling frequency we propose to be conducted during -- prior to operations and during early phase of operation. And this is a very, very high sampling frequency. If I go back to that table I showed earlier on, it essentially said you need one sample for 1000 tons of material, and here, we are collecting one sample, per about 700 for example, for the carbonate, and 200 tons for this shale. This is a very high accuracy, and we think it will provide valuable additional information ahead of operation. And during operation, we can scale down the sampling process because by then we would have acquired a lot of information to inform us on the behaviour of these formations in the subsurface. It also involves a waste management strategy. Now, unlike traditional mine sites, as you all know, there are thousands of tonnes, millions of tonnes of waste rock and tailings that get left at the surface for generations to come. This -- this project will collect all those materials that will be extracted, store it in tanks, and take it away for -- to designated licensed facilities for disposal. This means that the usual environmental risks associated with mining are completely eliminated. To our understanding, those who are -- have been drilling wells in this region, they generally use -- they -- they -- they leave their -- their residue at the site. But in this case, the project elects not to build any stockpile outside at the site, but to take away everything for disposal. This also means that the intensive network of monitoring that's generally associated with waste piles and tailings facilities will be eliminated. However, we stress the importance of keeping our groundwater monitoring in place, as my colleague just discussed. We also outline a procedure for documenting all that work, the sampling process, the characterization, and the management, into a deliverable, which includes the geochemical data and any other improvement required, and document that in a report and make it available when it's required.

MR. MILLS: Ryan Mills. I'll just wrap up quickly with one slide on the water management plan, and -- and really, this is a -- a plan that has yet to be developed. It is -- these are fairly routine in projects involving the conveyance of -- of or management of -- of water. We've recommended that that be expanded in this case because there will be slurry transport that attracts the volume of solids as well as the volume of water, so perhaps the title may change, but this is just to track the mass of material as it moves through the system, both water and solids. And -- and -- and really, that is to just -- it would be a requirement of any Water Rights Act license, you know, to track the volume of -- of groundwater that is extracted. So this is -- this is something that's expected and routinely done. So, it would describe the configuration of the project elements, how water is moving through the system in addition to solids. It would establish a framework for monitoring of those -- those elements moving through the -- the -- the process system. It would establish the parameter frequency and locations where this -- the monitoring of flows and -- and perhaps quality within that system would occur, and identify best management practices to ensure that groundwater and surface water are preserved. There would be a framework, again, for reporting of the findings to the community and regulatory agencies on a regular basis. And this would of course be prepared after a license is issued and submitted in advance of operations.

And so in -- in summary, on the balance of

-- of all of the field investigation, literature review, involvement of -- of peer reviewers to make sure that the numerical analysis of -- of both the groundwater flow system and the groundwater quality and geochemistry components of things, and the application of these mitigation plans which are typically reserved for much later in these processes -- we have a high degree of confidence in the -- the findings that we've presented here and that the results are conservative and can be relied upon. Thank you, Chair.

THE CHAIRMAN: Chair, thank you very much. We've covered a lot of ground here. All right, let's try a little exercise in time management. So, we would now move to questions, and we've got a little less than a day to do it. Dennis, how much time do you think you're going to need? Is the Rural Municipality of Springfield still here? Will you be questioning and if so, how much time will you require? No questions. Okay. Our Line in the Sand? There'll be no questions, okay. MSSAC? Manitoba Eco-Net? Okay, so, two -- four -- we're looking at about six hours before we even pull in the public or the panel. Dennis, would you like to start? We got 20 minutes left. I'd suggest we not waste a minute. Chair, so, let's go to 4:30 and see how we're doing. I don't really want to go much later than that, but I also don't want to waste 20 minutes.

MR. LENEVEU: It's Dennis LeNeveu. Could you put up slide 11? I think I'll just start with the hydrogeological modelling that are -- questioning that was done this morning because I -- I have only two slides, but it may develop into a -- a -- more extent could be developed into an extensive discussion. Now, the one thing I want to stress -- this is a modelling study that I did using a -- a solution for the head. Evolving head in the sandstone, using an analytical solution from Carl's law and Yeager. Now this is not dissimilar from the theist solution. That was already taken, but developed in Carl's (ph) Law and Yeager (ph). Now, this is not dissimilar from the Theis solution that was already taken -- developed in Carl's Law and Yeager. This is a heat conduction code, but the governing differential equation for the head is the same. And this particular solution allows you to put a point source withdrawal representing a will or a point source emitter representing an injection, and the situation is, for Sio Silica, you have both going on. You have withdrawal at the bottom of the well and injection near the top of the sandstone layer of -- by gravity feed, apparently, of returned water. Now, I would like to make an observation that in the hydrogeological modelling undertaken and talked about this morning, there was no actual reinjection of water. It was just a -- a reduction in the withdrawal rate. Now, in this model, there was actually two injections points, one at the bottom near or -- or about ten metres or -- no, about 20 metres down and near the top, representing the withdrawal at the bottom of the production pipe. And injection -- actual water injection rate -- the input parameters were water injection rate, not pumping pressure. Just rate at 15 percent less than the withdrawal rate, because apparently 15 percent is lost to the sandpiles. And you get an interesting phenomenon. There's three wells there. You get a positive head. This is head change. You get a positive head at the top where the water comes in, and and negative at the bottom. So, you get circulation of water coming down the pipe and coming back up and out into the aquifer. Now, there -- because there's a positive head at the top, this is near the carbonate, and you could get transfer of water into the carbonate when the shale is gone. Now, this is completely missing from the hydrogeological model it described this morning. With the opposite occurs, you only get head reduction. Now, my question is, In the hydrogeological model this morning, I assume you discretize finally where the water withdrawal was and put in water withdrawal well boundary conditions. Could you not have done another discretization at the top, where water is reinjected, and put in a water reinjection rate to represent actual water reinjection rather than just reducing your withdrawal, which is not the same as injection. I want to make this point. Injection and reducing the water withdrawal are not the same. So my question is, Could you not discretize your finite element model, finally, and put in a water injection point near the top of the aquifer corresponding to the withdrawal weight at the bottom of the production pipe for a well?

MR. HARVEY: Miln Harvey. So, first of all, you used an analytical solution. An analytical -- an analytical solution is a simplified mathematical representation of the groundwater flow environment that involves a number of simplifying assumptions, including no recharge, uniform properties, and essentially no boundary conditions left and right, which means that the numerical model that we developed is a much, much better tool to represent groundwater flow. Net withdrawal -- no, no, wait, we get a few points to unpack here. Net withdrawal is extraction minus injection on a mass balance. What you take out and what you put back at the -- in -- across the same aquifer is essentially -- you are -- you're doing the net injection, so it's extraction minus injection is -- is -- is net -- net injection. So, they are the same thing. With regards to discretization, we discretized the model to include one layer to represent the sandstone because it -- to -- to -- to represent each of the hydrostratigraphic units because it is a regional scale model, and the type of discretization that you're looking for, that you propose, is unrealistic in this type of analysis. And just to confirm, the numerical model that we used did an extremely good job of representing the impacts associated with pumping.

MR. LENEVEU: Thank you for your answer. I agree with you. On a regional scale, an analytical solution wouldn't be appropriate. But on a local scale, for a single well, such as the Theis solution, it is very appropriate, and in fact, it's not impeded by boundary conditions. And what I'm trying to focus on here is the local scale around a single well, where you can discretize finally to discriminate between an injection and withdrawal point, and you've described how that was not done in your model because you're dealing with a regional scale. But -- for you can see from this modeling on the local scale, the actual position of the withdrawal point and the injection point are very important, and it's not the same situation as a net withdrawal. It is water coming in at the top to create a higher pressure zone and water withdrawal at the bottom. And you get a circulation of this nature, and a situation can -- water can escape into the carbonate. Now, you have to be -- realize that the cavity is bounded over a small region, and you can't get any transfer because of the aquitard on a regional scale. But on the local scale where the aquitard has collapsed, you -- this demonstrates -- this modelling would demonstrate that that's what happened. You would get transfer of water into the carbonate. So, rather than people having a drawdown in their well, they would have water transferred, and this is aerated water that can cause geochemical effects. This is completely aerated water from the surface is what you have to worry about, and -- and once again, okay, you don't want to discretize on a regional scale. Then I would suggest that in order to -- or ask you, in order to get the proper effect in discriminating between actual injection and withdrawal, which you haven't done, do this on a local scale where you can discretize to see what the effect would be, and -- and pick up this effect that is not modelled in the regional effect and of the possible transfer through the damaged shale there. Now, one other thing. This is going to be repeated many, many times for your clusters, so it may not seem like a big deal for one, but for over and over and over again, now you get a big water transfer going on into the carbonate. So, my question is, Can you not do this in your model, on a local scale where you actually do discretize finally in two places to get the effect of water withdrawal and water reinjection?

MR. DUNCANSON: Mr. Chair, just before we let the witnesses answer the question, this is Sander Duncanson. I made some comments earlier about the purpose of what today is supposed to be about, which is asking questions of the Sio witnesses versus what we're going to hear next week, which is an opportunity for Mr. LeNeveu and others to provide their views to the panel and be asked questions about that. Out of fairness to Mr. Mann, I -- I -- I -- I feel like if -- if I let Mr. LeNeveu provide his views and not make the same comment, that would not be fair to him. So, I just wanted to make the same comment, that really, what we should be doing here is -- is having questions asked of the Sio witnesses, not a presentation of Mr. LeNeveu's views, which will be for next week. And just one other observation, which is -- I think it's -- it's difficult for the witnesses to be able to answer questions when there's a five minute preamble with a whole bunch of different stuff embedded in it. So, in -- in fairness to the witnesses, it would be much easier and I think more efficient for everyone to have individual questions, allow the witnesses to answer those questions, and then we can move on to the next.

THE CHAIRMAN: Chair. Thank you for that, Sander. You probably noticed my finger was starting to get a little twitchy. I was giving Dennis a little latitude, but I think he went over the line. I think the preambles need to be short, and I take the point that this -- the purpose right here and now is not to put forward your own position or ideas, but to ask questions.

MR. LENEVEU: Okay, I'll just ask a simple question. Can you not do a local -- a scale model with this type of discretization of both an injection and withdrawal?

MR. HARVEY: We have. We assigned well boundary conditions across the Winnipeg sandstone. We adjusted the hydraulic properties or hydrogeological properties of the Winnipeg shale, and we've shown the transfer of drawdown from the Winnipeg sandstone into the Red River carbonate by assigning a net injection -- or sorry, a net withdrawal rate. And from a mass balance perspective, what you take out minus what you inject is net extraction.

MR. LENEVEU: Yes, I appreciate that's true on a regional scale, but my -- let me ask the question again. Can you not define a local scale, much smaller model, and do this type of modelling with two different points just to examine what the potential difference is, especially across a small area of field aquitard? Is this not possible? I don't want to hear what you did about it, I just asking the question, Is this not possible for your finite element model?

MR. HARVEY: So, I have two comments. One, we refined the finite element model around each of the extraction and observation wells to properly assess localized conditions. So, we did do that, and I -- I have that in the presentation. When we -- we updated the operational plan, we refined the -- the -- the mesh to properly assess drawdown impacts associated with the extraction plan. To -- more to your point, we could refine the model, but it's of no value to assessing the impacts because we've done that on the regional scale model on the scale of those impacts. So, we -- we've shown that those impacts have a zone of influence which --

which moves out and contracts on an appropriately sized mesh to get -- to essentially, to get reasonable impact assessment done. So, we could refine it really, really well, but it will provide no more value than the model that we currently have. The model that we have is quite appropriate for making the impact assessment that we proposed and -- and completed.

MR. LENEVEU: Thank you for your answer. I think you're making a statement before you have the evidence. I mean, you can't make a statement like that until you've actually done a -- a small scale model, like it is done here, to see if there is an impact. Your right -- go back to your regional scale model, which I would imagine is not appropriate to get this fine scale effect. So, I would say -- ask you, because you do admit that you could do this, just to verify that -- or examine if there is any problem or any difference for this very localized system, would -- and to verify what you said, there's -- there wouldn't show any difference. Would -- could you not do an exercise in this very small scale to make that -- to give evidence for your claim that there's -- this is of no value?

MR. HARVEY: The level of mesh refinement that was -- the level of mesh refinement that was used to make our predictions of drawdown impacts was appropriate for the scale of the model and the scale of the impacts. We did refine the mesh. We refined it around the -- each of the observation wells in each of the pumping wells, and we refined it down to a very, very fine level in order to understand that both spatial and temporal impacts, and that level of refinement was appropriate for the scale of this project and the scale of the model.

MR. LENEVEU: Thank you for your answer. I agree with you on a regional scale, it's appropriate. I'm asking you on a local scale, just in the area of the damage zone of the aquitard, where you could get transfer on the carbonate. I think you could, from what I've heard, do a local scale model. It's just that you've said you're not going to, based on an opinion that there is of no value. I don't think there's any point in pursuing it any further. But I -- I do disagree with your statement that there -- it is no value to do a localized model unless you actually do it.

MR. HARVEY: One last point. Industry standard guidelines on the development of models to assess the impacts of proposals like what we -- what is being put forward by Sio -- we have done the level of parameterization of the model and the level of refinement of the mesh that is appropriate. So, we've done an -- an appropriate level assessment based on industry standard.

THE CHAIRMAN: Could we -- Chair. I -- I think we'll -- I think we'll call it a -- a day and adjourn and reconvene in the morning, where you will again have the floor, sir, and we'll pick it back up at 9:30. Thank you.

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